BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE BENCH AT CHENNAI

ORIGINAL APPLICATION NO.220 of 2021
(UNDER SECTION 18(1) READ WITH SECTIONS 14, 15 OF THE NATIONAL GREEN TRIBUNAL ACT, 2010)

IN THE MATTER OF:-

K.Jayakumar,
S/o.S.Kalitheerthan,
14, 15 Anugraha GJV Homes,
RakkiyaPalayamPrivu,
Near Century Foundation School,
Nallur, Tirupur – 641 606
Also at
No.1, East Street, Somandagudi Village,
Kallakurichi – 606 202.
Email: skjayakumar@hotmail.com
Phone No: 9150664659 ...Applicant

Vs

1. M/s. Ministry of Environment,
Forest and Climate Change
Rep. by its Joint Secretary
2nd Floor, Agni Block,
Indira Paryavaran Bhawan,
Jorbagh Road, New Delhi – 110 003
Email: mefcc@gov.in
Phone No: +91-11-24695328 & 7 others ...Respondents

ADDITIONAL TYPED SET I

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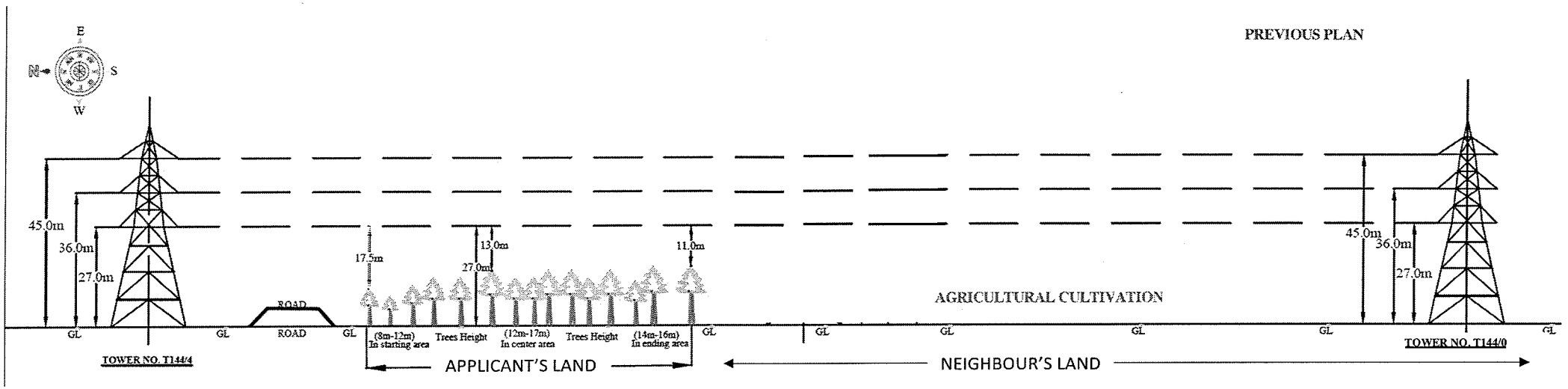
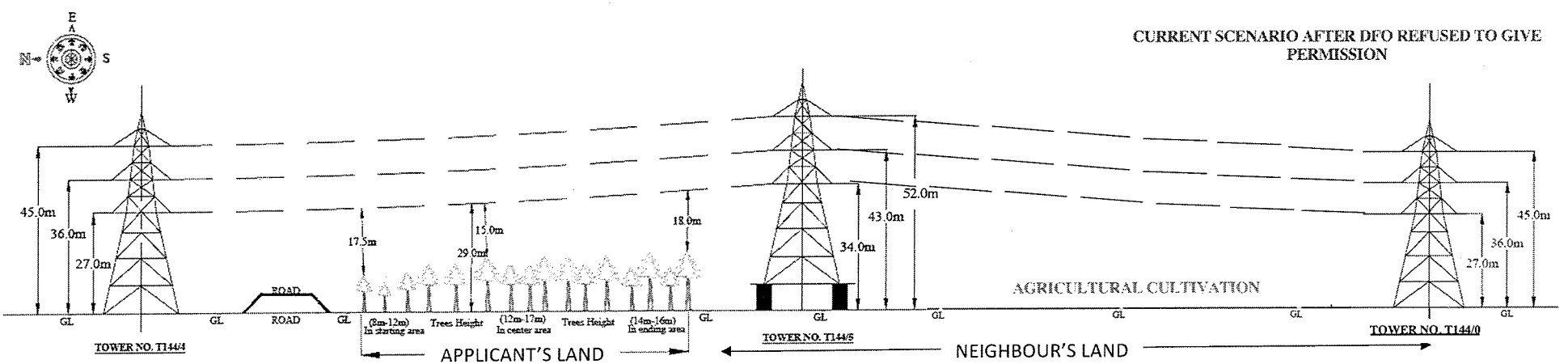
Dated at Chennai on this the 25th day of November 2021

Counsel for the Applicant





DRAWING SHOWING ADDITIONAL TOWER

BOX 4.1 : POWERGRID'S EXPERIENCE AND INITIATIVES TO MITIGATE ENVIRONMENTAL IMPACTS

POWERGRID has been implementing Environment and Social Policy and Procedure since 1998. Prior to that, transmission lines of approximately 27,000 Ckm were laid across the country. This involves approximately 6% of forest area. However, after implementation of ESPP w.e.f. 1998, diversion of forest area has been reduced to approximately 1.35% from 6% taking into consideration the addition of approximate 20,500 Ckm of line up to March, 2004 and 21,483 Ckm during April'04 to Dec'08 (since 1998). The cumulative total of forest area is around 3.3% for 69,482 Ckm line constructed. (**Appendix XXVIII**).

Measures like Compensatory Afforestation, which involves plantation over twice the area, affected by the project has not only helped in compensating loss of vegetation, but has also increased forest cover. POWERGRID have contributed about US $ 25 million towards afforestation on more than 10,000 ha of land over the last decade. Massive plantation in all of its installations not only improves aesthetics but also contributes greatly in maintaining the desired ecological balance.

To minimise adverse impacts on natural habitats, human habitations, majority of towers are located on agricultural lands. To minimise damage to the environment POWERGRID uses manual stringing in thick forests and on slopes whenever possible.

POWERGRID has incorporated the best technical practices to deal with environmental issues. In landslide prone areas, POWERGRID designs tower bases with leg extension and revetments that prevent soil erosion near the tower. POWERGRID has also designed special towers such as very high (80 m and occasionally over 140 m) for reducing impact on trees, orchard, wildlife and crossing of wetlands, riverbeds. Wherever appropriate multi circuit and compact towers have been installed for reduction in ROW requirement. *We have taken initiatives to optimize ROW requirement through change in tower design, resulting in reduction of the requirement from 85 m to 64 m for 765 KV and from 52 m to 46 m in 400 KV D/C line.*

The mitigation measures for environmental issues are summarised in **Table 4.3**

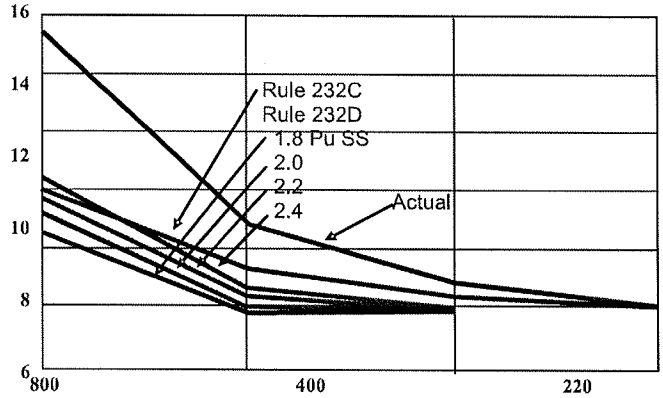
Appendix - XIV

ELECTRO-MAGNETIC FIELD

Power Technologies, Inc. has been requested to review POWERGRID's 132 KV, 220 KV, 400 KV and 800 KV lines with respect to conductor to ground, phase to phase and circuit to circuit clearances and their appropriateness in light of present practice.

Based on a review of POWERGRID's designs, we find that the phase to phase and circuit to circuit clearances are consistent with practices used for line clearances throughout the world. The values used by POWERGRID are generally in the middle range of that used throughout the world and are expected to provide satisfactory performance.

The conductor to ground clearances are within typical limits and meet or exceed the requirements of the National Electrical Safety Code, American National Standard Institute, C2, as shown on Figure.



Analysis of POWERGRID Transmission Line Clearances

The analysis was based on the following data as supplied by POWERGRID.

800 KV S/c Line

Configuration - Horizontal

Conductor Bundle - Quad CSR Bursitis (35.1 mm id)

Max. conductor sag - 14.56 m

Phase to phase spacing - approx. 15 m.

Ground clearance - 12.4 m (as per IE rules):15 m (maintained to limit max. electric field to 10 KV/m)

Right of way - 85 m

400 KV S/c Line

Configuration - Horizontal

Conductor Bundle - Twin ACSR Moose (31.77 mm dia)

Maximum conductor sag - 12.87 m

Phase to phase spacing - 10 to 12 m

Ground clearance - 8.84 m (as per IE rules)

Right of way - 52 m

400 KV D/c Line

Configuration - Vertical

Conductor Bundle - Twin ACSR Moose (31.77 mm dia)

Maximum conductor sag - 12.87 m

Phase to phase spacing - 8 to 9 m

Ckt. to ckt. spacing - 12 to 14 m

Ground clearance - 8.84 m (as per IE rules)

Right of way - 52 m

220 KV D/C Line

Configuration - Vertical

Maximum conductor sag - approximately 9.8 m

Phase to phase spacing - 5 to 5.5 m

Ckt. to ckt. spacing - approximately 10

Ground clearance - 7.015 m (as per IE rules)

Right of way - 35 m

132 KV D/c Line

Configuration - Vertical

Conductor - ACSR Panther (21 mm dia)

Maximum conductor sag - approximately 6.6 m

Phase to phase spacing - approximately 4 m

Ckt. to ckt. spacing - approximately 7 m

Ground clearance - 6.1 m (as per IE rules)

Right of way - 27 m

Appendix - XV

TREE AND CROP COMPENSATION PROCEDURES

Statutory Requirements:

As per the statutory requirements (IS-5613, Part 3, 1989) all the trees and bushes, including saplings coming in the ROW limit i.e. clearance belt of transmission lines must be cut and removed. The procedure for clearing of trees and crops is as illustrated below.

In exercise of the powers vested with Power Grid Corporation of India Limited (POWERGRID) under Indian telegraph Act'1885, part 3, section 10 to 19 conferred under section 164 of the Electricity Act 2003 through Gazette by India, extra ordinary dated 24th Dec. 2003, has the authority to place and maintain transmission lines under over along or across and posts in or upon, any immoveable property. As per the provisions of Indian Telegraph Act1885 Part III Section 10 (b) which prohibits acquisition of any rights other than that of use only, land for tower and right of way is not acquired and agricultural activities are allowed to continue. However, as per clause 10 (d) of same act stipulates that the user agency shall pay full compensation to all interested for any damages sustained during the execution of said work. Accordingly, POWERGRID pays compensation to land owners towards damages if any to trees or crop during implementation of transmission project as well as during Operation and maintenance phase. The procedure followed for such compensation is as follows:

POWERGRID follows the principle of avoidance, minimization and mitigation in the construction of line in agricultural field having crop due to inherent flexibility in phasing the construction activity and tries to defer construction in cropped area to facilitate crop harvesting. However, if it is unavoidable and is likely to affect project schedule, compensation is given at market rate for standing crops. All efforts are also taken to minimize the crop damage to the extent possible in such cases. As regards trees coming in the Right Of Way (ROW) following procedure is adopted for enumeration:

All the trees which are coming within the clearance belt of ROW on either side of the center line are identified and marked/numbered from one AP to the other and documented. Type, Girth (Measured 1 m. above ground level), approximate height o the tree is also noted for each tree. Trees belonging o Govt., Forest, Highways and other local bodies may be separately noted down or timely follow up with the concerned authorities for inspection and removal. Cashew, Guava, Lemon and other hybrid trees which are not of tall growing nature are not marked for cutting since these trees can be crossed using standard tower extensions if required.

A notice under Indian Telegraph Act is served to the landowners informing that the proposed transmission line is being routed through the property of the individual concerned. The notice

रजिस्ट्री सं० डी० एल०-33004/99

REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

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केंद्रीय विद्युत प्राधिकरण

अधिसूचना

नई दिल्ली, 20 सितम्बर, 2010

सं. सी.ई.आई./1/59/सीईए/ई. आई.—केन्द्रीय विद्युत प्राधिकरण विद्युत अधिनियम, 2003 (2003 का 36) की धारा 177 द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए सुरक्षा तथा विद्युत आपूर्ति संबंधी उपाय के लिए निम्नलिखित विनियम बनाता है :—

अध्याय I

1. संक्षिप्त नाम और प्रारम्भ :— (1) इन विनियमों का संक्षिप्त नाम केंद्रीय विद्युत प्राधिकरण (सुरक्षा तथा विद्युत आपूर्ति संबंधी उपाय) विनियम, 2010 है ।

(2) ये राजपत्र में इनके अंतिम प्रकाशन की तारीख से प्रवृत्त होंगे ।

2. परिभाषाएं :—(1) इन विनियमों में, जब तक कि संदर्भ में, अन्यथा अपेक्षित न हो,

(क) "अधिनियम" से विद्युत अधिनियम, 2003 अभिप्रेत है;

(ख) "सुगम" से किसी उपकरण का अथवा विशेष प्रयास किए बिना शारीरिक उपयोग पहुंच के भीतर अभिप्रेत है;

(ग) "एम्पीयर" से अभिप्रेत विद्युत धारा की एक इकाई है और यह ऐसा कॉन्स्टेंट करेंट है जो निर्वात में एक मीटर की समानान्तर दूरी पर रखे नगण्य अनुप्रस्थ काट वाले अनन्त लम्बाई के दो सुचालकों से गुजरने पर इन दोनों सुचालकों के बीच प्रति मीटर लम्बाई पर 2×10^{-7} न्यूटन का बल पैदा करेगा;

(घ) "उपकरण" से विद्युत उपकरण अभिप्रेत है और इसमें सभी मशीनें, फिटिंग्स, सहायक उपकरण तथा उपकरण सम्मिलित हैं, जिनमें सुचालकों का उपयोग किया जाता है;

(ङ) "अनावृत" से अभिप्रेत है जो विद्युत-रोधी पदार्थ से आवृत न हो;

(च) "केबल" से अभिप्रेत है, ऐसा एकल सुचालक (ठोस या तन्तुरूपी) अथवा दो या दो से अधिक ऐसे सुचालक जिन्हें अलग-अलग विद्युतरोधी पदार्थ से आवृत किया गया हो और साथ-साथ बिछाया गया हो। ऐसे सुचालक या सुचालकों को यांत्रिक सुरक्षा कवच उपलब्ध कराया जा सकता है, या नहीं भी कराया जा सकता है;

(छ) "परिपथ (सर्किट)" से अभिप्रेत है, विद्युत प्रवाह के लिए सुचालक अथवा सुचालकों का एक व्यवस्थित क्रम जो एक विद्युत व्यवस्था या इस व्यवस्था का एक अंग निर्मित करते हैं;

(ज) "परिपथ भंजक (सर्किट ब्रेकर)" से ऐसा उपकरण अभिप्रेत है, जो सभी परिस्थितियों में परिपथ बना सकता है या ब्रेक कर सकता है, और जब तक इसे अन्यथा विनिर्दिष्ट न किया गया हो, यह इस प्रकार डिजाइन किया गया है कि असाधारण परिस्थितियों में यह स्वत: ही विद्युत प्रवाह रोक देता है ;

CENTRAL ELECTRICITY AUTHORITY

NOTIFICATION

New Delhi, the 20th September, 2010

No. CEI/1/59/CEA/EI.—In exercise of the powers conferred by section 177 of the Electricity Act, 2003 (36 of 2003), the Central Electricity Authority hereby makes the following regulations for Measures relating to Safety and Electric Supply, namely:-

Chapter I

1. **Short title and Commencement.-** (1) These regulations may be called the Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010.

(2) They shall come into force on the date of their final publication in the Official Gazette.

2. **Definitions.-** (1) In these regulations, unless the context otherwise requires,

(a) "Act" means the Electricity Act,2003;

(b) "accessible" means within physical reach without the use of any appliance or special effort;

(c) "ampere" means a unit of electric current and is a constant current which, flowing in two parallel straight conductors of infinite length of negligible cross section and placed at a distance of one meter apart in a vacuum will produce a force of 2×10^{-7} Newton per meter length between the conductors;

(d) "apparatus "means electrical apparatus and includes all machines, fittings, accessories and appliances in which conductors are used;

(e) "bare" means not covered with insulating materials;

(f) "cable" means a length of insulated single conductor(solid or stranded) or of two or more such conductors each provided with its own insulation, which are laid up together. Such insulated conductor or conductors may or may not be provided with an overall mechanical protective covering;

(g) "circuit" means an arrangement of conductor or conductors for the purpose of conveying electricity and forming a system or a branch of a system;

(h) "circuit breaker" means a device, capable of making and breaking the circuit under all conditions, and unless otherwise specified, so designed as to break the current automatically under abnormal conditions;

(i) "concentric cable" means a composite cable comprising an inner conductor which is insulated and one or more outer conductors which are

Chapter VII

Safety requirements for overhead lines, underground cables and generating stations

55. Material and strength.- (1) All conductors of overhead lines other than those specified in regulation 68 shall have a breaking strength of not less than 350 kg.

(2) Where the voltage does not exceed 250 V and the span is of less than fifteen metres and is drawn through the owner's or consumer's premises, a conductor having an actual breaking strength of not less than 150 kg may be used.

56. Joints.- (1) No conductor of an overhead line shall have more than one joint in a span and joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation.

(2) The ultimate strength and the electrical conductivity of the joint shall be as per relevant Indian Standards.

57. Maximum stresses and factors of safety.- (1) The load and permissible stresses on the structural members, conductors and ground wire of self supporting steel lattice towers for overhead transmission lines shall be in accordance with the specifications laid down, from time to time, by the Bureau of Indian Standards.

(2) Overhead lines not covered in sub-regulation (1) shall have the following minimum factors of safety, namely:-

(i)	for metal supports	-	1.5
(ii)	for mechanically processed concrete supports	-	2.0
(iii)	for hand-moulded concrete supports	-	2.5
(iv)	for wood supports	-	3.0

(3) The minimum factors of safety shall be based on such load as may cause failure of the support to perform its function, assuming that the foundation and other components of the structure are intact.

(4) The load shall be equivalent to the yield point stress or the modulus of rupture, as the case may be, for supports subject to bending and vertical loads and the crippling load for supports used as strut.

(5) The strength of the supports of the overhead lines in the direction of the line shall not be less than one-fourth of the strength required in the direction transverse to the line.

(6) The minimum factor of safety for stay-wires, guard-wires or bearer-wires shall be 2.5 based on the ultimate tensile strength of the wire.

(7) The minimum factor of safety for conductors shall be two, based on their ultimate tensile strength, in addition, the conductor's tension at 32^0 C, without external load, shall not exceed the following percentages of the ultimate tensile strength of the conductor:-

(i)	Initial unloaded tension	.....	35 per cent
(ii)	Final unloaded tension	.....	25 per cent

Provided that for the conductors having a cross section of a generally triangular shape, such as conductors composed of 3-wires, the final unloaded tension at 32^0 C shall not exceed thirty per cent of the ultimate tensile strength of such conductor.

(8) For the purpose of calculating the factors of safety in sub-regulation (2), the following conditions shall be observed, namely:-

(i) the maximum wind pressure shall be as specified in the relevant Indian Standards;

(ii) for cylindrical bodies the effective area shall be taken as full projected area exposed to wind pressure; and

(iii) the maximum and minimum temperatures shall be such as specified in the relevant Indian Standards.

(9) Notwithstanding anything contained in sub-regulation (2) to (8) in localities where overhead lines are liable to accumulations of ice or snow, the load and permissible stresses on the structural members, conductors and ground wire of self supporting steel lattice towers for overhead transmission lines shall be in accordance with the specifications laid down, from time to time, by the Bureau of Indian Standards or as specified by Appropriate Government, by order in writing.

58. **Clearance above ground of the lowest conductor of overhead lines.-** (1) No conductor of an overhead line, including service lines, erected across a street shall at any part thereof be at a height of less than-

(i)	for lines of voltage not exceeding 650 Volts	-	5.8 metres
(ii)	for lines of voltage exceeding 650 Volts but not exceeding 33 kV	-	6.1 metres

(2) No conductor of an overhead line, including service lines, erected along any street shall at any part thereof be at a height less than-

(i)	for lines of voltage not exceeding 650 Volts	-	5.5 metres
(ii)	for lines of voltage exceeding 650 Volts but not exceeding 33 kV	-	5.8 metres

(3) No conductor of an overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than -

(i)	for lines of voltage upto and including 11,000 Volts,if bare	-	4.6 metres
(ii)	for lines of voltage upto and including 11,000 Volts, if insulated	-	4.0 metres
(iii)	for lines of voltage exceeding 11,000 Volts but not exceeding 33 kV	-	5.2 metres

(4) For lines of voltage exceeding 33 kV the clearance above ground shall not be less than 5.2 metres plus 0.3 metre for every 33,000 Volts or part thereof by which the voltage of the line exceeds 33,000 Volts;

Provided that the minimum clearance along or across any street shall not be less than 6.1 metres.

(5) For High Voltage Direct Current (HVDC) lines, the clearance above ground shall not be less than:-

Sl.No.	DC Voltage(kV)	Ground Clearance (mtrs.)
1.	100 kV	6.1
2.	200 kV	7.3
3.	300 kV	8.5
4.	400 kV	9.4
5.	500 kV	10.6
6.	600 kV	11.8
7.	800 kV	13.9

(6) Ground clearances shall be as specified in schedule-X.

59. **Clearance between conductors and trolley wires.-** (1) No conductor of an overhead line crossing a tramway or trolley bus route using trolley wires shall have less than the following clearances above any trolley wire-

(i) lines of voltage not exceeding 650 Volts - 1.2 metres

Provided that where an insulated conductor suspended from a bearer wire crosses over a trolley wire the minimum clearance for such insulated conductor shall be 0.6 metre.

(ii) lines of voltage exceeding 650 Volts up to and including 11,000 Volts - 1.8 metres

(iii) lines of voltage exceeding 11,000 Volts but not exceeding33,000 Volts - 2.5 metres

(iv) lines of voltage exceeding 33 kV - 3.0 metres

(2) In any case of a crossing specified in sub-regulation (1), whoever lays his line later in time, shall provide the clearance between his own line and the line which will be crossed in accordance with the provisions of the said sub-regulation:

Provided that if the later entrant is the owner of the lower line and is not able to provide adequate clearance, he shall bear the cost for modification of the upper line so as to comply with this sub-regulation.

60. Clearance from buildings of lines of voltage and service lines not exceeding 650 Volts.- (1) An overhead line shall not cross over an existing building as far as possible and no building shall be constructed under an existing overhead line.

(2) Where an overhead line of voltage not exceeding 650 V passes above or adjacent to or terminates on any building, the following minimum clearances from any accessible point, on the basis of maximum sag, shall be observed, namely:-

(i) for any flat roof, open balcony, varandah roof and lean-to-roof-

(a) when the line passes above the building a vertical clearance of 2.5 metres from the highest point, and

(b) when the line passes adjacent to the building a horizontal clearance of 1.2 metres from the nearest point, and

(ii) for pitched roof-

(a) when the line passes above the building a vertical clearance of 2.5 metres immediately under the line, and

(b) when the line passes adjacent to the building a horizontal clearance of 1.2 metres.

(3) Any conductor so situated as to have a clearance less than that specified above shall be adequately insulated and shall be attached at suitable intervals to a bare earthed bearer wire having a breaking strength of not less than 350 kg.

(4) The horizontal clearance shall be measured when the line is at a maximum deflection from the vertical due to wind pressure.

(5) Vertical and horizontal clearances shall be as specified in schedule-X.

Explanation:- For the purpose of this regulation, the expression "building" shall be deemed to include any structure, whether permanent or temporary.

61. Clearances from buildings of lines of voltage exceeding 650 V.- (1) An overhead line shall not cross over an existing building as far as possible and no building shall be constructed under an existing overhead line.

(2) Where an overhead line of voltage exceeding 650 V passes above or adjacent to any building or part of a building it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line, of not less than-

(i) for lines of voltages exceeding 650 Volts upto and including 33,000 Volts	- 3.7 metres
(ii)for lines of voltages exceeding 33 kV	- 3.7 metres plus 0.30 metre for every additional 33,000 Volts or part thereof.

(3) The horizontal clearance between the nearest conductor and any part of such building shall, on the basis of maximum deflection due to wind pressure, be not less than-

(i)	for lines of voltages exceeding 650 V upto and including 11,000 Volts	- 1.2 metres
(ii)	for lines of voltages exceeding 11,000 V and up to and including 33,000 V	- 2.0 metres
(iii)	for lines of voltages exceeding 33 kV	- 2.0 metres plus 0.3 metre fore every additional 33kV or part thereof.

(4) For High Voltage Direct Current (HVDC) systems, vertical clearance and horizontal clearance, on the basis of maximum deflection due to wind pressure, from buildings shall be maintained as below:

Sl.No	DC Voltage (kV)	Vertical Clearance (mtrs.)	Horizontal Clearance (mtrs.)
1.	100 kV	4.6	2.9
2.	200 kV	5.8	4.1
3.	300 kV	7.0	5.3
4.	400 kV	7.9	6.2
5.	500 kV	9.1	7.4
6.	600 kV	10.3	8.6
7.	800 kV	12.4	10.7

(5) Vertical and horizontal clearances shall be as specified in schedule-X.

Explanation.- For the purpose of this regulation the expresssion "building" shall be deemed to include any structure, whether permanent or temporary.

62. **Conductors at different voltages on same supports.**- Where conductors forming parts of systems at different voltages are erected on the same supports, the owner shall make adequate provision to guard against danger to linemen and others, from the lower voltage system being charged above its normal working voltage, by leakage from or contact with the higher voltage system and the methods of construction and the applicable minimum clearances between the conductors of the two systems shall be as specified in regulation 69 for lines crossing each other.

63. Erection or alteration of buildings, structures, flood banks and elevation of roads.- (1) If at any time subsequent to the erection of an overhead line, whether covered with insulating material or not, any person proposes to erect a new building or structure or flood bank or to raise any road level or to carry out any other type of work whether permanent or temporary or to make in or upon any building, or structure or flood bank or road, any permanent or temporary addition or alteration, he and the contractor whom he employs to carry out the erection, addition or alteration, shall, give intimation in writing of his intention to do so, to the supplier or owner and to the Electrical Inspector and shall furnish therewith a scale drawing showing the proposed building, structure, flood bank, road or any addition or alteration and scaffolding thereof required during the construction.

(2) On receipt of such intimation, the supplier or owner shall examine,-

(i) whether the line under reference was laid in acordance with the provisions of these regulations and any other law;

(ii) whether it is technically feasible;

(iii) whether it meets the requirement of Right of Way (ROW);

(iv) whether such person was liable to pay the cost of alteration of the overhead line and if so, send a notice without undue delay, to such person together with an estimate of the cost of the expenditure likely to be incurred to so alter the overhead line and require him to deposit, within thirty days of the receipt of the notice, with the supplier or owner, the amount of the estimated cost.

(3) If such person disputes the cost of alteration of the overhead line estimated by the supplier or owner or even the responsibility to pay such cost, the dispute may be referred to the Electrical Inspector whose decision thereof shall be final.

(4) The Electrical Inspector shall estimate the cost of alteration of overhead line on the following basis, namely:-

(i) the cost of material used on the alteration after crediting the depreciated cost of the material which shall be available from the existing line;

(ii) the wages of labour employed in affecting the alteration;

(iii) supervision charges to the extent of fifteen per cent of the wages mentioned in sub clause (ii); and charges incurred by the supplier or owner in complying with the provisions of section 67 of the Act, in respect of such alterations.

(5) Any addition or alteration to the building or structure shall be allowed only after the deposite of such estimated cost to the supplier or owner.

(6) No work upon such building, structure, flood bank, road and addition or alteration thereto shall be commenced or continued until the Electrical Inspector

has certified that the provisions of regulation 58, 60 and 61 should not be contravened either during or after the aforesaid construction:

Provided that the Electrical Inspector may, if he is satisfied that the overhead line has been so guarded as to secure the protection of persons or property from injury, certify that the work may be executed prior to the alteration of the overhead line or in the case of temporary addition or alteration, without alteration of the overhead line.

(7) The supplier or owner shall, on receipt of such deposit, alter the overhead line in such a way that it does not contravene the provisions regulation 58, 60 and 61 either during or after such construction within two months from the date of such deposit or within such longer period as the Electrical Inspector may allow.

64. Transporting and storing of material near overhead lines.- (1) No rods, pipes or similar materials shall be taken below, or in the vicinity of, any bare overhead conductors or lines if these contravene the provisions of regulations 60 and 61 unless such materials are transported under the direct supervision of a person designated in this behalf by the owner of such overhead conductors or lines.

(2) No rods, pipes or other similar materials shall be brought within the flash over distance of bare live conductors or lines.

(3) No material or earth work or agricultural produce shall be dumped or stored, no trees grown below or in the vicinity of, bare overhead conductors, or lines to contravene the provision of regulations 60 and 61.

(4) No flammable material shall be stored under the electric supply line.

(5) No fire shall be allowed above underground cables.

(6) Firing of any material below electric lines shall be prohibited.

65. General clearances.- (1) For the purpose of computing the vertical clearance of an overhead line, the maximum sag of any conductor shall be calculated on the basis of the maximum sag in still air and the maximum temperature as specified under regulations 57 and computing any horizontal clearance of an overhead line the maximum deflection of any conductor shall be calculated on the basis of the wind pressure specified under regulations 57.

(2) No blasting for any purpose shall be done within 300 metres from the boundary of a sub-station or from the electric supply lines of voltage exceeding 650 V or tower structure thereof without the written permission of the owner of such sub-station or electric supply lines or tower structures and in case of mining lease hold area, without the written permission of the Inspector of Mines.

(3) No cutting of soil within ten meters from the tower structure of 132 kV and above voltage level shall be permitted without the written permission of the owner of tower structure.

(4) No person shall construct brick kiln or other polluting units near the installations or transmission lines of 220 kV and above within a distance of 500 metres.

66. **Routes proximity to aerodromes.-** Overhead lines shall not be erected in the vicinity of aerodromes unless the Airport Authorities have approved in writing the route of the proposed lines as per relevant Indian Standards.

67. **Maximum interval between supports.-** All conductors shall be attached to supports at intervals not exceeding the safe limits based on the ultimate tensile strength of the conductor and the factor of safety specified under regulations 57.

Provided that in the case of overhead lines carrying conductors of voltage not exceeding 650 V when erected in, over, along or across any street, the interval shall not, without the consent in writing of the Electrical Inspector, exceed 65 metres.

68. **Conditions to apply where telecommunication lines and power lines are carried on same supports.-** (1) Every overhead telecommunication line erected on supports carrying a power line shall consist of conductors each having a breaking strength of not less than 270 kg.

(2) Every telephone used on a telecommunication line erected on supports carrying a power line shall be suitably guarded against lightning and shall be protected by cut-outs.

(3) Where a telecommunication line is erected on supports carrying a power line of voltage exceeding 650 V, arrangement shall be made to safeguard any person against injury resulting from contact, leakage or induction between such power and telecommunication lines.

69. **Lines crossing or approaching each other and lines crossing street and road.-** Where an overhead line crosses or is in proximity to any telecommunication line, the owner of either the overhead line or the telecommunication line, whoever lays his line later, shall arrange to provide for protective devices or guarding arrangement and shall observe the following provisions, namely:-

(i) when it is intended to erect a telecommunication line or an overhead line which will cross or be in proximity to an overhead line or a telecommunication line, as the case may be, the person proposing to erect such line shall give one month's notice of his intention so to do along with the relevant details of protection and drawings to the owner of the existing line;

(ii) guarding shall be provided where lines of voltage not exceeding 33 kV cross a road or street;

(iii) where an overhead line crosses or is in proximity to another overhead line, guarding arrangements shall be provided so to guard against the possibility of their coming into contact with each other;

(iv) where an overhead line crosses another overhead line, clearances shall be as under:-

Sl. No	Nominal System Voltage	Minimum clearance in metres				
		Upto and including 11 kV	Above 11 kV and upto and including 33 kV	Above 33 kV and upto and including 132 kV	Above 132 kV and upto and including 220 kV	Above 220 kV and upto and including 400 kV
1	Low and Medium Voltage	2.44	3.05	4.58	5.49	7.94
2	11-66 kV	2.44	3.05	4.58	5.49	7.94
3	110-132 kV	3.05	3.05	4.58	5.49	7.94
4	220 kV	4.58	4.58	4.58	5.49	7.94
5	400 kV	5.49	5.49	5.49	5.49	7.94
6	800 kV	7.94	7.94	7.94	7.94	7.94

Provided that [illegible] exceeding 3.66 kV between wire and earth in the case of lines of voltage not exceeding 25 kV and 4.58 kV in the case of lines of voltage exceeding 25 kV and upto and including 66 kV, may be provided between the [illegible]

6.	300 kV AC	5.32	5.32	5.32	6.04	6.79	7.54
7.	400 kV AC	5.49	5.49	5.49	6.04	6.79	7.54
8.	400 kV DC	6.04	6.04	6.04	6.04	6.79	7.54
9.	500 kV DC	6.79	6.79	6.79	6.79	6.79	7.54
10.	600 kV DC	7.54	7.54	7.54	7.54	7.54	7.54
11.	800 kV DC	7.94	7.94	7.94	7.94	7.94	7.94

(vi) a person erecting or proposing to erect a line which may cross or be in proximity with an existing line, shall provide arrangements on his own line or require the owner of the other overhead line to provide guarding arrangements as referred to in clause (iii) and (iv);

(vii) in all cases referred to in this regulation the expenses of providing the guarding arrangements or protective devices shall be borne by the person whose line was last erected;

(viii) where two lines cross, the crossing shall be made as nearly at right angles as the nature of the case admits and as near the support of the line as practicable, and the support of the lower line shall not be erected below the upper line;

(ix) the guarding arrangements shall ordinarily be carried out by the owner of the supports on which it is made and he shall be responsible for its efficient maintenace.

70. **Guarding.**- (1) Where guarding is required under these regulations the following shall be observed , namely:-

(i) every guard-wire shall be connected with earth at each point at which its electrical continuity is broken;

(ii) every guard-wire shall have an actual breaking strength of not less than 635 kg and if made of iron or steel , shall be galvanised;

(iii) every guard-wire or cross-connected systems of guard-wires shall have sufficient current-carrying capacity to ensure them rendering dead, without risk of fusing of the guard-wire or wires, till the contact of any live wire has been removed.

(2) In the case of a line crossing over a trolley-wire the guarding shall be subjected to the following conditions, namely:-.

(i) where there is only one trolley-wire, two guard-wires shall be erected as in DIAGRAM-A;

(ii) where there are two trolley –wires and the distance between them does not exceed 40 cms, two guard-wires shall be erected as in DIAGRAM-B;

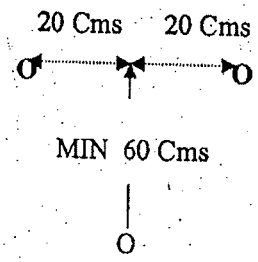
(iii) where there are two trolley wires and the distance between them exceeds 40 cms but does not exceed 1.2 metres, three guard-wires shall be erected as in DIAGRAM-C;

(iv) where there are two trolley-wires and the distance between them exceeds 1.2 metres, each trolley-wire shall be separately guarded as in DIAGRAM-D;

(v) the rise of trolley boom shall be so limited that when the trolley leaves the trolley-wire, it shall not foul the guard-wires; and

(vi) where a telegraph-line is liable to fall or be blown down upon an arm, stay-wire or span-wire and so slide-down upon a trolley-wire, guard hooks shall be provided to prevent such sliding.

DIAGRAM-A



... land carrying vegetative association demarcated by trees of any size, whether cultivated or not, capable of producing wood or other forest products or having an influence on the climate or on the water regime or providing shelter to livestock and wildlife"

... Judgment delivered in the case of *T.N. Godavarman Thirumulpad* **v.** *Union of India & Ors.*[10] the Supreme Court clarified that the term *forest* must be ... in the sense of the dictionary, meaning *a large tract of land covered with* ... It was further said that practical approach has to be adopted in ... constitutes forest which implies an area measuring 10 hectares or ... average 200 trees per hectare.[11]

... standard meaning has to be ensued to the subject of legislation. As ... Court in the aforesaid case the fluid meaning accrued to the term ... of abuse and exploitation and proves to be a constant hurdle in ... objectives of the legislations.[12]

... Forest Rights Act, 2006, forest land has been defined as 'land of ... falling within any forest area and includes unclassified forests, ... existing or deemed forests, protected forests, reserved forests, ... National Parks'.[13] Apart from the legal interpretation, its definition is ... development as a resource of the nation, for sustainable forest ... policy formulation, investment and economic ... similar concerns.[14] Forests can be of different varieties. Although ... provisions of the Act are wide enough to cover all types of ... specifically deals with the following four categories of forests:

Reserved forests

... Sections 2 to 20 of the Act, deal with reserved forests, wherein the ... constitute any forest-land or waste-land, which is the property of ... over which the Government has proprietary rights, or to the whole ... or any forest produce of which the Government is entitled, a reserved

... *Indian Institute of Forest Research*, ICFRE, Dehradun (Oct. 20, 2016, 10:30 AM).
... as well, for certificate in mct pdf assignment \VENKATESWARLU.pdf.
... Sec. 3. Where the land is part of permanently settled estate, it constitutes private ... subject to reservation.

DIAGRAM-B

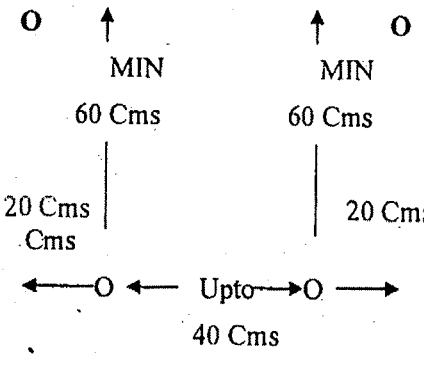


DIAGRAM-C

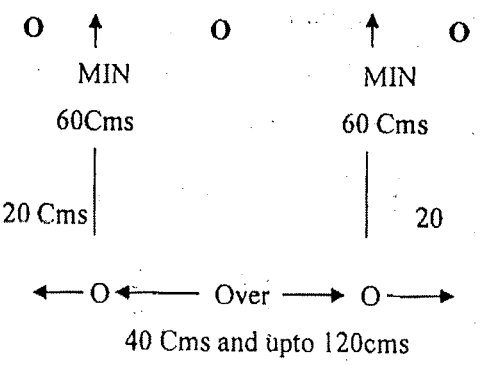
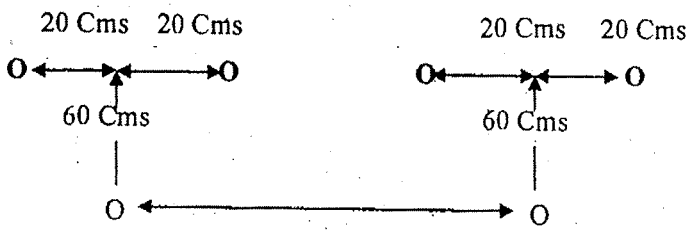


DIAGRAM-D



OVER 120cms.

71. Service lines from overhead lines.- No service-line or tapping shall be taken off an overhead line except at a point of support:

Provided that the number of tappings per conductor shall not be more than four in case of connections at voltage not exceeding 650 V.

72. Earthing.- (1) All metal supports and all reinforced and prestressed cement concrete supports of overhead lines and metallic fittings attached thereto, shall be either permanently and efficiently earthed by providing a continuous earth wire and securely fastening to each pole and connecting with earth ordinarily at three points in every km. with the spacing between the points being as nearly equidistant as possible or each support and the metallic fitting attached thereto shall be efficiently earthed.

(2) Metallic bearer wire used for supporting insulated wire of overhead service lines of voltage not exceeding 650 V shall be efficiently earthed or insulated.

(3) Each stay-wire shall be similarly earthed unless insulator has been placed in it at a height not less than 3.0 metres from the ground.

73. Safety and protective devices.- (1) Every overhead line which is not being suspended from a dead bearer wire, not being covered with insulating material and not being a trolley-wire, is erected over any part of a street or other public place

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or in any factory or mine or on any consumer's premises shall be protected with earth gaurding for rendering the line electrically harmless in case it breaks.

(2) An Electrical Inspector may, by notice in writing, require the owner of any such overhead line, wherever it may be erected, to protect it in the manner specified in sub-regulation (1).

(3) The owner of every overhead line of voltage exceeding 650 V shall make adequate arrangements as per relevant Indian Standards to prevent undesignated persons from ascending any of the supports of such overhead lines which can be easily climbed upon without the help of a ladder or special appliances.

Explanation.- For the purpose of this relgulation, rails, reinforced cement concrete poles and pre-stressed cement concrete poles without steps, tubular poles, wooden supports without steps, I-sections and channels' shall be deemed as supports which cannot be easily climbed upon.

74. **Protection against lightning.-** (1) The owner of every overhead line, sub-station or generating station which is exposed to lightning shall adopt efficient means for diverting to earth any electrical surges due to lightning which may result into injuries.

(2) The earthing lead for any lightning arrestor shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the lightning arrestor without touching any metal part to a separate vertical ground electrode or junction of the earth mat already provided for the sub-station of voltage exceeding 650 V subject to the avoidance of bends wherever practicable.

75. **Unused overhead lines.-** Where an overhead line ceases to be used as an electric supply line:

(i) the owner shall maintain it in a safe mechanical condition in accordance with regulation 57 or remove it.

(ii) the Electrical Inspector shall, by a notice in writing served on the owner, require him to maintain it in a safe mechanical condition or to remove it within thirty days of the receipt of the notice.

76. **Laying of cables.-** (1) No underground power cable of voltage exceeding 33 kV shall be laid without a minimum underground depth of 1.2 meters.

(2) No underground telecommunication cable shall be laid without a minimum separation distance of 0.6 meters to the underground power cable of voltage exceeding 33 kV.

77. **Protection against electromagnetic interference.-** The owner of every overhead power line of voltage level 11 kV or higher shall submit proposal for obtaining Power Telecommunication Co-ordination Committee clearance to ensure safety of the personnel and telecom equipment.

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पावरग्रिड

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Table of Contents

PURPOSE AND SCOPE

Industrial and domestic consumption of electric power in our country is on the rise. In order to meet the challenge of this ever increasing demand for electricity, transmission of large amounts of power from the source centre to load centres over long distances is being planned. This mandates for power transmission at EHV and UHV levels. Power transmission lines especially at high voltage levels generate electric and magnetic fields in its vicinity.

Researches are going worldwide to ascertain the biological effects of Electric & Magnetic fields. However, nothing conclusive has been reported and no relation has been established between exposure to Electric & Magnetic field and possible biological effects. However, some countries and regulatory bodies have stipulated safety limits on exposure to electric & magnetic field in terms of magnitude and duration as a precautionary measure.

As transmission lines runs through the length & breadth of our country and number of transmission lines has been planned to evacuate bulk power from North Eastern region to Northern and Central parts of India at EHV / UHV levels, it becomes imperative that the power system operator shall know the EMF field environment around these lines through field surveys.

POWERGRID, *Central Transmission Utility of the country,* is entrusted with the responsibility to safely transmit power throughout the country. In this direction POWERGRID has taken the responsibility to carry out field surveys and determine the Electric & Magnetic field present in the vicinity of transmission lines and take suitable measures to improve transmission line design, if Electric & Magnetic Field are found above the values prescribed in International Standards.

POWERGRID undertook a project to measure & assess Electric & Magnetic field in the vicinity of transmission lines/Substations at 400kV & 800kV power frequency voltage level. Further, the results were validated by comparing with the permissible limits prescribed by ICNIRP guidelines (International Commission on Non Ionization Radiation Protection).

This document comprises a comprehensive detail about ELF Electric & Magnetic field, measurement data obtained from field surveys, review of data of ELF fields, results & recommendations.

This study is limited to Electric & Magnetic Field (ELF) emanating from POWERGRID transmission lines.

INTRODUCTION

The world is facing the burden of environmental exposures to many new physical or chemical agents. Among these agents, electromagnetic fields (EMF) are one of the most diffuse and ubiquitous. The common sources are electricity generation & transmission, wireless communication systems etc.

Transmission lines especially at high voltage level produce Electric Field (due to voltage) and Magnetic Field (due to flow of current) in its vicinity. The field strength at any point is inversely proportional to square of the distance from the source. It is comparatively easy to shield against electric field generated by nearby power lines than to shield against the magnetic fields.

Debate on the possible effect of electric and magnetic fields on human and animal health has continued since the 1970s. Many research laboratories have carried out substantial research to ascertain the effect of Electric & Magnetic fields. Many studies have been undertaken all over the world to assess any potentially harmful effects from power lines, electrical appliances and Domestic wiring. These studies, taken individually or as collectively reviewed by expert groups, didn't make a conclusive judgment on causality or to quantify appropriate exposure restrictions.

An independent scientific organization was formed in 1974 which was later renamed as ***ICNIRP (International Commission on Non-Ionizing Radiation Protection)*** with the objective to develop International guidelines on Non-Ionizing Radiation (includes Electric & Magnetic Field) Exposure limits, and deal with all aspects of NIR protection. The permissible limit of Electric & Magnetic field for occupational exposure is 10kV/m & 500μT and for general public exposure is 5kV/m & 100μT respectively.

POWERGRID carries out measurement of Electric & Magnetic field at the time of commissioning of the transmission line and then after regular intervals to ensure that the field values lies within the permissible limits and take suitable measures if any deviation is found. POWERGRID recently carried out field measurement of electric and magnetic fields on select 400 kV lines and Sub-stations at different place of country to review the strength of electric & magnetic field present in the vicinity of transmission lines and substation equipment. Measurements on 800kV Seoni Substation & transmission line were also conducted. The field measurements have shown that the Electric & Magnetic field strength in the transmission line vicinity is much below the limits prescribed by International Standards.

ELECTROMAGNETIC FIELD-FUNDAMENTAL & ITS SOURCES

1.1 Introduction

An electromagnetic field (EMF) is a generic term for field of force generated by electrical charges or magnetic fields. Electromagnetic waves are produced when a charged particle undergoes acceleration. Accordingly, a 50 Hz alternating current in a wire produces 50 Hz electromagnetic radiation. Under certain circumstances EMF can be considered as radiation when they radiate energy from the source of the fields. The electromagnetic field may be ionic or non-ionic in nature.

1.2 Ionic Radiation

Ionic radiations are those which contain sufficient energy to cause ionization, i.e., they can dislodge orbiting electrons from atoms or break bonds that holds molecule together, producing ions or charge particles. Production of ions or ionization in tissues may result in direct damage to cells causing health effects. This type of high energy radiation includes X-rays, radioactivity, nuclear energy etc. Human beings are constantly exposed to low levels of ionizing radiation from natural sources. This type of radiation is referred to as natural background radiation, and its main sources are:

- Visible light, ultraviolet light and infrared light (sunlight)
- Radioactive materials on the earth's surface (contained in coal, granite, etc.)
- Radioactive gases leaking from the earth (radon)
- Cosmic rays from outer space entering the earth's atmosphere through the ionosphere
- Natural radioactivity in the human body

1.3 Non-Ionic Radiations

Non-ionic radiations are low energy radiations which do not have sufficient energy to dislodge orbiting electrons from atoms. Non-ionic radiations can be classified based on their frequency level:

- Static electromagnetic fields from direct current (0 Hz)
- Low-frequency waves from electric power (50-60 Hz)
- Extremely Low Frequency (ELF) fields (0-300Hz)
- Radio Frequencies (RF), including Low Frequency (LF), Medium Frequency (MF) High Frequency (HF), Very High Frequency (VHF), Ultra High Frequency (UHF) and Microwave (MW) and Millimeter wave (30 kHz to 300 GHz)
- Infrared (IR) light, Visible light and Ultraviolet (UV) light (above 300 GHz)

These EMF radiations can be located on Electromagnetic spectrum. Figure-1.1 shows the Electromagnetic spectrum

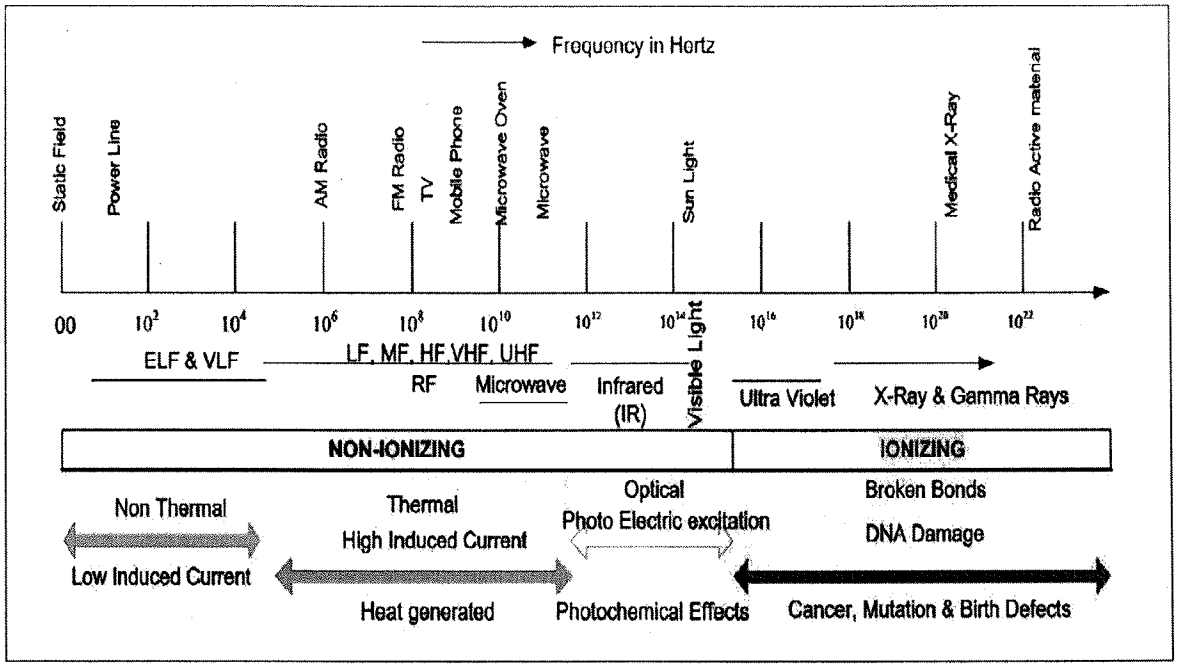


Fig 1.1: ***Electromagnetic Spectrum***

1.4 Extremely Low Frequency Fields (ELF fields)

Extremely low frequency (ELF) field are non-ionic in nature and lie in the frequency range of 0-300Hz on Electromagnetic spectrum. This is fairly low on the electromagnetic spectrum. ELF field arises from various sources discussed below, and may have effect on living beings if found beyond the stipulated limits.

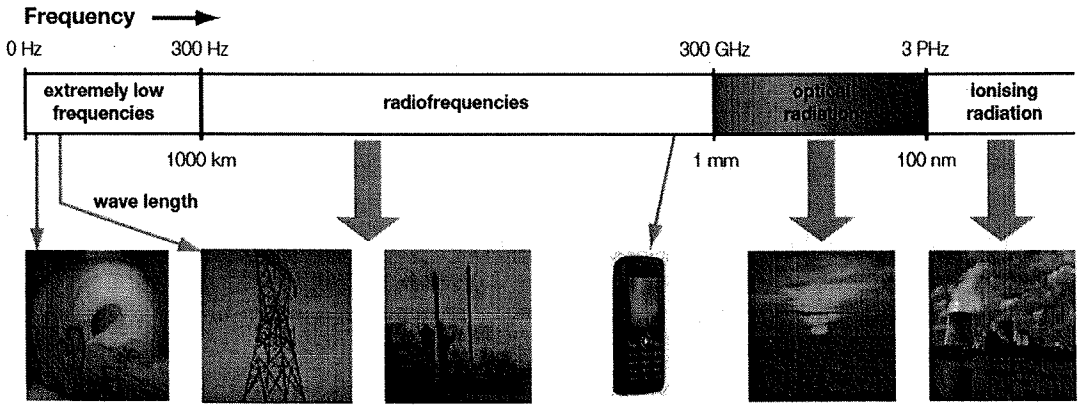


Figure 1.2: ***Sources of Electromagnetic Radiations***

1.5 Sources of ELF Field

The principal man-made sources of ELF are HV transmission lines, and all devices containing current-carrying wire, including equipment and appliances in industry.

Electrical energy is transmitted from the power plant, where it is generated, along conductors, metallic transmission connections (overhead power lines or underground cables) to substations and finally to energy consumers.

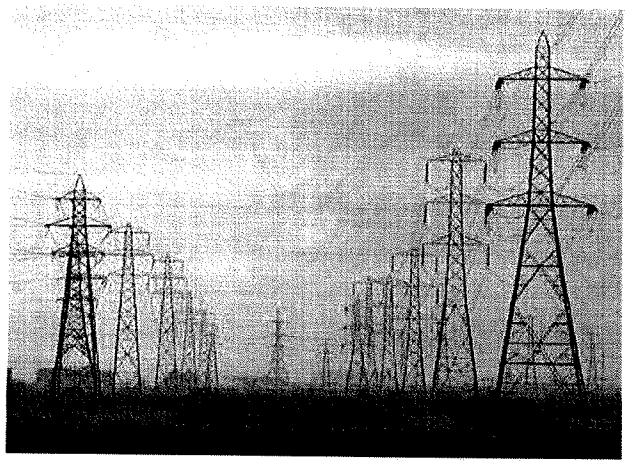


Fig.1.3 ***Electric power lines***

1.5.1 Electric Fields near Transmission lines and inside the Sub-Stations

At ground level, beneath high-voltage transmission lines, the electric fields created have the same frequencies as those carried by the power lines. The characteristics of these fields depend on the line voltage, and on the geometrical dimensions and positions of the conductors of the transmission line. The field intensity selected for reference or comparison purposes is the undisturbed ground level electric field strength. There are several factors which primary influences the electric field strength beneath an overhead transmission line. These include:

a. Actual (rather than the nominal) voltage on the line

b. Height of the conductors above ground (*which is influenced considerably by the ambient temperature and heating caused by the current passing through the conductor*)

c. Geometric configuration of conductors and earthing wires on the towers, and in the case of two circuits in proximity, the relative phase sequencing

d. Proximity of the grounded metallic structure of the tower

e. Proximity of other tall objects (trees, fences, etc.)

f. Lateral distance from the centre line of the transmission line

g. Height above ground at the point of measurement

The figure 1.4 shows the variation of Electric field strength for 400 & 765 kV Voltage level

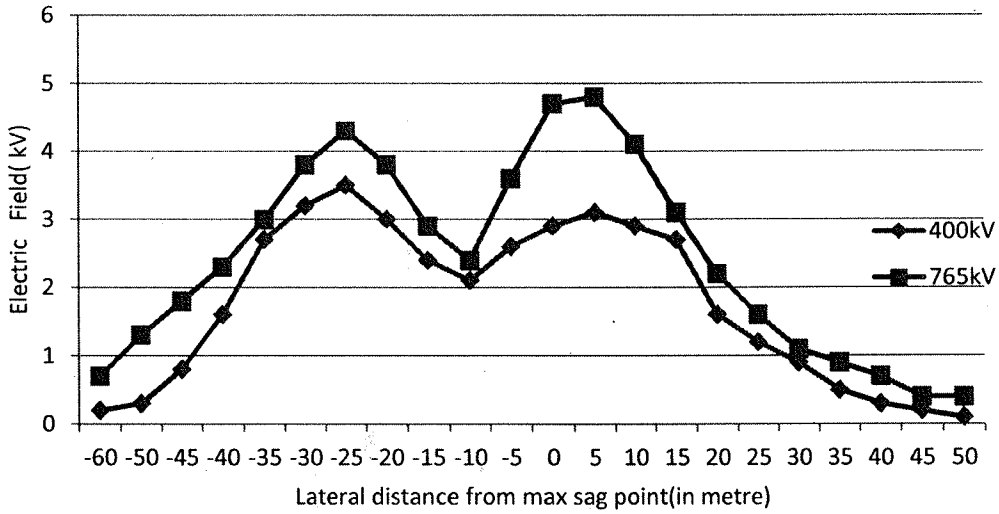


Fig 1.4: ***Variation of Electric Field strength for 400 & 765 kV lines***

1.5.2 Magnetic Fields near Transmission lines and inside the Sub-Station

Just as an electric field is always linked with the presence of charges, a magnetic field always appears when electric current flows. A static magnetic field is formed in the case of direct current, whereas time-varying electric and magnetic fields are induced in the vicinity of alternating current power transmission systems.

The magnetic field beneath high-voltage overhead transmission lines is directed mainly transversely to the line axis. The maximum flux density at ground level may be either on the route centre line or approximately under the outer conductors, depending on the phase relationship between the conductors. Apart from the geometry of the conductor, the maximum magnetic field strength is determined only by the magnitude of the current.

In contrast to an electric field, a magnetic field is more penetrating and very difficult to shield. It easily penetrates human beings and, in the case of an alternating or rotating field, induces circulating or eddy currents that are not conducted to ground. Unlike the electric field, they are also directly affected by the current carried by the line. The magnetic flux density decreases in an approximately linear fashion with distance from the conductor.

In principle, these magnetic fields can induce electric currents in the body and could induce effects via the same mechanisms as electric field-produced currents. The largest current

densities occur at the periphery of the body and they are lower inside. Fig. 1.5 shows the magnetic field distribution near a 765 kV & 400 kV transmission line.

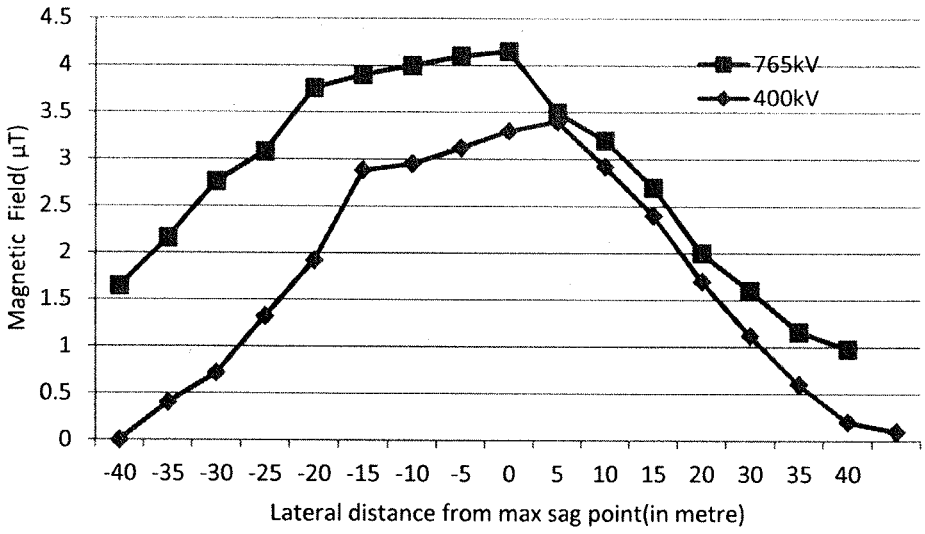


Fig 1.5: ***Magnetic field distribution for 765 kV & 400kV line***

Figure 1.6 & 1.7 shows the magnetic field distribution for 765 kV & 400kV lines. It can be seen that maximum field strength occurs below the conductor while it decreases on either side on conductor.

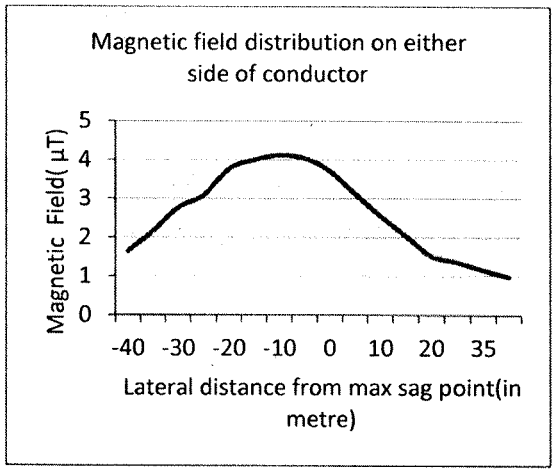


Fig 1.6: Magnetic field distribution for single circuit line

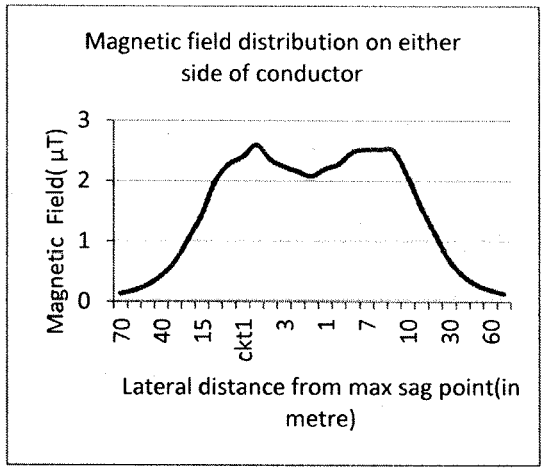


Fig 1.7: Magnetic field distribution for Double circuit line

INTERNATIONAL STANDRADS AND GUIDELINES

In recent years, the development of new technology has increased the possibility of human exposure to Electric & Magnetic field and raised some concern as to their possible health effects. In several countries, governmental or other competent authorities have issued exposure limits that are intended for specific issues.

IN 1974, the International Radiation Protection Association (IRPA) formed a working group on non-ionizing radiation (NIR), to examine the problems arising in the field of protection against the various types of NIR. At the IRPA Congress in Paris in 1977, this working group became the International Non-Ionizing Radiation Committee (INIRC). In cooperation with the Environmental Health Division of the World Health Organization (WHO), the IRPA/INIRC developed a number of health criteria documents on NIR as part of WHO's Environmental Health Criteria Programme, sponsored by the United Nations Environment Programme (UNEP).

At the Eighth International Congress of the IRPA, a new, independent scientific organization—the ***International Commission on Non-Ionizing Radiation Protection (ICNIRP)***—was established as a successor to the IRPA/INIRC. The functions of the Commission are to investigate the hazards that may be associated with the different forms of NIR, develop international guidelines on NIR exposure limits, and deal with all aspects of NIR protection. ICNIRP guidelines recommended the following limits for occupational exposure and for exposure of the general public

Table 2.1: ***Reference levels for occupational exposure to time varying electric and magnetic fields@.***

Sr No.	Frequency range	E-field (V/m)	H-field strength(A/m)	B-field(μT)	Equivalent plane wave power density Seq (W/m^2)
1.	Up to 1 Hz	---	1.63×10^5	2×10^5	---
2.	1 - 8 Hz	20,000	$1.63 \times 10^5 / f^2$	$2 \times 10^5 / f^2$	---
3.	8 - 25 Hz	20,000	$1.63 \times 10^4 / f$	$2.5 \times 104 / f$	---
4.	0.025 kHz - 0.82 kHz	500 / f	20 / f	25 / f	---
5.	0.82 - 65 kHz	610	24.4	30.7	---
6.	0.065 - 1 MHz	610	1.6 / f	2.0 / f	---
7.	1 - 10 MHz	610 / f	1.6 / f	2.0 / f	---
8.	10 - 400 MHz	61	0.16	0.2	10
9.	400 - 2000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01 f^{1/2}$	f / 40
10.	2 - 300 GHz	137	0.36	0.45	50

@ Note:

1. f is the frequency and has the following unit
   Hz- Sr No. 1, 2 & 3
   kHz- Sr no. 4 & 5
   MHz- Sr No. 6, 7, 8 &9
   GHz- Sr No. 10

2. Provide the basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded
3. For frequencies between 100 kHz and 10 GHz, Seq, E^2, H^2 and B^2 are to be averaged over any 6-min period
4. No E-field value is provided for frequencies < 1 Hz, which are effectively static electric fields. Electric shock from low impedance sources is prevented by established electrical safety procedures for such equipment

Table a.2: ***Reference levels for general public exposure to time varying electric and magnetic fields***@

Sr No.	Frequency range	E-field (V/m)	H-field strength (A/m)	B-field (μT)	Equivalent plane wave power density Seq (W/m^2)
1.	Up to 1 Hz	---	3.2×10^4	4×10^4	---
2.	1 - 8 Hz	10,000	$3.2 \times 10^4 / f^2$	$4 \times 10^4 / f^2$	---
3.	8 - 25 Hz	10,000	4000 / f	5000 / f	---
4.	0.025 kHz - 0.8 kHz	250 / f	4 / f	5 / f	---
5.	0.8 - 3 kHz	250 / f	5	6.25	---
6.	3 - 150 kHz	87	5	6.25	---
7.	0.15 - 1 MHz	87	0.73 / f	0.923 / f	---
8.	1 - 10 MHz	$87 / f^{1/2}$	0.73 / f	0.92 / f	---
9.	10 - 400 MHz	28	0.073	0.092	2
10.	400 - 2300 MHz	$1.375 f^{1/2}$	$0.0037 f^{1/2}$	$0.0046 f^{1/2}$	f / 200

@ Note:

1. f is the frequency and has the following unit
   Hz- Sr No. 1, 2 & 3
   kHz- Sr no. 4 & 5
   MHz- Sr No. 6, 7, 8 &9
   GHz- Sr No. 10
2. Provide the basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded
3. For frequencies between 100 kHz and 10 GHz, Seq, E^2, H^2 and B^2 are to be averaged over any6-min period
4. No E-field value is provided for frequencies < 1 Hz, which are effectively static electric fields. Perception of surface electric charges will not occur at field strengths less than 25 kV/m. Spark discharges causing stress or annoyance should be avoided.

LITERATURE SURVEY

- Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz), in Health Phys., International Commission on Non Ionizing Radiation Protection (**ICNIRP**), vol. 74, pp. 495–523, 1998.[1]

IN 1974, the International Radiation Protection Association (IRPA) formed a working group on non-ionizing radiation (NIR) to examine the problems arising out of various types of NIR fields. At the IRPA Congress in Paris in 1977, this working group became the International Non-Ionizing Radiation Committee (INIRC). In cooperation with the Environmental Health Division of the World Health Organization (WHO), the IRPA/INIRC developed a number of health criteria documents on NIR as part of WHO's Environmental Health Criteria Programme, sponsored by the United Nations Environment Programme (UNEP). Each document includes an overview of the physical characteristics, measurement and instrumentation, sources, and applications of NIR, a thorough review of the literature on biological effects, and an evaluation of the health risks of exposure to NIR. These health criteria have provided the scientific database for the subsequent development of exposure limits and codes of practice relating to NIR.

At the Eighth International Congress of the IRPA (Montreal, 18–22 May 1992), a new independent scientific organization "International Commission on Non-Ionizing Radiation Protection" (ICNIRP) was established as a successor to the IRPA/INIRC. The functions of the Commission are to investigate the hazards that may be associated with the different forms of NIR, develop international guidelines on NIR exposure limits and deal with all aspects of NIR protection. The main objective of this organization is to establish guidelines for limiting EMF exposure that will provide protection against known adverse health effects. The guidelines for limiting EMF exposure are covered under chapter on "*International Standards & guidelines*".

- ***"Possible effect of Electro Magnetic Field (EMF) on Human Health***", report by Scientific committee on Emerging and Newly health risks, European Commission, 21st March 2007.[2]

The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) has updated the previous opinion on "Possible effects of Electromagnetic Fields (EMF), Radio Frequency Fields (RF) and Microwave Radiation on human health" by the Scientific Committee on Toxicity, Eco-toxicity and the Environment (CSTEE) from 2001, with respect to whether exposure to electromagnetic fields (EMF) is a cause of disease or other health effects. The opinion is divided into frequency (f) bands, namely: radio frequency (RF) (100 kHz $< f \leq$ 300 GHz), intermediate frequency (IF) (300 Hz $< f \leq$ 100 kHz), extremely low frequency (ELF) ($0 < f \leq 300$ Hz).

The most prominent sources of ELF field are power transmission lines. The exposure limit for transmission lines operating at 110 to 400kV voltage level can be 2 to 5kV/m. The exposure due to magnetic flux density depends on the actual current on the line; fields up to 40 μT are possible but are usually lower. It is important to notice that such exposure levels

occur only directly below the lines; exposure decreases with the square of distance to the lines. In a few locations in installations of the electric power industry the exposure limits given in the directive 2004/40/EC for occupational exposure can be reached or exceeded. Safety measures for such areas needs to be implemented.

- ***"Health Effect from exposure to power line frequency Electric & magnetic Field"***, report by National Institute of Environmental health sciences/National institute of health, USA, NIHS Publication No 99-4493'1999.[3]

The alternating current electricity is associated with Electric & Magnetic Field. Studies were conducted by NIEHS to assess the same & their effects if any on humans. The NIEHS health effects research program focused on mechanistic, cellular and laboratory studies in the areas of neurophysiology, behavior, reproduction, development, cellular research, genetic research, cancer and melatonin. The scientific evidence suggested that health risk due to exposure to ELF-EMF field is negligible. Mechanistic studies & animal toxicology failed to demonstrate that exposure to ELF fields may lead to biological effects.

- S.R.Azzuhri, WNL Mahadi, Department of Electrical Engineering and Telecommunications, University of Malaya, Kuala Lumpur ***"Power Transmission Line Magnetic Fields: A Survey on 120 kV Overhead Power Transmission Lines in Malaysia"***, TENCON 2004. 2004 IEEE Region 10 Conference[4].

The paper describes basic properties of power lines, various methods available for measurement of magnetic field etc. Spot magnetic field method has been used for measurement of field along 120kV transmission line and results have been reported.

The magnetic field measurements were carried out at peak load (peak current) in the transmission line. The results shows same characteristic for all the measurements. The highest value of the magnetic field recorded for all measurements is at the centre of the transmission line and it reduces on moving away from the line and approaches to zero. The safe area suggested by the author is 20 meter from the centerline.

- H. Ahmadi, S. Mohseni, A. A. Shayegani Akmal, School of Electrical and Computer Engineering, University of Tehran, Tehran, Iran, ***"Electromagnetic Fields Near Transmission Lines– Problems and Solutions"***, Iran. J. Environ. Health Sci. Eng., 2010, Vol. 7, No. 2, pp. 181-188.[5]

Electro Magnetic Field of various frequencies is ubiquitous in our environment and human beings are continuously exposed to these fields. In this paper, studies has been conducted in different areas like overhead transmission lines, GIS compartments etc. for measurement of EMF fields and results have been compared with the standard tolerances. Simulation Studies have been conducted for different configuration of 230kV to ascertain the best configuration of the line.

Electromagnetic field measurement has been carried out at various places on 230kV & 400kV transmission lines. It has been found that the electric & magnetic field intensity 40 m

away from the TLs & SS is below the threshold values. A simulation study shows that the circular arrangement is the best configuration for transmission lines. The paper also discusses about the effects due to continuous exposure transmission lines.

- B.K.Singh, R.S.Sharma, R.Ajumeera, A.K.Mathur, ***"Electromagnetic Field in environment and its health hazards"***, International conference on Microwave-2008.[6]

Use of large scale electrical technologies has led to widespread environmental exposures to electromagnetic fields (EMF) over wide frequency range. Dominant sources of human made fields in the environment are power lines at extremely low frequencies and high powered broad cast transmitters at radio frequencies (RF), but many other sources of EMF exist that can produce fields in a local environment. All alternating electric currents generate electric and magnetic fields - collectively known as EMFs. The electric field is proportional to the voltage. The magnetic field is proportional to the current that is to the amount of electricity flowing through the wires. Electric fields can be easily shielded but the shielding of magnetic fields is technically difficult and therefore very expensive. Buried power lines generate lower magnetic fields than overhead power lines because of their design.

Human studies have consistently shown that there is no evidence that prolonged exposure to weak electric fields results in adverse health effects. However it is an open question as no conclusive results have been reported in respect of magnetic fields. They opined that the chronic exposure to weak magnetic fields is also equally harmless.

- Dejan M. Petković, Dejan D. Krstić, Vladimir B. Stanković, ***" The Effect Of Electric Field On Humans In The Immediate Vicinity Of 110 kV Power Lines"***, FACTA UNIVERSITATIS, Series: Working and Living Environmental Protection Vol. 3, No 1, pp. 63 – 72,2006.[8]

Abstract

Sudden growth in population and technological advancement have led to increasing demands for larger quantities of electric energy, which in turn led to the increase in the EM field level in urban and working environments. Since this phenomenon cannot be avoided, there is the issue of effect of this field on human health and the need to define safe exposure limits for both professional and general population. The paper presents the effect of the electric component of an electromagnetic field (ELF) of 50 Hz, originating from over ground 110 kV power line, on humans in its immediate vicinity. In the paper, the electric field which penetrates the human body was calculated with the help of a human model.

Discussion

The paper presented a study for calculating the electric field which penetrates the human body. The distribution of the electric field surrounding humans will be given, as well as the values of the field which penetrates humans. Comparison has been made between calculated values and the values obtained through the usage of adequate software solutions. The studies concluded that human head is exposed to maximum electric field.

- R. Tukimin, W.N.L Mahadi, M.Y.M Ali, M.N.M Thari, "***Extremely Low Frequency Electromagnetic Field (ELF EMF) Survey of Residential Areas Around Transmission Lines***", Radiation Health and Safety Division, Malaysian Nuclear Agency, Department of Electrical Engineering, University Malaya, Kuala Lumpur , pp.4-6, Asia pacific conference on applied electromagnetic proceedings, Melaka, Malaysia-2007.[9]

Abstract

Extremely low frequency (ELF) electromagnetic fields (EMF) are categorized as non-ionizing radiation (NIR). They are generally generated by overhead transmission power lines. A study of ELF EMF was conducted at residential areas around the transmission line located at Kelang Valley. The objectives of the study were to determine the strength of the ELF EMF present besides to assess the potential exposure received by future residents. The results obtained were compared against the permissible exposure limits recommended by International Commission of Non-Ionizing Radiation Protection (ICNIRP) for members of public to ensure that they are acceptable in term of safety.

Discussion

The results obtained shows that the electric and magnetic field levels were found to vary against measurement locations, which were strongly influenced by vertical and horizontal distance from cables. The field strengths at the housing area found to be lower than those present directly under the cables. The magnetic fields usually increase a little bit in the middle of the between the two pylons supporting the cables because of cable sagging, which causes the cables to become nearer to the ground. However, for this particular study area, such effect was not obviously seen because of unleveled ground surface as move along the length of the Cables. The study show that field strength in close space was much lower compared to that measured in open space.
It was found that EMF level were very much lower than recommended exposure limit by ICNIRP which were 0.03% and 5.26% for magnetic and electric field respectively. However study and evaluation are still important in determining of the long term effect of ELF EMF.

- S.Shahnawaz Ahmed and. Rezaul Haque "***Assessing How Safe are the Rural Tin-shed Houses in the Vicinity of EM Fields of the Cross-Country Power Lines***" Dept. of Electrical and Electronic Engineering Bangladesh University of Engineering and Technology Dhaka 1000, Bangladesh pp 401-404,2002.[10]

Abstract

High voltage grid lines are mostly routed through the rural areas. Asian countries are usually roofed with thin galvanized and corrugated steel sheets termed 'tin'. An analysis of the electromagnetic Field effects on a tin-shed house from a nearby power line has been reported in the literature. This paper presents the way this practical issue has been investigated thoroughly. The induced circulating current densities and resulting power dissipation in the roofs of tin-shed houses neighboring to a 132 kV and a 230 kV transmission line have been

quantified as a function of the distance of the nearest edge of a tin sheet from the line, the tin sheet's slant angle with respect to the vertical plane and the height of the roof. The results of this investigation would help the electric utility planners in defending a renewed public concern about transmission lines' effects upon the health of rural mass.

Discussion

A comprehensive study of the current densities induced and resulting power dissipation (in the form of heat) in the roof of a tin-shed house in the vicinity power transmission line(132kV and 230kV) was conducted by author. He has been found that the 'induced flux density at the topmost point on a tin sheet and a line current much higher than the normal one. The obtained results show that with increase in the slant angle of the roof of the tin-shed house the induced current density increases and for a flat roofed (90" slant angle) house this was the maximum. It was reported that with an increase in the distance of the house from line ROW centre the induced current and dissipated power densities fall off rapidly respectively in proportion to the second and the fourth power of the distance. However, it was found that the induction effects of electromagnetic fields are concerned the tin-shed houses in the vicinity of transmission lines and their dwellers are not at risk.

- Makarand Mukund Kane. Guide: Prof. S. V. Kulkarni, ***"Effects of ELF Electric and Magnetic Fields on Human Beings and Their Computations"***, IIT-Bombay.[11]

The paper elaborated on the effect of extremely low frequency (ELF) electric & magnetic field on humans. As the electric & magnetic field are not coupled at low frequencies, they have been analyzed separately in this paper. Methods has been provided for calculation of electric & magnetic field in the vicinity of power transmission lines and simulation has been done to calculate transmission line electric field in presence of human body.

- P. S. Wong, M. A. Janoska, C. Light, and R. W. McCourt, "Long term magnetic field monitoring near power lines," *IEEE Trans. Power Delivery*, vol. 12, pp. 922–927, Apr. 1997.

Abstract

The papers show the procedure of measurement of EMF at different substation before and after a substation expansion. For monitoring the EMF near Power Lines Public Service electric and Gas Company (PSE&G) of New Jersey measured EMF levels both from the substation and the surrounding distribution lines.

Discussion

This paper concluded that monitoring of power line loadings by gathering load currents every 15 minutes provides enough information for long term load distribution planning, Since magnetic fields are related to currents, a 15 minute interval should therefore be adequate and is mandated by the protocol. This interval produces -35000 samples per year for the Township to evaluate an annual average. A sudden increase or decrease of field levels lasting

less than 15 minutes does not produce a significant change to the annual average. Sampling more often than 15 minutes only produces unnecessarily larger amounts of data for analyses.

- Carlos Garrido, Antonio F. Otero, José Cidrás, ***"Low-Frequency Magnetic Fields from Electrical Appliances and Power Lines"*** IEEE Trans. Power Delivery, vol.18, pp. 1310–1320, 2003.[12]

Abstract

The study was conducted to measure the magnetic field generated by electrical appliance and high voltage overhead line to establish the degree of compliance with the recent European regulation. At the same time, a mathematical model was developed for electrical lines that can be used to calculate the magnetic field of the lines under different loads and unbalanced situations. The study of the harmonics of the magnetic field was also done in this paper. The model is used to simulate the behavior of the lines under given conditions. In both cases, an FFT analysis of the magnetic field waveform was performed to study the frequency and amplitude of the possible induced currents.

Discussion

This work involved the study of the magnetic field generated by electrical appliances and electrical lines of 132kV and develops a model which was useful to approach theoretical lines study in situations and configurations that are not possible to study in real situations but that can arise under different service conditions. It was also concluded that the harmonic generated by some electrical appliances can give rise to induced current of a higher value than that generated by the fundamental frequency field. In the case of electrical lines, the FFT analysis of the generated fields has found fifth harmonic component.

- I.O. Habiballah, T. K. Abdel-Galil, M. M. Dawoud, C. A. Belhadj, M. Arif Abdul-Majeed, and T.A. Al-Betairi ***"ELF Electric and Magnetic Fields Exposure Assessment of Live-Line Workers for 132 kV Transmission Line of SEC",*** Transmission & Distribution conference and exposition: Latin America, pp1-5Aug. 2006.[13]

Abstract

This paper presents an exposure assessment study for live-line workers exposed to transmission line power frequency electric and magnetic fields. The charge simulation method is adopted to compute the external electric field around the selected 132 kV double circuit transmission line&. A method based on Ampere law (Biot savart law) was used to compute the external magnetic field around the transmission line. Both methods were numerically solved using the EPRI's (Electric power research institute) EMF Workstation software and compared with IEEE standard.

Discussion

Comparison of the values of external electric and magnetic fields, with the allowable limits set by the international standards it is revealed that the levels of workers exposures to extremely low frequency electromagnetic field were well below the recommended international standards limits for the four scenarios considered in this study.

FIELD MEASUREMENT FOR 400kV VOLTAGE LEVEL

4.1 Introduction

Electric [E] & Magnetic [M] field intensity measurements have been carried out for following substations & transmission lines as mentioned under:

Substations:

i. 400/220 kV Hyderabad Substation (D type)
ii. 400/220 kV Bhiwadi Substation (I Type)
iii. 765/400kV Seoni Substation

Transmission Lines

i. Ballabhgarh-Maharanibagh and Ballabhgarh-Greater Noida, 400 kV Double Circuit Line with quad conductor
ii. Bhiwadi-Agra 400kV Double circuit line with twin conductor
iii. Hyderabad-Ramagundam 400kV Double Circuit Line (Ckt. 3 & 4) with twin conductor
iv. Ramagundam-Nagarjunsagar 400 kV double circuit line with twin conductor
v. Gooty-Raichur 400 kV double circuit line with quad conductor

4.2 Measurement Procedure

All the measurements were carried out at 1 meter height from the ground level as per IEEE standard 644-1994 guidelines and Also, at 1.8 meter from the ground. (i.e. at normal human height) to study the effective field intensity levels on human beings. For transmission line, measurements were carried out at 30kms to 40 kms from substation.

a) Lateral profile of electric and magnetic field strengths near power lines

The lateral profile of electric and magnetic field strengths along a span were measured at intervals in a direction normal to the line at 1 m above the ground level. The measurement of lateral profiles was done at intervals starting from the maximum sag point of the span under the line and to a lateral distance up to 50 m from each of double circuit transmission line or to a distance of insignificant field. Profile measurements were also made at intervals in between two lines of a double circuit line.

b) Longitudinal profile of electric and magnetic field strengths near power lines

The longitudinal profile of electric and magnetic field strengths were measured parallel with the line and 1 m above the ground. The measurements of the longitudinal profiles was done under both the lines of double circuit line, at intervals starting from the maximum sag point and in both directions for a total distance equal to one span.

c) Measurement of electric and magnetic field strengths in sub-stations

The electric and magnetic field strengths around the periphery of equipment of sub-stations were measured at 1 m above the ground level and 1 m away from the equipment. Measurements of electric and magnetic field strengths were made for equipment connected in heavily loaded circuit and for equipment connected in minimum current carrying circuit of the sub-station.

4.3 Measuring Instruments Used

a. Electric field measurement meter

Electric field strength was measured with Manro Electric make Spherical digital Electric field meter. The meter measures the power frequency induced charge between two hemispherical electrodes of an isolated conductive body in an Electric field. The incident field on the meter electrodes is directly proportional to kV/m. The field intensity is expressed in kV per meter. The instrument has been calibrated at CPRI as per IEEE 644-1994 with parallel plate arrangement. The Spherical Digital Electric Field Meter used for the measurement of electric field strength is shown in figure 1.

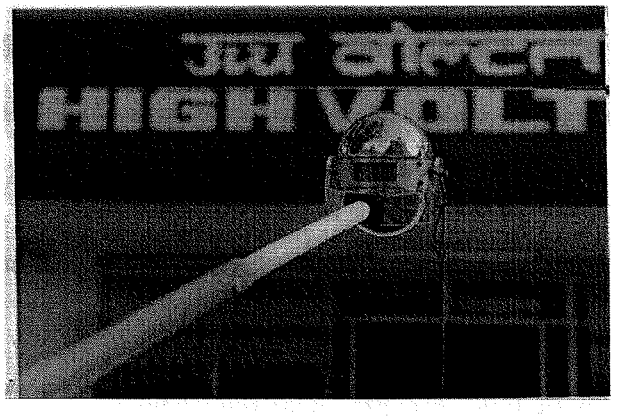


Fig 4.1: ***Spherical Digital Electric Field Meter***

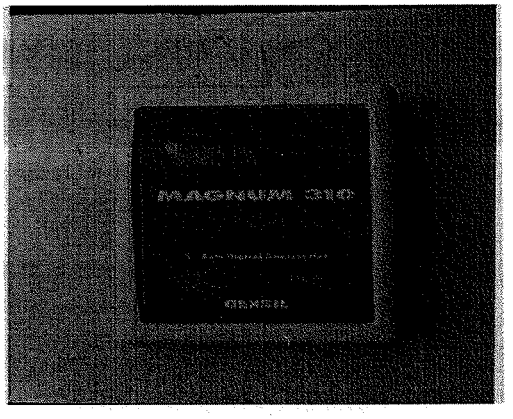


Fig 4.2: ***Digital AC Gauss meter***

b. Magnetic field measurement meter

Magnetic field was measured by Digital AC gauss meter. It has three axis digital read out. The meter is calibrated as per IEEE Standard no. 644 -1994.

4.4 Field Measurements

4.4.1 Ballabhgarh - Maharanibagh and Ballabhgarh-Greater Noida, 400 kV Double circuit line with Quad conductor

The load particulars recorded during the lateral and longitudinal profile measurements of electric and magnetic field strengths are as shown in Table 4.1 below:

Table 4.1: ***Load data during lateral and longitudinal profile measurements***

Load Particulars				
Time	Voltage in kV		Load in MW	
	Maharanibagh circuit	Greater Noida circuit	Maharanibagh circuit	Greater Noida circuit
12.00 Noon	406	406	144	240
01.00 PM	413	413	107	170
02.00 PM	406	406	132	192
03.00 PM	403	403	121	162
04:00PM	408	408	169	149

The span between tower numbers 99 and 100 approximately about 25 kms from the PGCIL"s Ballabhgarh 400 kV sub-station was used for the measurement. The weather parameters during the measurement were as under: Temperature: 25^{0}C and Relative Humidity: 39 %

LATERAL PROFILE

The lateral profile of electric and magnetic field strength is shown in table 4.2 and the corresponding profiles in figure 4.3 & 4.4 respectively.

Table 4.2: ***Lateral profile results of electric and magnetic fields***

Lateral distance in meters from max. sag point	Electric Field kV/m		Magnetic Field µT	
	1m Height	1.8m Height	1m Height	1.8m Height
50	00	0.0	0.164	0.172
40	00	0.0	0.216	0.224
30	00	0.0	0.356	0.376
20	0.3	0.4	0.684	0.700
15	0.8	1.1	0.912	0.952
10	1.6	2.0	1.140	1.300
5 From line	2.7	3.1	1.520	1.840
Line	3.0	3.6	1.600	1.880
5	2.6	3.0	1.64	1.820
3	2.2	2.4	1.68	1.880
1	1.9	2.1	1.72	1.98
0(mid of ckt-1 & ckt-2)	1.8	2.1	1.68	1.96
1	1.8	2.1	1.72	2
3	2.2	2.4	1.64	1.88
5	2.6	2.9	1.60	1.84
Line	3.0	3.5	1.60	1.88
5 From line	2.7	3.1	1.36	1.48

10	1.6	2.0	1.04	1.2
15	0.9	1.1	0.768	0.828
20	0.3	0.4	0.572	0.592
30	0.0	0.0	0.308	0.312
40	0.0	0.0	0.200	0.204
50	0.0	0.0	0.128	0.136

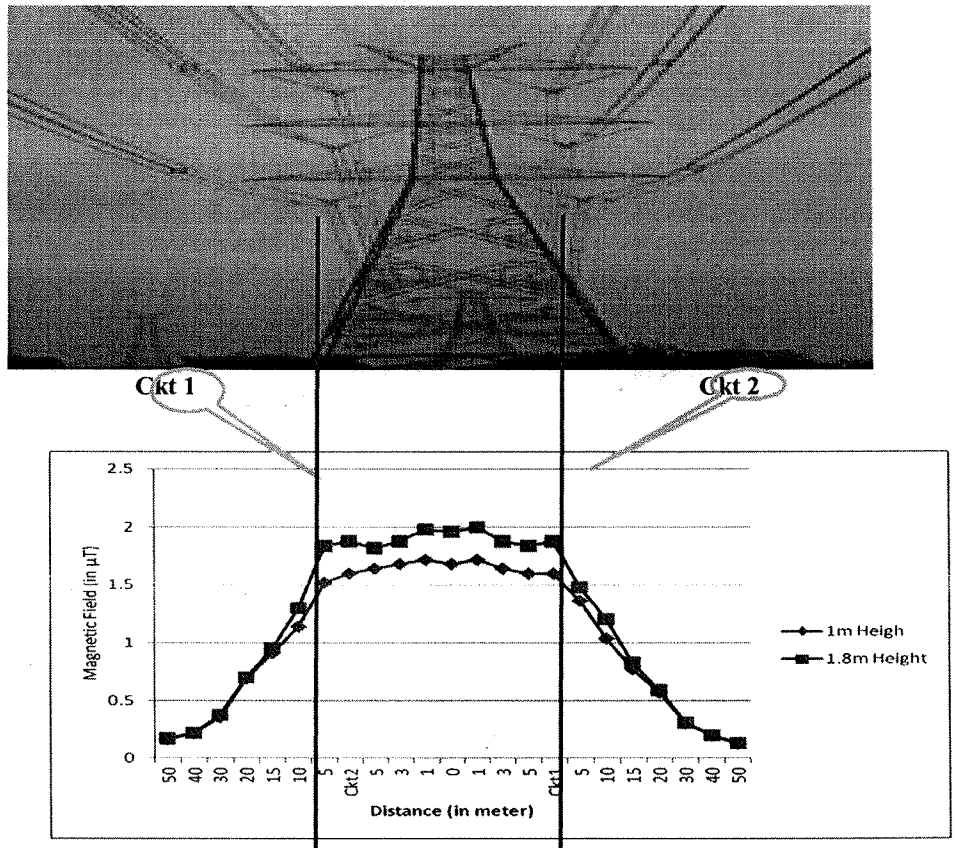


Fig 4.3: ***Lateral profile of electric field***

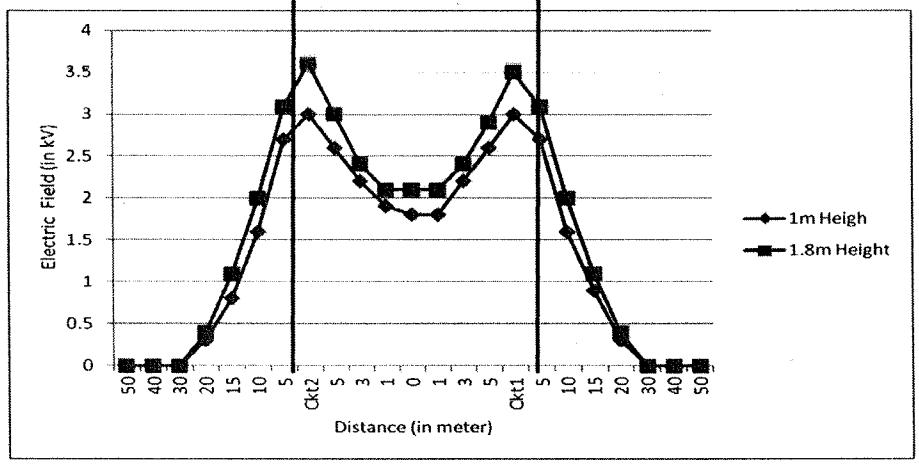


Fig 4.4: ***Lateral profile of magnetic field***

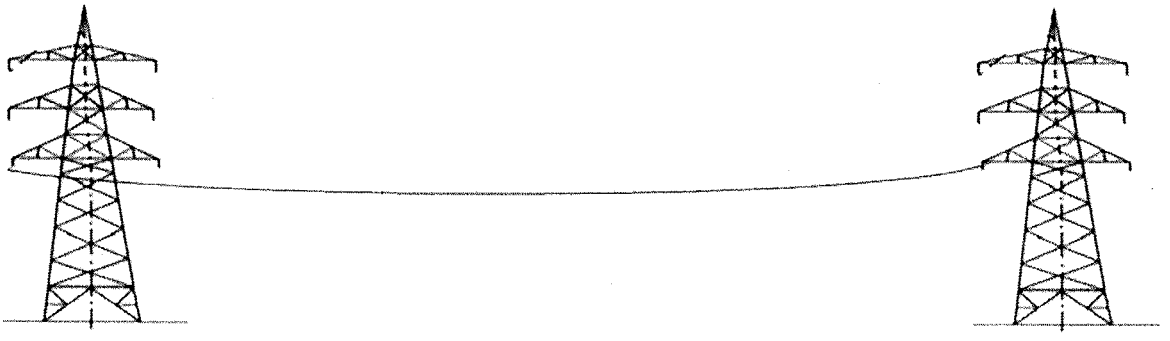
LONGITUDINAL PROFILE (Ckt-1)

The longitudinal profile of electric and magnetic field strengths are shown in Table 4.3 and the corresponding profiles in figures 4.5 & 4.6

Table 4.3 ***Longitudinal profile results of electric and magnetic fields (Ckt-1)***

Longitudinal distance in meter from mid span of two towers	Electric Field kV/m		Magnetic Field μT	
	1m Height	1.8m Height	1mHeight	1.8m Height
Near tower 100	0.1	0.1	0.536	0.604
180	0.6	0.8	0.608	0.664
150	1.1	1.2	0.756	0.840
120	1.3	1.5	0.948	1.080
90	1.6	2.2	1.200	1.400
60	2.1	2.4	1.320	1.560
40	2.4	3.0	1.440	1.680
20	2.6	3.2	1.560	1.720
10	2.8	3.4	1.720	1.840
0	3.0	3.6	1.760	1.920
10	3.0	3.4	1.640	1.900
20	3.0	3.4	1.640	1.900
40	3.0	3.4	1.620	1.800
60	2.8	3.2	1.600	1.780
90	2.3	2.8	1.580	1.740
120	1.8	2.3	1.480	1.680
150	1.6	1.8	1.320	1.400
180	1.2	1.5	1.040	1.120
Near tower 99	0.2	0.4	0.876	0.984

Schematic of Ballabgarh - Maharanibagh 400 kV, D/C line with Quad Conductor at tower no. 99 &100



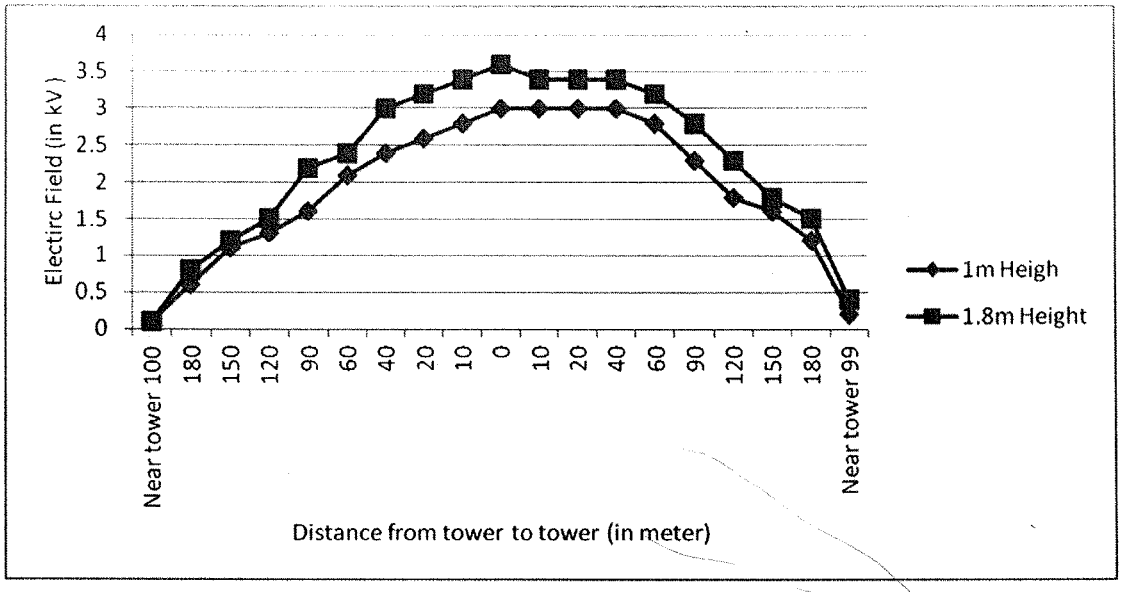


Figure 4.5: ***Longitudinal profile of electric field (Ckt-1)***

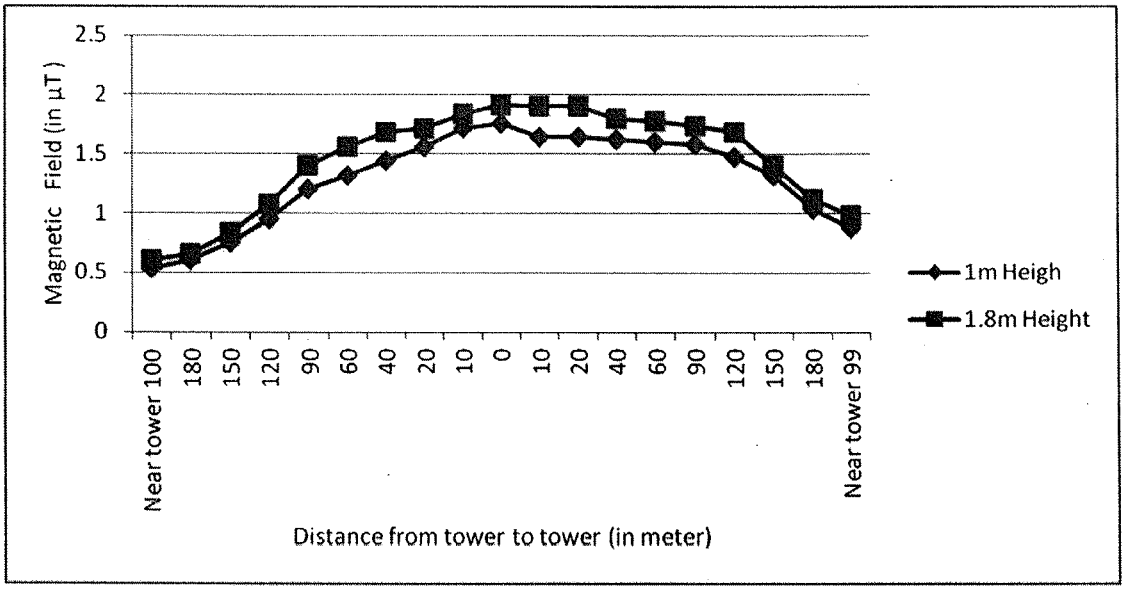


Figure 4.6: ***Longitudinal profile of magnetic field (Ckt-1)***

LONGITUDINAL PROFILE (Ckt-2)

The longitudinal profile of electric and magnetic field strengths are shown in Table 4.4 below. The profiles obtained are shown in figures 4.7 & 4.8.

Table 4.4: ***longitudinal profile results of electric and magnetic fields (Ckt-2)***

Longitudinal distance in meter from mid span of two towers	Electric Field kV/m		Magnetic Field μT	
	1m Height	1.8m Height	1m Height	1.8m Height
Near tower 99	0.1	0.1	0.524	0.580
180	0.5	0.8	0.604	0.660
150	1.1	1.2	0.840	0.924
120	1.4	1.6	1.080	1.200
90	1.5	2.1	1.280	1.400
60	2.2	2.6	1.520	1.680
40	2.4	3.0	1.640	1.920
20	2.7	3.2	1.840	2.000
10	3.0	3.4	1.880	2.240
0	**3.1**	**3.7**	**1.960**	**2.320**
10	3.0	3.6	1.960	2.300
20	3.0	3.6	1.940	2.260
40	2.8	3.4	1.920	2.220
60	2.7	3.3	1.900	2.020
90	2.6	3.1	1.860	1.920
120	1.8	2.3	1.600	1.900
150	1.1	1.4	1.560	1.720
180	0.9	1.2	1.040	1.160
Near tower 100	0.3	0.5	0.844	0.956

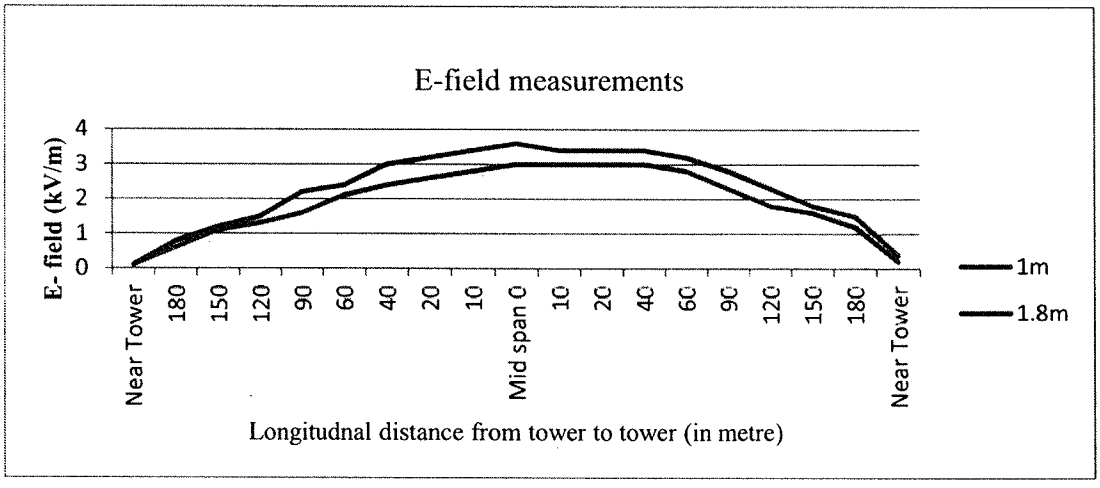


Fig4.7*Longitudinal profile Electric field (Ckt-1)*

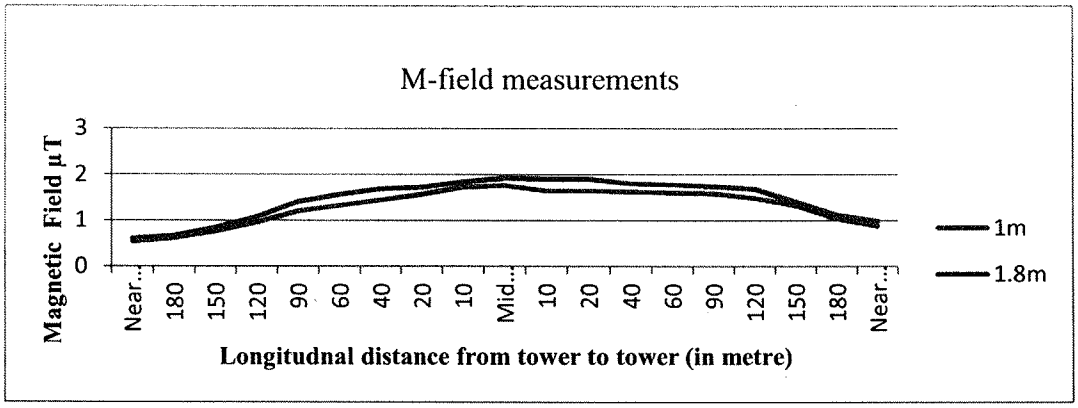


Fig.4.8 ***Longitudinal profile of Magnetic field (Ckt-2)***

4.4.2 Bhiwadi - Agra 400 kV double circuit line with twin conductor

The load particulars recorded during the lateral and longitudinal profile measurements of electric and magnetic field strengths are as shown in Table 4.5 below:

Table 4.5: ***Load data during lateral and longitudinal profile measurements***

Load Particulars				
Time	**Voltage in kV**		**Load in MW**	
	Ckt1	Ckt2	Ckt1	Ckt2
01:00 PM	427	427	138	137
02:00 PM	416	416	153	148
03:00 PM	413	413	178	178
04:00 PM	415	415	187	188

The span between tower numbers 483 and 484 located at Nau village, approximately about 40 kms from the PGCIL"s Bhiwadi 400 kV sub-station was used for the measurement. The weather parameters during the measurement were as under: Temperature: 24° C and Relative Humidity: 34 %

LATERAL PROFILE

The lateral profile of electric and magnetic field strengths are shown in Table 4.6.

Table 4.6: ***Lateral profile of Electric & magnetic field strength***

Lateral distance in meters from max. sag point	Electric field, kV/m		Magnetic field, µT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
50	00	0	0.280	0.284
40	00	0	0.430	0.460

30	00	0	0.660	0.672
20	0.1	0.3	1.040	1.200
15	0.6	0.8	1.440	1.640
10	1.3	1.6	2.000	2.240
5	2.6	3.2	2.280	2.840
Line ckt-2	4.0	4.6	2.400	2.840
7	4.0	4.6	2.400	2.760
5	3.9	4.5	2.360	2.640
3	3.8	4.4	2.240	2.440
1	3.4	4.4	2.160	2.240
0(mid of ckt-1 & ckt-2)	**3.2**	**4.4**	**2.080**	**2.240**
1	3.2	4.4	2.220	2.400
3	3.4	4.6	2.280	2.480
5	3.8	4.6	2.480	2.720
7	4.0	4.6	2.520	2.840
Line ckt-1	4.0	4.8	2.520	2.840
5	2.8	3.4	2.500	2.800
10	1.5	2.1	2.080	2.280
15	0.8	1.0	1.560	1.760
20	0.2	0.4	1.120	1.320
30	0.0	0	0.690	0.720
40	0.0	0	0.430	0.456
50	0.0	0	0.280	0.292

LONGITUDINAL PROFILE (Ckt-1)

The longitudinal profile of electric and magnetic field strengths are shown in Table 4.7

Table 4.7: ***Longitudinal profile results of electric and magnetic fields (Ckt-1)***

Distance from mid span of two towers	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
Near tower 483	0.4	0.5	0.953	0.992
180	1.7	2.0	0.984	1.040
150	2.3	2.5	1.120	1.280
120	2.8	3.0	1.320	1.520
90	3.0	3.4	1.640	1.760
60	3.3	3.8	1.800	2.000
40	3.6	4.2	1.800	2.040
20	3.6	4.2	2.000	2.240
10	3.6	4.6	2.200	2.480
0	4.0	4.6	2.200	2.500

10	3.8	4.6	2.180	2.360
20	3.6	4.2	2.080	2.280
40	3.6	4.2	2.060	2.140
60	3.6	4.2	1.980	2.060
90	3.2	3.7	1.920	2.040
120	2.0	3.0	1.680	1.840
150	1.6	2.6	1.880	1.800
180	1.4	2.2	1.680	1.680
Near tower 484	0.4	0.8	1.440	1.440

LONGITUDINAL PROFILE (Ckt-2)

The longitudinal profile of electric and magnetic field strengths are shown in Table 4.8 below.

Table 4.8: ***Longitudinal profile results of electric and magnetic fields (Ckt-2)***

Distance from mid span of two towers	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
Near tower 483	0.5	0.6	0.976	1.000
180	1.8	2.2	0.984	1.040
150	2.3	2.6	1.120	1.320
120	2.6	3.0	1.360	1.640
90	3.2	3.6	1.680	1.840
60	3.4	3.8	1.740	2.000
40	3.4	4.2	1.920	2.080
20	3.8	4.4	2.040	2.440
10	4.0	4.6	2.200	2.480
0	4.2	4.6	2.200	2.480
10	3.8	4.6	2.140	2.320
20	3.8	4.6	2.100	2.520
40	3.8	4.6	1.960	2.280
60	3.6	4.2	1.900	2.080
90	3.4	3.8	1.860	2.040
120	2.0	3.2	1.800	2.000
150	1.4	2.6	1.760	1.880
180	1.2	2.0	1.480	1.720
Near tower 484	0.4	0.6	1.400	1.520

4.4.3 Hyderabad - Ramagundam 400 kV double circuit line (Ckt-3 & Ckt- 4) with twin conductor

The load particulars recorded during the lateral and longitudinal profile measurements of electric and magnetic field strengths are as shown in Table 4.9 below:

Table 4.9: ***Load data during lateral and longitudinal profile measurements***

Load Particulars				
Time	Voltage in kV		Load in MW	
	Ckt3	Ckt4	Ckt3	Ckt4
11.00 AM	419	419	360	340
12.00 noon	418	418	350	330
01.00 PM	419	419	360	340
2.00 PM	421	421	350	330
3.00 PM	417	417	360	340
4.00 PM	418	418	350	330

The span between tower numbers 511 and 512 located at Rahimkhanguda village, approximately about 25 kms from the PGCIL's Hyderabad 400 kV sub-station was used for the measurement. The weather parameters during the measurement were as under: Temperature: 33° C and Relative Humidity: 42 %

LATERAL PROFILE

Table 4.10: ***Lateral Profile for Electric & Magnetic field strength***

Distance in m from max sag point	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
50	00	0.0	0.588	0.580
40	00	0.0	0.816	0.812
30	00	0.0	1.120	1.200
20	0.2	0.2	1.680	1.720
15	0.5	0.5	2.080	2.240
10	1.2	1.3	2.600	2.920
5	1.9	2.1	2.680	3.360
0 Line ckt-3	2.6	2.7	3.000	4.120
7	2.4	2.5	3.880	4.280
5	2.1	2.3	3.920	4.140
3	1.9	2.2	3.820	4.120
1	1.6	2.0	3.682	4.140
0 mid of ckt-3 & ckt-4	1.5	2.0	3.682	4.120
1	1.6	2.0	3.680	4.160
3	1.9	2.2	3.830	4.140
5	2.0	2.3	3.930	4.140

7	2.4	2.4	3.890	4.240
0 Line ckt-4	2.6	2.6	3.880	4.240
5	1.8	2.2	3.650	3.520
10	1.0	1.2	2.620	2.960
15	0.6	0.8	2.265	2.440
20	0.3	0.4	1.860	1.880
30	0.0	0.0	1.160	1.280
40	0.0	0.0	0.870	0.916
50	0.0	0.0	0.660	0.642

LONGITUDINAL PROFILE (Ckt-3)

The longitudinal profile of electric and magnetic field strengths are shown in Table 4.11 below.

Table 4.11: ***Longitudinal profile results of electric and magnetic fields (Ckt-3)***

Distance from mid span of two towers	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
Near tower 511	0.5	0.8	2.600	2.880
160	0.9	1.4	3.320	3.680
120	1.0	1.8	4.160	4.520
80	1.5	2.4	4.460	5.040
40	1.9	2.4	3.680	4.120
0	2.1	2.6	3.680	4.040
40	2.0	2.6	3.560	3.880
80	1.6	2.1	2.760	2.960
120	1.2	1.4	2.180	2.400
160	1.0	1.2	1.720	1.880
180	0.6	0.7	1.600	1.720
Near tower 512	0.5	0.8	2.600	2.880

LONGITUDINAL PROFILE (Ckt-4)

The longitudinal profile of electric and magnetic field strengths are shown in Table 4.12 below.

Table 4.12: ***Longitudinal profile results of electric and magnetic fields (Ckt-4)***

Distance from middle span of two towers	Electric field kV/m		Magnetic field μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
Near tower 511	0.4	0.9	2.520	2.800

160	2.0	1.4	3.240	3.520
120	2.2	2.8	3.720	4.240
80	1.9	3.0	4.280	4.920
40	2.1	3.2	3.520	3.920
0	**2.3**	**2.6**	**3.600**	**4.120**
40	2.4	2.6	3.240	3.560
80	1.6	2.1	2.560	2.840
120	1.2	1.4	2.200	2.340
160	1.0	1.2	1.800	1.920
Near tower 512	0.3	0.5	1.600	1.840

4.4.4 Ramagundam-Nagarjunsagar 400 kV double circuit (Ckt-1 and Ckt-2) line with twin conductor

The load particulars recorded during the lateral and longitudinal profile measurements of electric and magnetic field strengths are as shown in Table 4.13 below:

Table 4.13: ***Load data during lateral and longitudinal profile measurements***

Load Particulars				
Time	Voltage in kV		Load in MW	
	Ckt1	Ckt2	Ckt1	Ckt2
02:00 PM	416	417	370	370
03:00 PM	417	417	360	360
01:00 PM	417	417	360	360
02:00 PM	417	417	360	360

The span between tower numbers 574 and 575 approximately about 25 kms from the PGCIL's Nagarjunsagar 400 kV sub-station was used for the measurement. The weather parameters during the Measurement were as under: Temperature: 35° C and Relative Humidity: 38 %

Lateral Profile

The table 4.14 the Electric & Magnetic field strength for lateral profile

Table 4.14: ***Lateral Profile for Electric & Magnetic field strength***

Lateral distance in meters from max. sag point	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
50	0	0	0.116	0.124
40	0	0	0.188	0.196
30	0	0	0.325	0.328
20	0	0	0.800	0.840

15	0.5	0.6	1.600	1.840
10	0.8	1.3	2.480	2.760
5	2	2.6	3.600	4.200
Line ckt-2	3.2	3.8	5.080	5.800
7	3	3.6	5.240	6.000
5	2.1	3.4	5.480	6.400
3	2	2.6	5.620	6.520
1	0.9	1.3	5.920	6.500
0 (mid of ckt-1 & ckt-2)	0.9	1.2	5.440	6.440
1	0.9	1.4	5.440	6.280
3	1.7	2.2	5.560	6.160
5	2	3.2	5.440	6.200
7	2.2	3.8	5.200	5.960
Line ckt-1	3.2	3.5	4.800	5.400
5	2.0	2.8	3.440	3.800
10	0.7	1.4	2.200	2.440
15	0.3	0.6	1.440	1.640
20	0.2	0.2	1.080	1.080
30	0	0	0.548	0.562
40	0	0	0.304	0.308
50	Further measurements not taken because of mango trees			

LONGITUDINAL PROFILE (Ckt-1)

The longitudinal profile of electric and magnetic field strengths along ckt-1, are shown in Table 4.15 below.

Table 4.15: ***Longitudinal profile results of electric and magnetic fields (Ckt-1)***

Distance from middle span of two towers	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m ove ground
Near tower 574	0.7	1.0	1.920	2.120
180	1.0	1.4	1.920	2.320
150	1.3	1.7	2.680	2.460
120	2.0	2.6	3.360	2.680
90	2.4	3.2	3.960	4.480
60	2.3	3.9	4.880	5.400
40	3.2	4.0	5.000	5.600
20	2.2	4.2	5.040	5.800
10	2.6	4.7	5.120	5.760
0	2.5	4.1	5.080	5.800
10	2.1	3.9	4.960	5.720
20	2.4	3.7	4.620	5.280
40	2.4	3.3	4.120	4.880
60	2.0	3.1	3.680	4.200
90	1.6	2.4	3.040	3.480
120	1.2	2.0	2.440	2.600
150	1.0	1.9	1.880	1.960
180	0.4	0.9	1.820	1.900
Near tower 575	0.1	0.8	1.720	1.820

LONGITUDINAL PROFILE (Ckt-2)

The longitudinal profile of electric and magnetic field strengths along ckt-2 are shown in Table 4.16 below.

Table 4.16: ***Longitudinal profile results of electric and magnetic fields (Ckt-2)***

Distance from middle span of two towers	**Electric field, kV/m**		**Magnetic field, μT**	
	1 m above ground	**1.8 m above ground**	**1 m above ground**	**1.8 m above ground**
Near tower 574	0.5	1.1	0.976	2.240
180	1.8	1.3	0.984	2.400
150	2.3	1.6	1.120	2.920
120	2.6	2.5	1.360	3.760
90	3.2	3.2	1.680	4.400

60	3.4	3.9	1.740	5.240
40	3.4	3.9	1.920	5.720
20	3.8	4.0	2.040	5.920
10	4.0	4.1	2.200	5.600
0	4.2	4.1	2.200	5.800
10	3.8	3.9	2.140	5.820
20	3.8	3.7	2.100	5.320
40	3.8	3.4	1.960	4.890
60	3.6	3.2	1.900	4.560
90	3.4	2.5	1.860	3.680
120	2.0	1.6	1.800	2.680
150	1.4	1.4	1.760	2.480
180	1.2	1.2	1.480	2.040
Near tower 575	0.4	0.7	1.400	1.680

4.4.5 Gooty - Raichur 400 kV double circuit (Ckt-1 and Ckt-2) line with quadruple conductor

The load particulars recorded during the lateral and longitudinal profile measurements of electric and magnetic field strengths are as shown in Table 4.17 below:

Table 4.17: ***Load data during lateral and longitudinal profile measurements***

Load Particulars				
Time	Voltage in kV		Load in MW	
	Ckt1	Ckt2	Ckt1	Ckt2
3.00 PM	414	414	352	346
4.00 PM	415	415	322	316
5.00 PM	420	420	325	320
6.00 PM	416	416	352	350

The span between tower numbers 339 and 340, approximately about 25 kms from the PGCIL"s Gooty 400 kV sub-station was used for the measurement. The weather parameters during the measurement were as under: Temperature: 34^{0}C and Relative Humidity: 42 %

Lateral Profile

Table 4.18: ***Lateral Profile for Electric & Magnetic field strength***

Lateral distance in meters from max. sag point	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
50	0.0	0.0	0.252	0.256
40	0.0	0.0	0.400	0.412
30	0.0	0.0	0.716	0.724
20	0.1	0.2	1.320	1.440

15	0.5	0.8	1.920	2.180
10	1.0	1.8	2.880	3.360
5	2.8	4.6	4.680	5.200
Line ckt-1	3.8	5.8	6.320	7.400
7	3.2	5.6	6.360	7.520
5	2.4	4.2	6.520	7.720
3	1.8	2.5	6.560	7.880
1	0.8	1.2	6.600	7.800
0	0.5	1.1	6.520	7.320
1	0.8	1.3	6.320	7.280
3	1.6	2.6	6.320	7.040
5	2.2	4.2	5.960	6.840
7	3.4	5.0	5.760	6.560
Line ckt-2	3.8	5.2	5.320	5.960
5	2.4	3.7	3.640	4.320
10	1.2	1.9	2.440	2.760
15	0.5	1.2	1.520	1.800
20	0.2	0.4	1.160	1.400
30	0.0	0.0	0.580	0.592
40	0.0	0.0	0.320	0.328
50	0.0	0.0	0.184	0.202

LONGITUDINAL PROFILE (Ckt-1)

The longitudinal profile of electric and magnetic field strengths along ckt-1, are shown in Table 4.19 below.

Table 4.19: ***Longitudinal profile results of electric and magnetic fields (Ckt-1)***

Distance from middle span of two tower	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
180	0.3	0.5	1.280	1.400
150	0.8	1.1	1.680	2.020
120	1.4	2.5	2.440	2.680
90	1.8	3.5	3.440	3.800
60	2.0	5.1	4.680	5.520
40	2.4	5.8	5.320	6.400
20	3.4	6.8	5.800	6.640
10	3.6	5.8	5.960	6.960
0	2.9	6.3	5.480	6.200
10	2.8	5.2	5.280	6.360
20	2.6	5.2	5.340	6.240
40	2.4	4.3	4.760	5.400

60	2.2	3.8	3.880	4.280
90	2.0	2.8	3.080	3.480
120	1.8	2.1	2.280	2.480
150	1.2	1.4	1.960	2.280
180	0.6	0.8	1.440	1.620

LONGITUDINAL PROFILE (Ckt-2)

The longitudinal profile of electric and magnetic field strengths along ckt-2,are shown in Table 4.20 below.

Table 4.20: ***Longitudinal profile results of electric and magnetic fields (Ckt-2)***

Distance from middle span of two tower	Electric field, kV/m		Magnetic field, μT	
	1 m above ground	1.8 m above ground	1 m above ground	1.8 m above ground
180	0.4	0.6	1.200	1.320
150	1.2	1.5	1.800	1.960
120	1.2	2.1	2.240	2.620
90	2.2	3.0	3.240	3.720
60	1.4	4.2	4.360	5.080
40	2.2	4.8	4.800	5.400
20	3.8	5.3	5.040	5.800
10	3.8	5.4	5.360	6.020
0	3.2	5.2	5.160	5.840
10	2.4	4.6	4.860	5.680
20	2.8	4.6	5.040	5.600
40	2.0	3.8	4.640	5.520
60	2.2	3.4	3.720	4.240
90	2.1	2.6	2.800	3.200
120	1.8	2.2	2.240	2.480
150	1.2	1.4	1.680	1.800
180	0.8	1.1	1.480	1.680

4.4.6 400 kV Bhiwadi "I" sub-station

The single line diagram of the "I" type 400 kV Bhiwadi substation is shown in figure 4.9 below:

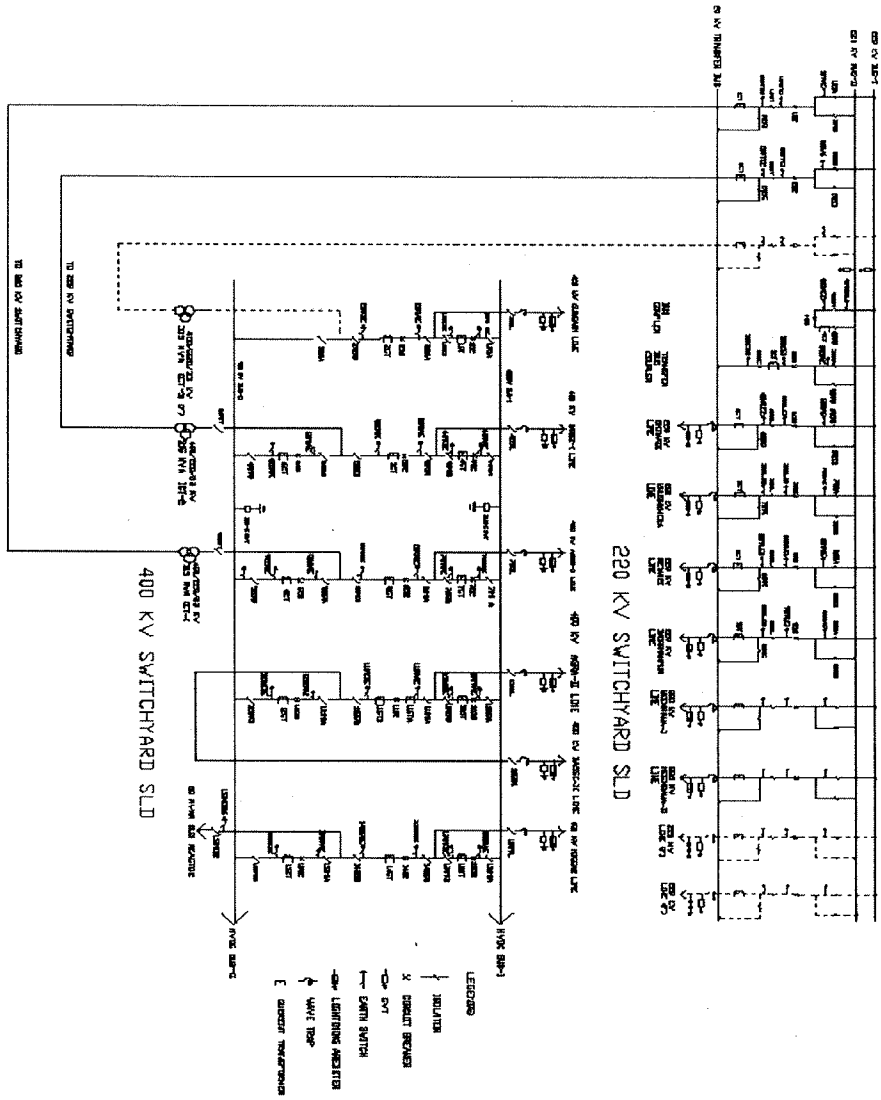


Figure: 4.9 ***the single line diagram of the "I" type 400 kV Bhiwadi substation***

i. 400 kV Bhiwadi sub-station (Equipment connected in Bhiwadi-Gurgaon feeder)

The load particulars recorded during the measurement of electric and magnetic field strengths are as shown in Table 4.21below:

Table 4.21: ***Load data during measurements of field strength around the periphery of equipment***

Time	Load Particulars	
	Voltage in kV	Load in MW
11:00 AM	417	299
12:00 Noon	405	312
01:00 PM	416	290
02:00 PM	418	321
03:00 PM	415	264
04:00 PM	420	262
05:00 PM	418	271

The electric and magnetic field strengths measured around the periphery of the sub-station equipment connected to Bhiwadi -Gurgaon feeder at 1 m &1.8m above the ground level and 1 m away from the equipment are shown in Tables 4.22. The weather parameters during the measurement were as under: Temperature: 24^0C to 27^0C and Relative Humidity: 42% to 46 % .

Table 4.22: ***Field strengths around the periphery of equipment connected in Bhiwadi-Gurgaon feeder***

Name of the Equipment	ID No of the equip ment	Height In meter	Locati on No	Electric field, kV/m			Magnetic field, µT		
				R	Y	B	R	Y	B
Lightning Arrester	1 LA	1m	1	2.3	1.6	2.8	2.52	2.40	2.24
			2	2.1	2.0	2.9	2.76	2.22	2.12
			3	1.9	1.4	2.3	2.76	2.48	2.16
			4	2.2	1.4	2.1	2.56	2.36	2.12
		1.8m	1	3.3	2.6	4.6	2.84	2.56	2.38
			2	3.2	3.2	4.5	2.92	2.64	2.32
			3	2.8	2.4	3.7	2,92	2.72	2.36
			4	3.2	2.5	3.5	2.76	2.56	2.28
Capacitor voltage transformer	1CV T	1m	1	2.1	1.7	3.4	6.28	5.24	5.36
			2	2.7	1.7	2.8	6.24	5.40	3.96
			3	2.3	1.6	2.2	6.32	5.08	3.80
			4	2.7	2.6	2.8	5.12	4.36	3.20
		1.8m	1	4.2	3.6	4.2	6.60	5.36	3.58
			2	4.2	3.5	4.2	7.44	6.24	4.44
			3	4.4	3.4	3.6	6.72	5.68	4.24
			4	4.9	3.8	4.6	5.44	4.72	3.52
Wave trap	1WT		1	1.7	1.6		7.86	7.86	
			2	1.3	1.2	Not	8.08	8.16	Not

		1m	3	1.6	1.7	Prese nt	8.28	8.40	Pres ent
			4	1.5	1.8		7.72	7.76	
		1.8m	1	3.3	3.2		10.8	10.4	
			2	3.2	2.4		10.8	10.8	
			3	3.6	2.8		10.4	1.8	
			4	3.6	3.2		10.0	9.80	
HCB disconnector with one earth switch	189L	1m	1	1.4	1.1	1.9	5.76	6.76	4.44
			2	1.5	1.4	2.1	6.84	6.86	7.88
			3	2.0	1.2	1.6	5.48	6.68	5.32
			4	1.9	1.0	1.6	7.56	8.04	7.44
		1.8m	1	2.4	1.7	3.1	7.64	8.68	5.48
			2	3.2	2.4	3.0	7.88	8.48	8.52
			3	3.4	2.0	2.2	6.32	8.76	7.28
			4	3.0	1.2	2.6	9.16	9.84	8.24
Circuit Breaker	CB152	1m	1	2.3	2.4	3.2	4.96	6.08	4.36
			2	3.2	4.2	5.6	4.48	4.32	4.20
			3	2.1	1.8	2.4	5.68	5.80	6.00
			4	2.4	3.2	3.0	6.36	6.68	4.40
		1.8m	1	4.3	5.3	5.4	6.88	7.68	5.52
			2	7.0	6.8	5.4	6.88	724	5.96
			3	5.4	3.2	4.2	6.76	7.76	7.48
			4	5.2	4.6	5.2	6.64	7.72	5.68
Current Transformer	1CT	1m	1	1.6	1.6	2.0	4.64	5.56	4.08
			2	1.6	1.0	1.6	5.08	5.60	4.36
			3	1.9	1.4	1.6	4.8	5.50	4.60
			4	1.8	1.4	2.0	5.24	5.94	4.28
		1.8m	1	3.1	2.2	3.2	6.24	6.88	4.92
			2	2.1	2.0	2.0	6.24	7.04	5.56
			3	2.1	2.4	1.8	5.48	6.68	6.28
			4	2.6	2.2	2.4	6.20	7.28	5.88
Lightning Arrester	2LA	1m	1	2.4	1.6	2.2	0.84	1.40	0.988
			2	2.5	1.8	2.2	0.68	1.64	1.12
			3	2.6	2.0	2.6	0.804	1.48	1.28
			4	2.6	1.8	2.5	0.972	1.84	1.00
		1.8m	1	3.6	3.2	3.4	1.16	1.92	1.08
			2	3.8	3.2	4.2	0.944	2.02	1.44
			3	3.5	2.8	3.8	0.904	1.92	1.42
			4	3.5	3.0	3.8	1.04	2.24	1.28
			1	2.2	2.6	3.6	3.28	4.04	3.60
			2	3.8	4.0	5.8	2.76	3.68	3.52

Circuit Breaker(CGL)	CB252	1m	3	2.4	1.8	3.2	3.40	3.80	3.08
			4	2.8	2.6	3.2	3.48	3.76	3.64
		1.8m	1	4.2	3.8	5.2	4.28	4.72	4,32
			2	6.8	5.6	7.2	3,88	4,52	4.16
			3	4.2	3.2	4.8	4.16	4.84	4.92
			4	4.4	3.6	4.6	3.80	4.44	4.05
Current Transformer	2CT	1m	1	1.6	2.3	1.7	3.28	3.84	2.40
			2	1.3	0.7	1.2	3.96	3.72	2.96
			3	1.6	0.9	1.5	3.24	3.96	3.68
			4	1.6	1.6	1.9	3.56	3.96	3.60
		1.8m	1	2.9	2.8	3.5	3.96	4.52	3.84
			2	1.8	1.7	2.2	4.48	4.64	4.44
			3	1.8	1.5	1.8	3.60	4.42	4.48
			4	2.0	2.5	2.8	4.32	4.88	4.56
400 kV Isolator	289 B	1m	1	1.3	1.2	1.6	2.32	2.92	2.36
			2	1.7	1.5	1.7	2.48	2.32	3.80
			3	1.6	2.2	1.3	2.48	2.08	3.00
			4	1.2	0.8	1.0	2.86	3.44	3.82
		1.8m	1	2.0	2.1	2,8	3.76	4.00	3.42
			2	2.1	2.2	2.8	4.32	3,44	4.36
			3	2.6	2.6	2.0	3.20	4.60	3.12
			4	2.2	1.2	1.4	4.68	4.36	5.32
315MVA 400/220/33 kV Power Transformer	689L			1m Height			1.8m Height		
		ICT2 HV Side	1 R	1.0		4.20	2.5		6.44
			2 Y	0.3		6.36	1.8		7.84
			3 B	0.4		8.48	1.9		11.2
		ICT2 MV Side	4 R	0.2		9.44	1.3		12.4
			5 Y	0.3		12.4	1.3		17.2
			6 B	0.2		10.0	1.5		14.8
		LVSide	7 R	0.2		4.84	0.8		5.04
			8 Y	0.1		4.60	1.0		5.36
			9 B	0.3		4.68	0.9		4.96

ii. 400 kV Bhiwadi sub-station (Equipment connected in Bhiwadi - Hissar feeder)

The load particulars recorded during the measurement of electric and magnetic field strengths are as shown in Table 4.23 below:

Table 4.23: ***Load data during measurements of field strength around the periphery of equipment***

Time	Load Particulars	
	Voltage in kV	Load in MW
11:00 AM	410	31

12:00 Noon	413	15
01:00 PM	420	77
02:00 PM	411	118
03:00 PM	412	47

The electric and magnetic field strengths measured around the periphery of the sub-station equipment connected to Bhiwadi -Hissar feeder at 1 m&1.8m above the ground level and 1 m away from the equipment are shown in Tables 4.24. The weather parameters during the measurement were as under: Temperature: 23^{0}C and Relative Humidity: 41 %

Table 4.24: ***Field strengths around the periphery of equipment connected in Bhiwadi-Hissar feeder***

Name of the Equipment	ID No of the equipment	Height In meter	Location No	Electric field, kV/m			Magnetic field, μT		
				R	Y	B	R	Y	B
Lightning Arrester	13LA	1m	1	2.6	1.8	2.3	0.452	0.548	0.608
			2	3.4	1.9	2.8	0.432	0.452	0.512
			3	3.0	1.8	2.4	0.420	0.560	0.596
			4	2.6	1.4	2.1	0.420	0.548	0.496
		1.8m	1	4.1	2.8	3.9	0.508	0.556	0.620
			2	4.4	2.6	3.6	0.484	0.584	0.564
			3	4.2	2.6	3.4	0.476	0.604	0.636
			4	4.2	2.4	2.9	0.436	0.572	0.536
Capacitor voltage transformer	13CVT	1m	1	2.4	2.6	2.6	0.952	0.944	0.724
			2	3.6	2.6	2.3	0.948	1.24	0.864
			3	4.3	2.2	2.5	1.12	0.960	0.820
			4	4.0	2.4	2.8	0.900	0.804	0.620
		1.8m	1	4.8	4.1	3.8	1.040	0.984	0.828
			2	4.2	4.4	2.9	1.280	1.320	0.934
			3	4.6	3.8	2.9	1.440	1.160	0.888
			4	5.6	3.6	3.4	0.992	0.936	0.732
Wave trap	13WT	1m	1	2.2	2.0	Not Present	1.44	1.32	Not Present
			2	3.0	1.9		1.56	1.36	
			3	3.6	2.3		1.56	1.48	
			4	2.6	2.2		1.36	1.36	
		1.8m	1	4.2	2.8		2.02	1.96	
			2	3.8	2.5		2.16	2.00	
			3	4.8	3.4		2.04	1.96	
			4	4.2	3.2		1.84	1.92	
HCB disconnector with one earth	1389	1m	1	2.4	1.6	2.2	1.40	1.60	1.12
			2	2.5	1.7	1.6	1.52	1.64	1.60
			3	3.0	2.1	1.6	1.40	1.52	1.40
			4	2.6	2.0	1.6	1.68	1.80	1.20

switch		1.8m	1	3.4	2.6	2.6	1.64	2.04	1.44
			2	3.3	2.2	2.2	1.72	1.96	1,76
			3	3.8	2.6	2.4	1.44	1.92	1,60
			4	4.4	3.6	2.6	2.08	2.04	1.36
HCB disconnector with one earth switch	1389	1m	1	1.0	1.7	2.4	1.56	1.36	1.40
			2	2.2	1.9	2.8	1.28	1.24	1.12
			3	1.0	1.4	2.1	1.72	1.50	1.44
			4	1.4	2.3	2.4	1.84	1.64	1.44
		1.8m	1	1.5	2.7	3.8	1.72	1.60	1.640
			2	3.2	2.9	4.8	1.56	1.40	1.440
			3	1.6	1.8	3.0	1.88	1.64	1.520
			4	1.6	2.6	3.4	2.24	1.92	1.680
Circuit Breaker(BHEL)	CB1352	1m	1	1.6	1.2	2.4	0.648	0.776	1.44
			2	3.2	1.8	2.4	0.604	0.752	1.04
			3	2.4	1.6	1.8	1.08	0.748	0.832
			4	2.2	1.6	2.4	1.12	0.936	1.20
		1.8m	1	2.2	3.0	3.8	0.668	0.784	1.640
			2	4.2	2.8	3.2	0.692	0.832	1.240
			3	3.2	2.0	2.2	1.200	0,824	0.896
			4	2.4	2.6	3.4	1.260	1.120	1.320
Current Transformer (BHEL)	13CT	1m	1	2.1	1.6	2.6	1.12	0.768	0.736
			2	1.8	1.6	2.2	1.12	1.872	0.560
			3	3.1	1.8	2.2	1.16	0.880	0.636
			4	3.2	2.1	3.0	1.24	0.880	0.680
		1.8m	1	4.1	2.3	4.8	1.240	1.040	0.836
			2	3.2	2.2	3.4	1.240	1.040	0.740
			3	3.4	2.6	2.7	1.440	1.040	0.780
			4	4.8	3.1	3.6	1.440	1.080	0.796
HCB disconnector with one earth switch	1489A	1m	1	1.9	1.6	2.4	1.12	1.24	0.820
			2	1.8	2.2	2.8	1.76	1.44	1.42
			3	2.1	2.0	2.1	0.944	1.20	0.892
			4	2.1	2.4	2.5	1.24	1.24	1.24
		1.8m	1	2.7	2.6	2.8	1.520	1.480	0.992
			2	4.0	3.4	3.4	2.000	1.88	1.640
			3	3.3	2.4	2.8	1.130	1.680	1.240
			4	4.4	3.8	3.2	1.560	1.560	1.320
Circuit Breaker(BHEL)	CB1452	1m	1	2.0	1.4	2.8	1.40	1.36	1.16
			2	3.5	2.2	2.6	1.28	1.40	1.20
			3	3.2	1.8	1.7	1.40	1.36	1.36
			4	2.6	1.6	2.4	1.44	1.44	1.36
		1.8m	1	2.6	2.8	3.4	1.760	1.640	1.480
			2	4.2	3.2	3.6	1.640	1.720	1.440
			3	3.6	2.4	2.4	1.640	1.840	1.640
			4	3.6	2.4	3.6	1.640	1.720	1.640
			1	2.0	1.8	2.4	1.72	1.56	1.28

Current Transformer (BHEL)	14CT	1m	2	2.6	1.6	2.4	1.52	1.76	1.36
			3	3.2	2.2	2.2	1.44	1.84	1.40
			4	2.6	2.2	3.0	1.56	1.64	1.24
		1.8m	1	3.6	3.2	4.4	2.160	2.040	1.480
			2	3.2	2.6	3.4	2.040	2.080	1.640
			3	3.6	2.6	2.8	1.840	2.240	2.440
			4	3.4	3.2	4.2	1.800	2.040	1.560

4.4.7 Measurement in 400 kV substations- *400 kV Hyderabad (D type) sub*-station

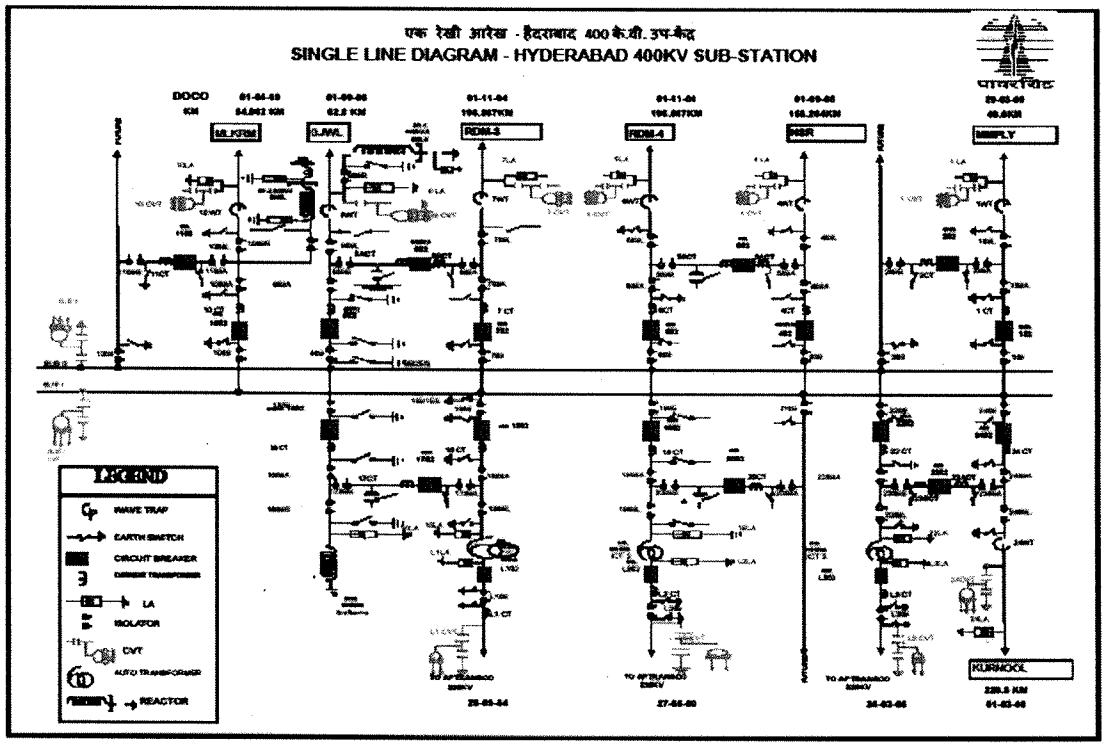


Figure 4.10: ***Single line diagram of 400 kV Hyderabad sub-station***

i. 400 kV Hyderabad sub-station (Equipment connected in Hyderabad-Ramagundam Ckt-4feeder)

The load particulars recorded during the measurement of electric and magnetic field strengths are as shown in Table 4.25 below:

Table 4.25: ***Load particular for Hyderabad Substation***

Time	Load Particulars	
	Voltage in kV	Load in MW
11:00 AM	417	320

12:00 Noon	416	320
01:00 PM	417	320
02:00 PM	419	320
03:00 PM	418	320
04:00 PM	418	330

The electric and magnetic field strengths measured around the periphery of the sub-station equipment connected to Hyderabad - Ramagundam circuit-4 feeder at 1 m&1.8m above the ground level and 1 m away from the equipment are shown in Tables 4.26. The measurements were done in all four directions of the equipment viz. location 1: East, location 2: South, location 3: West and location 4: North. In case of power transformer, location 1, 2 & 3 are near HV side, location 4, 5 & 6 near IV side and location 7 is near LV side. The weather parameters during the measurement were as under: Temperature: 30 to 34° C and Relative Humidity: 48 to 52 %

Table 4.26: ***Field strengths around the periphery of equipment connected in Hyderabad - Ramagundam feeder-4***

Name of the Equipment	ID No of the equipment	Height In meter	Location No	Electric field, kV/m			Magnetic field, μT		
				R	Y	B	R	Y	B
Lightning Arrester	6 LA	1m	1	3.5	1.8	2.1	5.28	4.64	3.04
			2	3.8	2.1	2.2	5.24	4.32	3.08
			3	4.3	2.3	2.6	5.32	4.08	2.92
			4	4.2	2.0	2.4	5.28	4.64	3.04
		1.8m	1	5.6	3.2	3.04	5.32	4.64	3.08
			2	5.6	3.8	3.08	5.52	4.96	3.24
			3	7.2	3.2	2.72	5.56	4.64	2,92
			4	5.8	2.8	2.40	5.72	4.48	2.48
Capacitor voltage transformer	6CVT	1m	1	3.5	2.4	2.2	6.84	5.36	3.32
			2	3.6	2.3	1.9	8.20	5.84	3.92
			3	3.7	5.2	2.1	8.08	7.04	3.32
			4	3.3	2.1	2.1	7.28	5.80	3.28
		1.8m	1	5.9	4.6	4.7	7.24	5.64	3.36
			2	4.3	4.2	3.7	8.64	6.68	4.44
			3	5.6	5.5	3.6	9.64	8.44	4.60
			4	4.8	4.2	4.2	8.28	6.12	3.32
Wave trap	6WT	1m	1	2.9	1.4	Not Present	11.6	9.64	Not Present
			2	3.0	2.0		12.8	10.8	
			3	2.2	1.8		12.4	11.6	

			4	2.4	2.3		11.2	10.4	
		1.8m	1	5.1	3.7		13.6	11.6	
			2	5.6	4.2		14.8	13.2	
			3	4.3	3.7		13.6	13.2	
			4	5.2	3.8		14.4	12.4	
HCB disconnecto r with one earth switch	689L	1m	1	3.0	1.6	1.8	12.4	6.68	6.68
			2	3.8	1.9	1.6	7.40	6.80	6.80
			3	3.2	2.4	2.1	7.86	7.04	7.04
			4	2.1	2.0	1.8	8.04	5.38	5.38
		1.8m	1	4.5	3.0	3.0	14.8	12.2	8.40
			2	4.8	3.1	2.8	8.4	10.8	8.44
			3	4.3	3.8	4.3	10.8	10.4	8.08
			4	2.8	2.8	2.9	9.6	10.4	6.52
Current transformer	6 CT	1m	1	1.2	0.6	0.8	6.48	5.28	5.16
			2	1.9	1.1	0.8	5.56	5.32	5.42
			3	1.0	1.1	1.3	6.08	4.96	5.24
			4	1.3	1.2	1.3	5.80	4.08	4.64
		1.8m	1	2.3	1.5	2.1	7.32	6.28	6.36
			2	3.6	2.3	2.0	6.56	6.28	6.52
			3	2.9	2.5	2.9	7.16	6.04	5.96
			4	2.5	2.8	2.8	6.64	6.44	5,36
Circuit Breaker	CB-652	1m	1	3.8	1.6	2.3	5.96	4.96	4.76
			2	3.4	1.9	2.6	4.76	5.20	5.08
			3	3.7	2.6	2.0	5.96	5.08	5.04
			4	3.1	2.2	2.3	5.16	4.16	4.32
		1.8m	1	6.6	4.3	5.9	6.52	5.76	5.92
			2	6.2	4.9	5.2	5.88	6.24	6.04
			3	6.7	4.6	5.6	6.64	5.88	5.84
			4	5.9	4.5	5.8	5.96	5.92	5.20
Below the Bus Bar	Bus Bar II	1m	1	7.0	3.6	5.7	5.8	5.92	5.1
		1.8m	1	8.2	5.1	6.9	6.72	7.32	6.42
HCB disconnecto r with one earth switch	1989L	1m	1	3.0	1.6	1.8	5.28	4.64	3.04
			2	3.8	1.9	1.6	5.24	4.32	3.08
			3	3.2	2.4	2.1	5.32	4.08	2.92
			4	2.1	2.0	1.8	5.28	4.64	3.04
		1.8m	1	3.8	2.7	4.5	3.82	2.96	4.12
			2	4.5	1.1	1.4	3.20	2.60	3.40
			3	3.4	2.5	2.6	3.56	3.72	3.56
			4	1.4	1.1	3.4	2.92	3,00	3.60
Circuit Breaker	CB1952	1m	1	3.6	2.1	3.1	2.8	2.84	2.92
			2	3.8	1.6	2.6	3.2	2.68	2.84
			3	3.5	1.4	2.8	2.96	2.68	2.84
			4	2.5	1.8	2.8	2.76	2.36	2.76
			1	5.8	4.4	5.1	3.32	3.36	3.44

		1.8m	2	6.4	4.4	4.5	3.52	3.28	3.56
			3	6.8	3.8	5.8	3.48	3.44	3.28
			4	5.1	3.3	5.6	3.24	3.12	3.44
Current Transformer	6CVT	1m	1	2.4	2.0	1.4	3.12	2.92	3.04
			2	2.4	1.3	1.4	3.04	2.88	2.92
			3	1.5	1.0	1.4	3.28	2.92	2.88
			4	1.8	1.5	2.2	2.92	2.96	2.92
		1.8m	1	4.6	3.4	3.4	3.60	3.76	3.60
			2	4.5	2.9	2.8	3.64	3.64	3.68
			3	2.6	2.2	2.2	3.80	3.68	3.64
			4	2.8	2.6	3.6	3.60	3.68	3.70
Lightning Arrester	6LA	1m	1	2.2	1.7	2.0	5.64	6.88	5.20
			2	2.3	2.1	2.2	5.04	6.88	5.68
			3	1.7	1.5	2.3	5.28	6.84	5.16
			4	2.3	1.9	2.4	5.84	6.92	4.84
		1.8m	1	4.5	3.4	3.8	6.32	7.68	6.04
			2	4.4	3.1	3.4	5.68	7.80	6.68
			3	2.8	2.8	3.4	6.28	7.76	5.96
			4	3.8	2,8	3.3	6.56	7.72	5.84
315MVA 400/220/33 kV Power Transformer	689L	ICT2 HV Side		1m Height			1.8m Height		
			1	0.2	9.84		0.8	11.6	
			2	0.5	13.2		1.2	14.4	
			3	0.6	7.84		1.2	12.0	
		ICT2 MV Side	4	0.6	17.6		1.0	27.6	
			5	0.2	23.2		0.8	34.8	
			6	0.2	19.2		0.8	27.6	
		LV Side	7	0.3	16.0		0.7	16.0	

ii. **400 kV Hyderabad sub-station (Equipment connected in Hyderabad-Nagarjunasagar feeder)**

The load particulars recorded during the measurement of electric and magnetic field strengths are as shown in Table 4.27 below:

Table 4.27: ***Load data during measurements of field strength around the periphery of equipment***

Time	Load Particulars	
	Voltage in kV	Load in MW
10:00 AM	415	120
11:00 AM	415	120

12:00 Noon	416	90
01:00 PM	417	100

The electric and magnetic field strengths measured around the periphery of the sub-station equipment connected to Hyderabad - Nagarjunasagar feeder at 1 m&1.8m above the ground level and 1m away from the equipment are shown in Tables 4.28. The weather parameters during the measurement were as under: Temperature: 30^0C and Relative Humidity: 46 %

Table 4.28: ***Field strengths around the periphery of equipment connected in Hyderabad-Nagarjunasagar feeder***

Name of the Equipment	ID No of the equipment	Height In meter	Location No	Electric field, kV/m			Magnetic field, μT		
				R	Y	B	R	Y	B
Lightning Arrester	6 LA	1m	1	1.72	2.2	2.1	1.72	2.32	2.10
			2	1.56	2.0	2.6	1.56	2.30	2.48
			3	1.68	2.0	2.5	1.68	2.56	2.52
			4	1.76	1.9	2.2	1.76	2.40	2.44
		1.8m	1	4.8	3.5	6.8	1.84	2.68	2.52
			2	5.4	2.8	5.8	1.84	2.60	2.72
			3	4.5	2.8	4.6	1.88	2.84	2.64
			4	4.2	3.6	5.8	1.96	2.68	2.64
Capacitor voltage transformer	4CVT	1m	1	2.7	2.1	3.2	1.96	2.68	2.44
			2	2.6	2.2	3.5	2.08	2.68	2.76
			3	2.6	1.8	2.8	2.48	2.96	2.48
			4	3.3	2.0	3.4	2.48	2.92	2.72
		1.8m	1	5.8	3.6	8.4	2.24	3.08	2.84
			2	5.4	3.4	5.8	2.44	3.20	3.04
			3	5.4	3.4	6.4	3.00	3.44	2.76
			4	4.6	3.2	6.8	2.76	3.24	2.88
Wave trap	4WT	1m	1	2.2	Not Present	3.0	4.04	Not Present	2.76
			2	2.8		2.0	4.08		3.28
			3	1.8		1.9	4.28		3.04
			4	2.5		3.1	4.32		2.64
		1.8m	1	5.8		5.8	5.08		3.28
			2	5.8		4.4	5.20		4.04
			3	5.1		4.2	5.72		3.72
			4	3.9		5.2	5.60		3.12
HCB disconnector with one earth	489L	1m	1	2.4	1.1	1.8	3.98	3.84	3.24
			2	3.2	1.6	1.8	3.08	3.80	3.68
			3	2.2	1.4	2.1	3.24	4.42	3.98
			4	2.2	1.2	2.1	3.64	4.28	3.08
		1.8m	1	4.8	2.1	5.0	4.92	4.80	3.92

switch			2	5.6	2.4	3.2	3,50	4.88	4.48
			3	5.1	2.9	3.2	3.96	5.48	4.72
			4	3.7	2.4	3.4	4.32	4.96	3.44
Current transformer	4 CT	1m	1	1.1	0.7	1.0	2.56	2.12	2.52
			2	1.1	1.1	1.1	5.64	1.96	2.36
			3	2.1	1.8	2.2	2.40	2.04	2.52
			4	1.4	1.2	2.0	2.20	2.16	2.40
		1.8m	1	2.3	1.5	1.9	3.12	2.88	3.28
			2	3.8	1.8	2.8	3.08	2.56	3.16
			3	2.6	3.2	3.2	3.16	2.80	3.22
			4	2.4	1.8	3.2	2.88	2.88	2.96
Circuit Breaker	CB-452	1m	1	1.2	0.8	1.4	2.36	2.12	2.44
			2	0.9	1.4	0.7	2.20	1.84	2.36
			3	1.2	1.0	1.8	2.76	1.76	2.68
			4	1.0	1.2	1.7	1.84	1.96	2.40
		1.8m	1	4.2	2.5	3.4	2.76	2.52	3.12
			2	4.4	2.5	1.7	2.96	2.36	3.04
			3	4,2	2.8	3.5	2.96	2.48	3.12
			4	3.2	2.4	4.2	2.32	2.64	2.84
Below the BusBar	Bus Bar II	1m	1	5.3	4.6	7.2	4.12	5.56	5.92
		1.8m	1	6.5	5.6	8.3	5.28	6.84	7.68
HCB disconnector with one earth switch	1989L	1m	1	2.2	1.8	2.1	2.82	1.72	2.58
			2	1.5	1.2	1.8	2.08	1.76	2.60
			3	3.2	1.7	2.2	2.72	2.04	2.60
			4	1.6	1.4	1.6	1.76	1.96	2.60
		1.8m	1	3.4	2.4	3.5	3.12	2.32	3.16
			2	2.2	2.0	2.2	2,20	2.12	3.12
			3	4.6	2.3	3.2	2.84	2.52	3.68
			4	2.4	1.8	2.6	1.92	2.36	3.16

FIELD MEASUREMENTS FOR 765 KV VOLTAGE LEVEL

Electric & Magnetic field intensity measurements were carried out at 765kVAC Transmission lines & Seoni Substation. For transmission lines, the measurements were carried out at 5 kms, 10 kms & 100 kms distance from Seoni substation. Brief details of the measured values are given here. All these measured values were comparable to ICNIRP limits.

i. Measurement of electric and magnetic fields of Sipat - Seoni 765 kV AC transmission line ckt 2 at 10 kilometer away from the substation

Table: 5.1

Date	Location	Between Tower Nos.	Conductor
16/09/2008	Bandal - Kalarbaki Road	915 - 916	Quadruple Bersimis

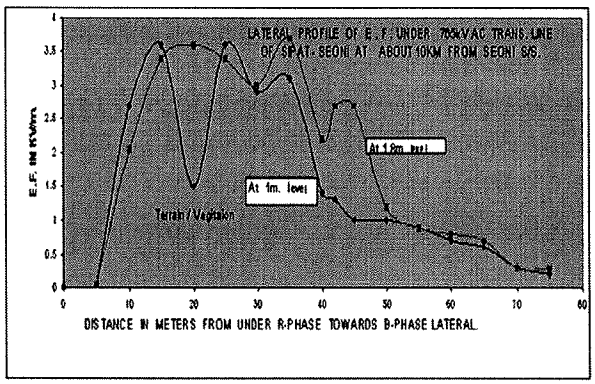
Table: 5.2

Time	Temp In ° C	RH In %	Wind velocity	Line Voltage in kV			Line Current In Amps (A)			Load In MW
3.40 pm	32.00	60%	6 kmph	R	Y	B	R	Y	B	630
				766	764	763	463	483	478	

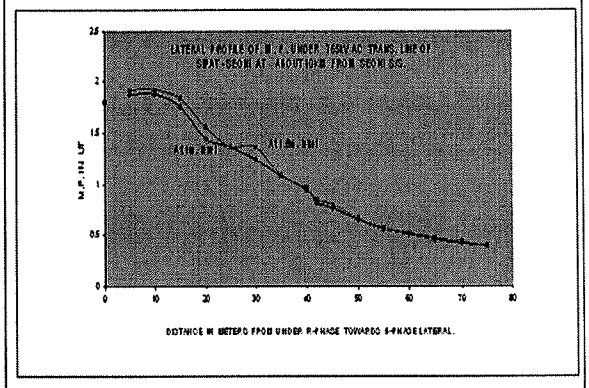
Table 5.3: Lateral profile at tower No. 915 [towards south].From under tower center, lateral to B - phase line

Location of measurement (Below B-phase Tower 915)	Electric field E F - in kV / m (Ref. graph 1)		Magnetic field M F - in μ T (Ref. graph 2)	
Lateral to Tower no. 915	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
0 metre (below center of the tower)	0.00	0.00	1.80	1.80
5	0.03	0.04	1.88	1.92
10	2.70	2.04	1.88	1.92
15	3.6	3.4	1.76	1.84
20 (vegetation)	1.5	3.6	1.44	1.56
25	3.6	3.4	1.36	1.36
30	2.9	3.00	1.24	1.36
35	3.1	3.7	1.08	1.09
40* *1-2kV/m. dist.	1.41	2.2	0.94	0.96

42* *ROW from tower centre either sides of trans. Lines.	1.30	2.7	0.82	0.85
45	1.0	2.7	0.77	0.80
50	1.0	1.2	0.65	0.67
55	0.9	0.9	0.56	0.57
60	0.7	0.8	0.51	0.52
65	0.6	0.7	0.46	0.47
70	0.3	0.3	0.42	0.44
75	0.2	0.3	0.40	0.40



Graph 5.1: Electric field profile of 765 kV AC trans. line at tower no. 915



Graph: 5.2 Magnetic field profile of 765 kV AC trans. line at tower no. 915

Longitudinal profile of trans. line, Below B-phase conductor, from tower no. 915 – 916

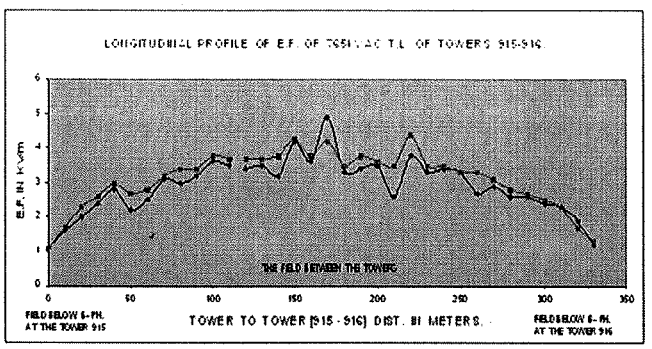
Table: 5.4

Date / Time	Temp In ° C	RH In %	Wind velocity	Line Voltage in kV			Line Current in Amps.			Load In MW
				R	Y	B	R	Y	B	
16-09-08 5.00 pm	27.7	70	6 kmph	764	763	761	471	488	487	635

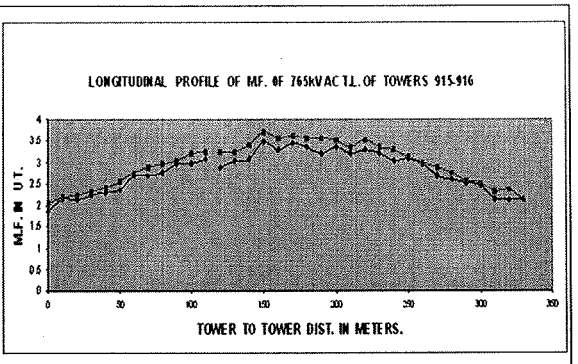
Table: 5.5

Location of measurement Under B- phase line Along the line	Electric field (E F) in kV / m (Ref. graph 3)		Magnetic field (M F) in μ T (Ref. graph 4	
Between	At 1.00	At 1.80	At 1.00	At

From Tower nos. 915 - 916	metre height	metre height	metre height	1.80 metre height
0 m Below B-phase	1.1	1.1	1.88	2.04
10	1.6	1.7	2.16	2.20
20	2.0	2.3	2.12	2.24
30	2.4	2.6	2.24	2.32
40	2.8	3.0	2.30	2.40
50	2.2	2.7	2.36	2.56
60	2.5	2.8	2.68	2.76
70	3.1	3.2	2.68	2.88
80	3.0	3.4	2.76	2.96
90	3.2	3.4	2.96	3.04
100	3.6	3.8	2.96	3.20
110	3.5	3.7	3.08	3.24
120	3.4	3.7	2.88	3.24
130	3.5	3.7	3.04	3.24
140	3.2	3.8	3.08	3.40
150	4.2	4.3	3.48	3.72
160	3.6	3.8	3.28	3.56
170	4.9	4.2	3.44	3.64
180	3.3	3.5	3.36	3.56
190	3.4	3.8	3.20	3.56
200	3.5	3.6	3.36	3.52
210	2.6	3.5	3.20	3.36
220	3.8	4.4	3.28	3.52
230	3.3	3.5	3.20	3.36
240	3.4	3.5	3.04	3.28
250	3.3	3.3	3.08	3.12
260	2.7	3.3	2.96	3.00
270	2.9	3.1	2.68	2.88
280 (near tower 916)	2.6	2.8	2.6	2.76
290	2.6	2.7	2.52	2.56
300	2.4	2.5	2.48	2.52
310	2.3	2.3	2.16	2.32
320	1.9	1.7	2.12	2.36
330	1.2	1.3	2.12	2.12



Graph: 5.3 E .F. Longitudinal profile between towers



Graph 5.4:M .F. Longitudinal profile between towers

Tower No. 915 – 916 of Y – phase line, field values.

Table: 5.6

Date	Location	Between Tower Nos.	Conductor
17/09/2008	Bandal – Kalarbaki Road	915 – 916	Quadruple Bersimis

Table: 5.7

Time	Temp. in° C	RH in %	Wind velocity	Line Voltage in Kava			Line Current in Amps.			Load MW
				R	Y	B	R	Y	B	
11.15 am	31.00	65	6kms/hr.	766	764	763	463	483	478	630

Table:5.8 Lateral profile of tower no. 915 – 916 of Y – phase line field values

Location of measurement	Electric field E F - in kV / m		Magnetic field M F - in μ T	
Between Tower nos. 915 – 916	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre eight
0 metre	3.2	3.3	308	3.32
5	2.8	2.9	3.36	3.64
10	2.1	2.3	3.64	3.76
15	2.7	3.1	3.64	3.76
20	4.2	4.5	3.48	3.56
25	4.3	4.7	3.00	3.24
30	4.1	4.2	2.44	2.64
35	2.5	2.8	1.84	2.00
40	2.0	2.1	1.56	1.68

42	1.9	1.9	1.40	1.52
45	1.6	1.6	1.28	1.32
50	1.1	1.2	1.08	1.08
55	0.8	0.9	0.89	0.92
60	0.6	0.7	0.76	0.77

Table: 5.9 Measurement from R-phase [centre phase] towards Y-phase from terrain & on road

Location of measurement	Electric field E F - in kV / m		Magnetic field M F - in μ T	
Between Tower nos. 915 - 916	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
0 metre(R - Phase Center)	2.0	2.2	3.4	3.76
5	2.7	2.8	3.32	3.4
10	3.3	3.5	3.04	3.12
15	3.5	3.8	2.68	2.80
20	3.3	3.5	2.36	2.44

Table 5.10: E & M field measurement in between towers 899 -900

Date	Location	Between Tower Nos.	Conductor
17/09/2008	Interior Fields At Towers 899 - 900	899 - 900	Quadruple BERSIMIS

Table: 5.11

Time	Temp in ° C	RH in %	Wind Velocity	Line Voltage in kV			Line Current in Amps.			Load MW
				R	Y	B	R	Y	B	
3.20 pm	34.00	65	6 kms/ hr	768	-	-	452	-	-	610

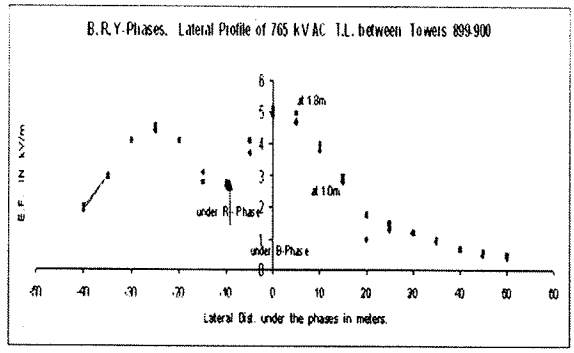
Table 5.12: Measurements from B – phase – U/L

Location of measurement	Electric field (E F) in kV / m		Magnetic field (M F) in μ T	
Between Tower nos. 899 - 900	At 1.00m height	At 1.80 m height	At 1.00 m height	At 1.80 m height
U/L R phase (height 34.28 mts) U/L- under the line	2.30	260	4.04	4.48
B & R phase center	4.0	4.2	4.04	4.28
U/L B-Ph centre 0 metre	4.9	5.4	3.68	3.84

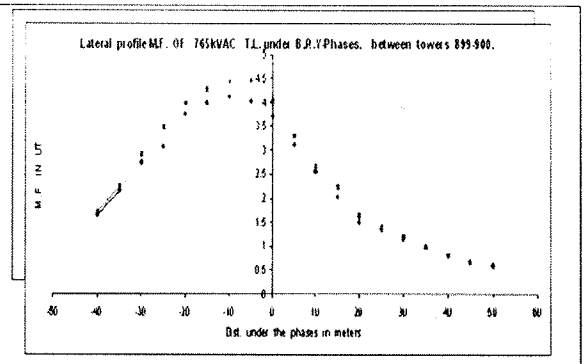
B-Phase Lateral				
5	4.7	5.2	3.24	3.44
10	4.3	4.4	2.40	2.64
15	2.9	3.1	1.92	1.96
20	2.1	2.2	1.60	1.64
25	1.5	1.6	1.28	1.36
30	1.1	1.2	1.04	1.08

Table 5.13: Lateral profile under B, R, and Y -Phases between tower no. 899- 900

Location of measurement	Electric field (kV/m) (Ref. graph 5)		Magnetic field (μ T) (Ref. graph 6)	
Between Tower nos. 899 – 900 lateral - either side	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
-40m	1.9	2.0	1.64	1.72
-35m	3.0	3.0	2.16	2.24
-30m	4.1	4.1	2.76	2.92
-25m	4.4	4.6	3.08	3.48
U/L Y phase, -20m Height 19.00 mts	4.1	4.1	3.76	4.00
-15m	3.1	2.8	4.00	4.28
U/L R phase, -10m Height 34.31 mts	2.7	2.8	4.12	4.44
-5m	3.7	4.1	4.04	4.48
U/L B- phase, 0 m. Height 18.4 mts	4.9	5.1	3.72	4.04
5m	4.7	5.0	3.12	3.32
10m	3.8	4.0	2.56	2.68
15m	2.8	3.0	2.04	2.24
20m	1.0	1.8	1.52	1.64
25m	1.3	1.5	1.36	1.40
30m	1.2	1.2	1.16	1.2
35m	0.9	1.0	0.98	0.99
40m	0.7	0.7	0.8	0.82
45m	0.5	0.6	0.68	0.68
50m	0.4	0.5	0.61	0.61



Graph 5.5 : E.F. Lateral profile



Graph: 5.6 M.F lateral profile

Table5.14: Profile measurements either side of Trans. Lines at 40m from the centre span towards tower 900

Location of measurement	Electric field (kV/m)		Magnetic field	
lateral - either side	At 1.00 metre height	At 1.80 metre height	At 1.0 m Height	At 1.80 metre height
-60	0.7	0.8	0.91	0.93
-50	1.3	1.3	1.28	1.28
-45	1.8	1.9	1.48	1.48
-40	2.3	2.5	1.8	1.88
-35	3.0	3.2	2.08	2.20
-30	3.80	4.0	2.56	2.60
-25	4.30	4.60	3.12	3.40
U/L Y phase, -20 height. 20.3 mts	3.80	4.30	3.48	3.8
-15	2.90	3.2	3.76	4.32
U/L R phase, -10 height. 34.44mts	2.40	2.60	4.00	4.24
-5	3.60	3.80	3.80	4.12
U/L B phase, 0 height. 18.95 mts	4.7	5.2	3.60	3.88
5	4.8	5.2	3.04	3.4
10	4.1	4.3	2.68	2.72
15	3.1	3.2	2.04	2.20
20	2.2	2.3	1.68	1.72
25	1.6	1.7	1.36	1.40
30	1.1	1.2	1.16	1.16
35	0.9	0.9	0.95	0.95

40	0.7	0.7	0.80	0.70
45	0.4	0.5	0.70	0.70
50	0.4	0.4	0.60	0.60

Table 5.15: Profile measurements either side of Line at 60m from the centre span towards tower 900 Under Y,R,B-Phases

-55	0.8	0.9	0.98	1.00
-50	1.2	1.2	1.2	1.24
-45	1.6	1.8	1.48	1.52
-40	2.2	2.3	1.8	1.84
-35	3.0	3.1	2.12	2.24
-30	3.8	4.0	2.80	2.72
-25	4.20	4.50	3.16	3.32
U/L Y phase, -20 height. 20. mts	3.90	4.20	3.64	3.92
-15	2.0	2.20	3.92	4.16
U/L R phase, -10 height. 33.7 mts	2.4	2.5	3.6	4.4
-5	3.20	3.4	3.92	4.2
U/L B phase, 0m height. 19.54 mts	4.20	4.60	3.44	3.84
5	4.10	4.50	3.08	3.24
10	3.8	4.6	2.68	2.84
15	2.8	3.0	2.08	2.24
20	2.2	2.3	1.68	1.72
25	1.6	1.6	1.40	1.48
30	1.2	1.2	1.16	1.16
35	0.8	0.9	0.93	0.93
40	0.6	0.7	0.78	0.79
45	0.5	0.5	0.67	0.67
50m	0.4	0.4	0.55	0.56

Table 5.16: Profile measurements either side of line at 80m from the centre span towards tower 900 under Y, R, B-Phases

-50	1.0	1.1	1.12	1.16
-45	1.4	1.5	1.4	1.44
-40	1.9	2.0	1.6	1.72
-35	2.60	2.70	1.88	2.00
-30	3.30	3.5	2.52	2.64
-25	3.70	3.9	3.04	3.08
Y-Phase below -20M	3.30	3.7	3.4	3.52
-15	2.50	2.80	3.68	3.84
R- Phase below -10M	2.00	2.4	3.76	3.94
-5	2.90	3.2	3.6	3.84
B-Phase below 0m	3.70	4.2	3.36	3.64

5	4.2	4.4	2.96	3.2
10	3.5	3.9	2.44	2.6
15	2.8	3.0	2.04	2.08
20	2.2	2.3	1.60	1.70
25	1.2	1.3	1.64	1.68
30	0.8	0.9	1.36	1.44
35	0.6	0.7	1.12	1.16
40	0.5	0.6	0.94	0.44
50	0.4	0.5	0.67	0.74

Table 5.17: Profile measurement on either side of at 100m from the centre span towards tower 900 Lateral. Under Y,R,B-Phases

-50	0.9	1.0	0.98	0.00
-45	1.2	1.4	1.28	1.24
-40	1.5	1.7	1.36	1.44
-35	1.7	2.0	1.56	1.68
-30	2.0	2.2	1.84	2.88
-25	1.8	2.1	2.08	2.16
U/L Y phase -20	1.3	1.6	2.2	2.32
-15	0.2	0.2	2.28	2.4
U/L R phase -10 height. 35.07 mts	0.1	0.1	2.24	2.44
-5	0.1	0.2	2.24	2.40
U/L B phase 0	1.0	1.2	2.12	2.16
5	1.5	2.0	1.92	2.78
10	2.0	2.3	1.68	1.88
15	1.7	2.3	1.48	1.68

Table: 5.18

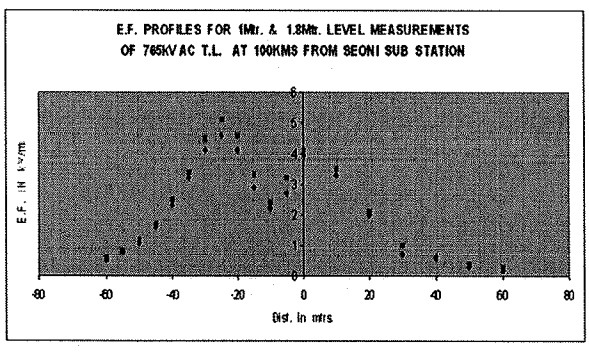
Date	Location	Between Tower Nos.	Conductor
18/09/2008	Chicholi / Mandla (100 Kms away)	717 - 718	Quadruple BERSIMIS

Table: 5.19

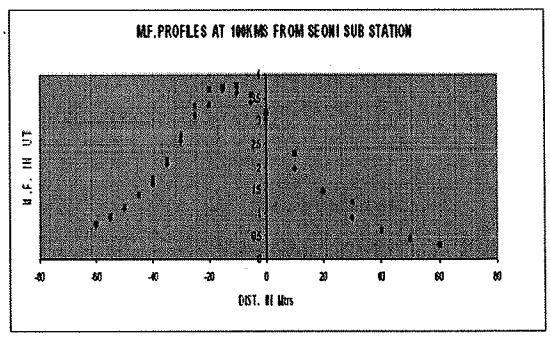
Time	Temp in ° C	Rh in %	Wind Velocity	Line Voltage in kV			Line Current in Amps.			Load MW
				R	Y	B	R	Y	B	
1.00 pm	26.4	89 (After Rain)	6 kms/hr	-	-	-	-	-	-	-

Table: 5.20

Location of measurement On road	Electric field -E F in kV / m (Ref. graph 6)		Magnetic field -M F in μ T (Ref graph 7)	
Between Tower nos. 717-718 Lateral - both sides	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
-60	0.5	0.6	0.77	0.76
-55	0.8	0.8	0.92	0.92
-50	1.1	1.2	1.12	1.12
-45	1.6	1.7	1.4	1.4
-40	2.3	2.5	1.64	1.76
-35	3.2	3.4	2.08	2.16
-30	4.1	4.5	2.56	2.68
-25	4.6	5.1	3.12	3.32
U/L Y phase -20 height.19.04 mts	4.1	4.6	3.36	3.68
-15	2.9	3.3	3.68	3.72
U/L R phase -10 height. 35.07 mts	2.2	2.4	3.6	3.76
-5	2.7	3.2	3.4	3.56
U/L B phase 0m height. 20.59 mts	3.9	4.1	3.02	3.2
10	3.3	3.5	1.96	2.28
20	2.0	2.1	1.48	1.48
30	0.7	1.0	0.9	1.24
40	0.6	0.6	0.62	0.63
50	0.3	0.4	0.46	0.45
60	0.2	0.3	0.33	0.33



Graph 5.6: E.L profiles



Graph 5.7: M.F. Profiles

Measurements at 100 kms from Seoni substation - in fields

Table: 5.21

Date	Location	Between Tower Nos.	Conductor
19/09/2008	Chicholi / Mandla (100 Kms away)	717 - 716	Quadruple BERSIMIS

Table: 5.22

Time	Temp in ° C	Rh in %	Wind velocity	Line Voltage in kV			Line Current in A			Load MW
				R	Y	B	R	Y	B	
1.45 pm	27.5	83	8 kms/hr	768	763	762	396	410	407	531

Table: 5.23

Location of measurement Chicholi / Mandla	Electric field (E F) in kV / m		Magnetic field (M F) in μ T	
Between Tower nos. 717-716 Lateral – either side	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
-60	0.4	0.4	0.40	0.43
-55	0.4	0.5	0.48	0.50
-50	0.6	0.7	0.57	0.57
-45	0.8	0.9	0.65	0.77
-40	1.1	1.1	0.75	0.80
-35	1.3	1.4	0.88	0.92
-30	1.7	1.7	1.08	1.12
-25	1.9	2.0	1.20	1.44
-20	2.0	2.2	1.36	1.44
-15	1.7	1.8	1.56	1.68
-10U/L below Y phase	0.8	1.0	1.52	1.56
-5			1.44	1.56
0 Below tower center	0	0	1.32	1.48
5	0	0	1.44	1.48
10 U/L below B phase	1.1	1.3	1.48	1.60
15	1.8	2.0	1.44	1.48
20	2.0	2.1	1.20	1.24

25	1.9	2.1	1.08	1.16
30	1.7	1.8	0.93	0.99
35	1.3	1.4	0.80	0.83
40	1.1	1.1	0.66	0.69
45	0.9	0.9	0.56	0.58
50	0.6	0.7	0.49	0.50
55	0.5	0.6	0.42	0.43
60	0.4	0.4	0.36	0.36
65	0.3	0.4	0.31	0.32
70	0.3	0.3	0.28	0.27
75	0.2	0.2	0.23	0.24
80	0.1	0.2	0.20	0.20
85	0.1	0.2	0.18	0.18
90	0.1	0.10	0.16	0.17
100	0.1	0.1	0.12	0.13

Field Measurements in 765 kV AC Seoni sub station

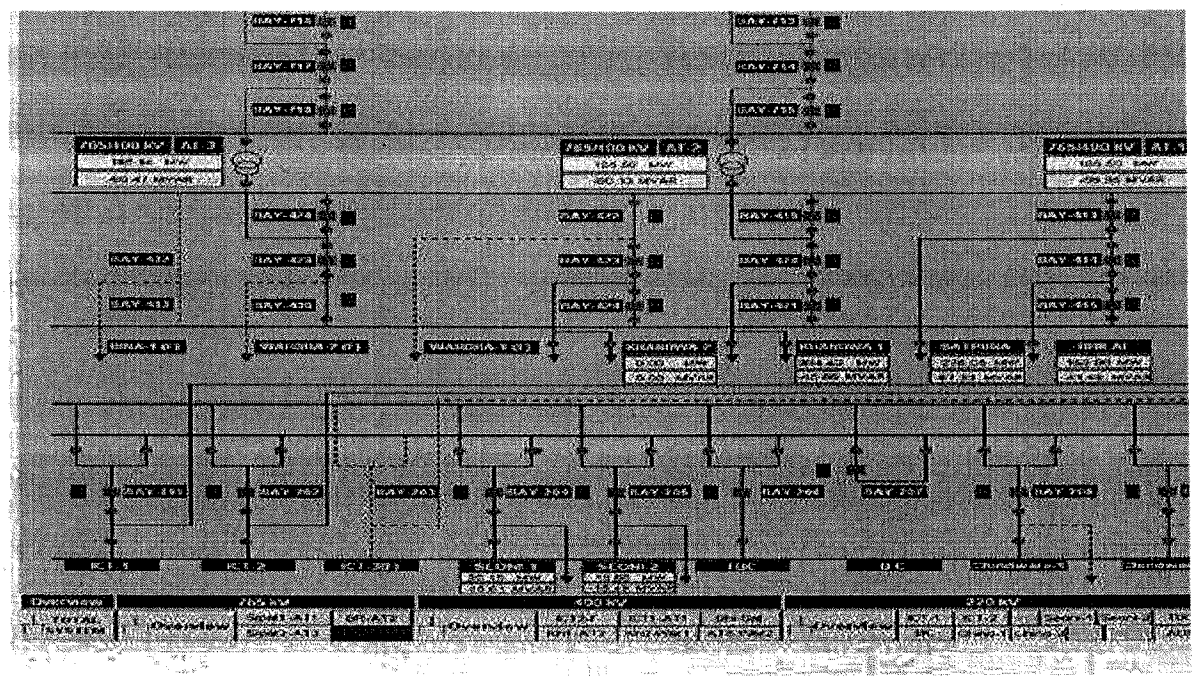


Fig: 5.8 765 k VAC Seoni substation single line diagram

Table: 5.24

Date	Location	Conductor
20/09/2008	765 kV sub station	Quadruple Bersimis

Table: 5.25

Time	Temp in °C	Rh in %	Line Voltage in kV			Line Current in A			Load in MW
11.10 am	30.5	74	R	Y	B	R	Y	B	
			762	762	762	410	-	-	539

Table: 5.26

Location of measurement	Electric field (E F) in kV / m		Magnetic field (M F) in μ T	
765 kV S/S, B PHASE Between [B/N]	At 1.00 metre Height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
B/N Tower & LA in S/S premises U/L	4.5	5.5	2.32	2.68
LA - BPI	5.4	5.7	2.84	2.92
BPI - CVT	5.0	5.7	2.04	3.4
CVT - WT	4.3	5.1	3.56	3.96
WT - ISO	1.7	2.1	4.4	4.96
ISO CENTER	1.5	1.7	3.24	3.32
ISO- GANTRY(GT)	2.8	3.6	3.84	4.04
GT - GT center	1.3	1.4	1.36	1.44
Gantry center U/L	0.9	1.1	1.56	1.68
at Reactor - NGR LA	0.7	1.0	5.32	5.44
At ABB POWER TRANSFORMER	1.5	2.5	3.2	3.64
TR -LA	2.5	3.6	5.6	5.96
LA - BPI On road	5.6	6.1	3.24	3.44
BPI - ISO B 71689R	2.2	2.5	3.00	3.08
ISO CENTER	1.5	1.6	1.8	2.04
ISO -ISO B71689	2.0	2.4	2.08	2.28
AT HIGH CORONA POINT Y - PHASE	1.9	2.2	1.6	1.56
ISO - BPI	5.2	5.5	1.32	1.48
BPI - BPI	3.3	3.5	1.32	1.44
BPI - BPI	2.8	3.0	1.48	1.78
BPI - ISO	2.8	3.10	1.8	2.0
ISO CENTER 71689 A	1.6	1.6	1.12	1.24
ISO - CB	4.3	7.0	1.48	1.72

CB CENTER 71652	2.9	3.3	1.00	1.12
CB - CT	4.7	5.4	1.28	1.52
CT - BPI On road	5.2	5.7	1.24	1.44
BPI - ISO	3.0	3.5	1.36	1.48
ISO CENTER 71689B	1.6	1.8	1.12	1.20
ISO - ISO (GT center)	3.5	4.2	1.96	2.08
ISO CENTER 71789A	1.6	1.7	2.04	2.32
ISO - BPI	3.8	4.3	3.16	3.52
BPI - CB On road	5.6	6.2	3.36	3.68
CB CENTER 71752	3.1	3.3	2.80	2.92
CB - CT	4.4	5.1	3.28	3.48
CT - ISO	2.5	2.9	3.68	3.84
ISO CENTER 71789B	1.7	1.9	2.2	2.32
ISO - ISO near GT	3.4	3.9	2.72	2.88
ISO CENTER 71889B	1.6	1.8	1.84	2.04
ISO -BPI	2.8	3.3	2.48	2.64
BPI - CT On road	4.8	5.4	2.12	2.28
CT - CB	4.9	5.4	2.16	2.40
CB CENTER 71852	2.6	2.9	1.56	1.64
CB - ISO	3.8	4.5	2.12	2.36
ISO CENTER 71889A	1.5	1.6	1.55	1.72
ISO -BPI	2.7	3.1	2.28	2.48
BPI -BPI	2.7	3.0	1.84	1.92
BPI - BPI	3.2	3.6	1.68	1.92
BPI - ISO At drain 71889B	5.2	5.8	1.48	1.56
BPI - ISO At GT	2.1	2.5	1.24	1.54
ISO CENTER 71889A	1.5	1.7	1.97	1.04
ISO -BPI	3.9	4.4	1.16	1.20

BPI - BPI Adj. road	3.5	3.9	1.28	1.29
BPI - LA	3.2	4.5	1.84	1.88
LA - ABB POWER TRANS.	1.2	1.3	2.44	2.72
TRANS CENTER	0.5	0.8	3.68	4.36

Table: 5.27

Date	Location	Conductor
20/09/2008	765 kV SUBSTATION	Quadruple BERSIMIS

Table: 5.28

Time	Temp In ° C	Rh In %	Wind velocity	Line Voltage in kV			Line Current in A			Load In MW
4.00 pm	27.10	81	3.9 Kmph	R	Y	B	R	Y	B	-
				-	-	-	-	-	-	

Table: 5.29

Location of measurement 765 kV S/S B- PHASE	Electric field (E F) in kV / m		Magnetic field (M F) in μ T	
Between BAY Nos. 713, 714 AND 715	At 1.00 metre Height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
HV BUSHING - LA	2.0	3.0	4.84	5.2
LA - BPI road center height 13.65 mts	5.3	5.9	2.80	3.04
BPI - ISO	1.8	2.0	2.40	2.68
ISO center 71389R	1.2	1.4	2.48	1.68
ISO - ISO 71389B	1.8	2.3	1.56	1.60
ISO - BPI	5.8	6.3	0.84	0.88
BPI- BPI shielded	3.4	3.7	1.2	1.36
BPI - BPI shielded	2.4	2.48	1.48	1.68
BPI - BPI	2.2	2.40	1.64	1.76
BPI - ISO(71389A)	1.2	1.3	1.24	1.36
ISO - CB(71352)	3.3	3.8	1.36	1.52
CB center	2.1	2.5	1.2	1.36

CB BOX LEVEL 8 mts level	23.90, 30.00 , 31.00, 36.00, 40.00, ----------			
CB - CT	3.8	4.5	1.4	1.56
CT - BPI On road	4.1	5.4	1.4	1.68
BPI - ISO(71389B)	2.5	8.0	1.6	1.84
ISO CENTER	1.2	1.6	1.04	1.16
ISO-ISO (71389A) at GT	2.9	3.7	1.44	1.72
ISO CENTER	1.2	1.3	1.16	1.32
ISO - BPI	3.0	3.6	1.64	1.86
BPI - CB On road, height 14.4 mts	4.7	5.5	1.52	1.86
CB CENTER	2.4	3.0	1.16	1.24
CB - CT	3.8	4.7	1.40	1.64
CT - ISO 714819B	2.1	2.6	1.44	1.72
ISO CENTER	1.3	1.7	0.92	1.24
ISO -ISO At GT	2.9	3.8	0.96	0.97
ISO CENTER 71589B	1.3	1.6	0.80	0.85
ISO - BPI	2.4	3.1	0.87	0.95
ISO - BPI	2.3	3.2	0.86	0.95
BPI - CT On road	4.2	6.0	0.90	0.97
CT - CB	4.1	5.5	1.08	1.36
CB CENTER	2.2	2.6	0.67	0.75
CB - ISO (71589A)	3.0	4.1	1.28	1.52
ISO CENTER	1.1	1.4	0.96	1.0
ISO - BPI	2.2	2.8	1.68	1.72
BPI - BPI drain	2.5	2.7	1.52	1.56
BPI - BPI shielded	3.2	3.5	1.52	1.64
BPI - BPI On road	5.4	6.2	1.16	1.28
BPI - ISO(71589B)	2.1	2.7	0.97	1.04
ISO CENTER	1.2	1.5	0.78	0.85
ISO - LA	2.8	3.6	0.81	0.82
LA - 400 Kv trans.	0.1	1.0	2.92	3.68

Measurements in the substation [contd.] in bay No. 712 along R-phase

Table: 5.30

Date	Location	Between	Conductor
21/09/2008	765 kV SUBSTATION	S/S EQUIPMENTS	Quadruple BERSIMIS

Table: 5.31

Time	Temp In ° C	Rh In %	Wind velocity	Line Voltage in kV			Line Current in Amps			Load In MW
9.50 am	27.80	84	12 kmph	R	Y	B	R	Y	B	182
				756	754	753	143	148	144	

Table: 5.32

Location of measurement	Electric field -E F in kV / m		Magnetic field -M F in μ T	
Between Bay No. 712 Along R-Phase Equipment	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
ISO - ISO (71289B) Bus height 14.34 mts	2.5	3.10	0.81	0.84
ISO CENTER	1.4	1.7	0.74	0.87
ISO - BPI	2.7	2.2	1.2	1.44
BPI - CT On road	4.7	5.4	1.28	1.36
CT -CB	5.2	5.8	1.28	1.36
CB CENTER 71252	2.8	3.2	0.92	1.00
CB - ISO	4.1	4.8	1.16	1.48
ISO - CENTER 71289A	2.0	2.0	1.36	1.24
BUS ISO 70899	2.5	3.3	0.62	0.58
BUS ISO CENTER Y - PH	1.3	1.9	0.83	0.41
BUS ISO CENTER B - PH (70989) interconnected	1.8	1.9	0.97	1.00
On Road to ISO - GT	1.3	1.6	0.66	0.74
ISO 71289B	1.6	1.0	1.04	1.20
ISO CENTER 71289A	1.3	1.6	0.75	0.88
ISO - LA On road	2.8	2.8	0.84	0.92
LA - below HV Bushing	1.6	2.5	2.48	3.24

Measurements in bayNo.711, along R – phase.[contd.]
Table: 5.33

Location of measurement	Electric field -E F in kV / m		Magnetic field -M F in μ T	
Between Bay No. 711 Along R- Phase Eqpt.	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
ISO 71189B	1.7	1.8	1.48	1.48
ISO - CT	2.5	3.0	2.12	2.36
CT - CB (71152)	2.7	5.1	1.88	2.08

ii. Field measurements in 400 kV AC substation, Seoni

Table: 5.34

Location 400 kV S/S	Electric field (E F) in kV / m		Magnetic field (M F) in μ T	
Between B- Phase Eqmt.	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
LA - BPI Near 400 KV Trans. cooler	2.2	2.5	4.36	5.28
S/S BAY B - Phase	2.4	4.3	0.87	1.08
ISO(42889A) - CB	3.8	5.4	1.44	1.76
CB(42852) - CT On road	5.5	7.0	1.44	1.76
CT - ISO	2.0	2.90	1.40	1.88
ISO CENTER 42889B	3.1	3.5	0.74	1.0
ISO -ISO	4.6	5.7	1.0	1.24
ISO CENTER 42989A	2.0	3.7	1.12	1.88
ISO - CT	1.3	1.7	2.68	2.80
CT - CB (42952) On road	5.3	6.3	2.48	3.16
CB - BPI	4.2	5.4	2.56	2.90
BPI - ISO	2.6	3.7	2.64	2.92
ISO CENTER 42989B	1.3	3.0	1.16	2.12
ISO - ISO On road	0.9	1.1	0.83	0.98
ISO(43089A) - BPI	7.4	8.5	2.4	2.96

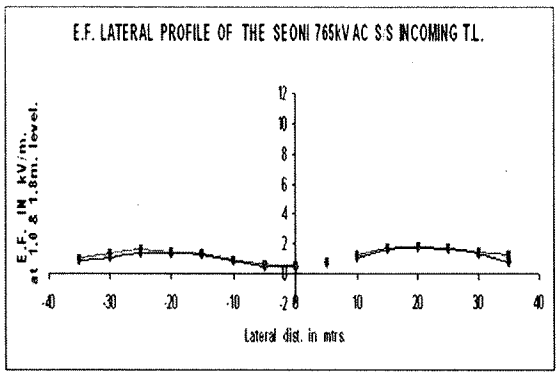
BELOW 400 KV BUS II	2.0	2.2	0.83	0.83

Measurements in 765kV AC Seoni Sub Station [Sipat to Seoni incoming]

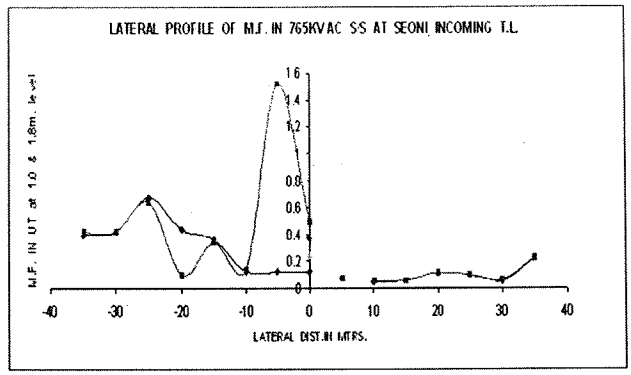
Table: 5.35

Location of measurement	Electric field (kV/m) (Ref. graph 8)		Magnetic field (μ T) (Ref. graph 9)	
Between SIPAT - SEONI INCOMING, Y - PHASE	At 1.00 metre height	At 1.80 metre height	At 1.00 metre height	At 1.80 metre height
INCOMING TO REACTOR THROUGH GANTRIES	1.4	1.6	2.92	3.04
0 metre In Between Line Eqpt. Bay & Main Bay	0.5	0.6	0.37	0.25
5	0.8	0.9	0.08	0.08
10	1.1	1.3	0.05	0.06
15	1.6	1.7	0.06	0.06
20	1.7	1.8	0.12	0.12
25	1.6	1.7	0.10	0.10
30	1.4	1.5	0.06	0.07
35	0.8	1.3	0.23	0.23
ON FENCE TOUCH	11.3		1.16	
-0 Y phase – other side	0.5	0.6	0.13	0.50
-5	0.5	0.7	0.13	1.52
-10	0.9	1.0	0.13	0.14
-15	1.3	1.4	0.36	0.35
-20	1.4	1.5	0.44	0.10
-25	1.4	1.6	0.68	0.64
-30	1.1	1.4	0.42	0.42
-35	0.9	1.1	0.40	0.42

E & M field profiles at Seoni s/s incoming side



Graph: 5.9 EF lateral profile



Graph: 5.10 MF lateral profile

DISCUSSIONS

The profile of field strengths near 400 kV line between Ballabhgarh- Maharanibagh and Greater Noida is smooth as the span was free from external interferences, trees and was a plain stretch. The electric and magnetic field strength was less than 5 kV/m and 5 μT respectively.

The electric and magnetic field strengths near 400 kV Bhiwadi - Agra line are less than 5 kV/m and 6 μT respectively. The span was in field slightly watered and with very small vegetation.

The electric and magnetic field strengths near 400 kV Hyderabad- Ramagundam line are less than 5 kV/m and 5 μT respectively. The span was in dry area with slightly uneven surface between two towers.

The span near 400 kV Ramagundam- Nagarjunsagar line was in uneven field with vegetation in dry condition. The lateral profile measurements were made up to 40 m only on one side of the double circuit line due to presence of mango trees. The electric field and magnetic field strength was less than 5 kV/m and 6 μT respectively

The electric and magnetic field strengths near 400 kV Gooty- Raichur line are less than 5 kV/m and 7 μT respectively. The span was near fields with dry and small vegetation.

The electric filed strengths measured around the periphery of equipment in both the sub-stations were less than 5 kV/m. The magnetic field strengths were less than 10 μT for all equipment in both the sub-stations except near wave-traps and power transformers where it was upto 25 μT.

The electric & Magnetic field for 765 kV Line & Transmission line lies within the permissible limits prescribed by ICNIRP guidelines.

CONCLUSION AND RECOMMENDATIONS

The power transmission lines at EHV & UHV voltage levels generate electric & magnetic field in its vicinity. Researches are going worldwide to ascertain any relation between exposure to Electric & Magnetic field and possible biological effects. However, nothing conclusive has been reported so far.

As POWERGRID is entrusted with the responsibility to transmit power across the length & breadth of the country, it was considered imperative to carryout Electric & Magnetic field measurements emanating from transmission lines. With this objective, the measurements were carried out 400 kV & 765 kV transmission lines and substations. The Electromagnetic field measurement for different type of Transmission line conductor and substation (D-type & I-type) was carried out and compared with ICNIRP limits. Field emanating from Power Transmission Line (ELF Field) is safe compare to high frequency signal [1] in addition to that it was found that measured values were well below the permissible limits prescribed by ICNIRP guidelines.

From the obtained results, it can be concluded that personnel working inside substation or near the transmission line are entirely safe. However, it would be wise to take following precautions even at lower electromagnetic field under high voltage (400kV & 765kV) Lines & substation equipment vicinity:

- Growing trees or grass inside the substation yard and nearby transmission line should be strictly avoided.
- It is not advisable to construct building within right of way for 400kV & 765kV transmission line.
- Effective grounding should be provided for electrical equipment, metallic structure near power line.

REFERENCES

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GLOSSARY

Adverse effect

An effect detrimental to the health of an individual due to exposure to an electric or magnetic field, or a contact current.

Conductivity

A property of materials that determines the magnitude of the electric current density when an electric field is impressed on the material, expressed in units of Siemens per meter (S/m); the inverse of resistivity.

Current density

A vector of which the integral over a given surface is equal to the current flowing through the surface; the mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor, Expressed in ampere per square meter (Am^{-2}).

Electric field

A vector field E measured in volts per meter.

Electric field strength (E)

Force exerted by an electric field on an electric point charge, divided by the electric charge. Electric field strength is expressed in Newton per coulomb or volts per meter (N/C = V/m).

Electromagnetic fields (EMF)

The combination of electric and magnetic fields in the environment. This term is often confused with "electromagnetic radiation" and can therefore be misleading when used with extremely low frequencies for which the radiation is barely detectable.

Electromagnetic radiation

The propagation of energy in the form of electromagnetic waves through space.

Epidemiology

Type of research that tries to find statistical links between the occurrence of specific diseases and people's exposure to possible causes.

Exposure

Exposure occurs wherever a person is subjected to electric, magnetic or Electromagnetic fields or contact currents other than those originating from physiological processes in the body.

Extremely low frequency (ELF)

Extremely low frequency fields include, in this document, electromagnetic fields from 1 to 300 Hz. second.

Ionizing radiation (IR)

Radiation, such as X-rays, which has sufficient energy to break chemical and electrical bonds.

Magnetic field

A vector quantity, H, specifies a magnetic field at any point in space, and is expressed in ampere per meter (Am^{-1}). See also magnetic flux density.

Magnetic field strength (H)

The magnitude of the magnetic field vector; expressed in units of ampere per meter (A/m).

Magnetic flux density (B)

A vector quantity that determines the force on a moving charge or charges (electric current). Magnetic flux density is expressed in tesla (T), One gauss (deprecated unit) equals 10^{-4} T.

Non-ionizing radiation (NIR)

Includes all radiations and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than about 12 eV, which is equivalent to wavelengths greater than 100 nm, or frequencies lower than 3×10^{15} Hz.

Occupational exposure

All exposure to EMF experienced by individuals as a result of performing their regular or assigned job activities.

Public exposure

All exposure to EMF experienced by members of the general public, excluding occupational exposure and exposure during medical procedures.

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भारत सरकार **Government of India**
विद्युत मंत्रालय **Ministry of Power**
केंद्रीय विद्युत प्राधिकरण **Central Electricity Authority**
क्षेत्रीय निरीक्षण संगठन (उत्तर) **Regional Inspectorial Organization(North)**
कमरा सं 328 उ0क्षे0नि0स0 भवन Room No.328, NRPC Building,
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website:www.cea.nic.in, टेली फैक्स: 011- 26510249

संख्या :**NRIO/CEA/Adm/2017/** 548-551 **Dated: 26.03.2018**

To,

Chief Engineer (ES), **Himachal Pradesh State Electricity Board Ltd.** **Hamirpur -177005 (H.P.)**	**Addl. Vice President,** **Parbati Koldam Transmission Co. Ltd.,** **Plot No.-391/04, Bhojpur,** **Sundernagar, Mandi (H.P.) – 175002.**
Shri Y K Dixit **General Manager,** **Corporate Office, Saudamini, Plot No. 2,** **Sector 29, Near IFFCO Chowk,** **Gurugram 122 001.**	

Subject: Measurement of induced voltage at site due to 400kV D/C Parbati Koldam transmission line of Parbati Koldam Transmission Company Ltd.

548/Adm/2018 dt. 26.3.2018

Reference is invited to minutes of the meeting to discuss the issue of induced voltage due to 400kV D/C Parbati Koldam transmission line of Parbati Koldam Transmission Company Ltd. held on 15.11.2017 in the office of Chief Engineer(CEI), CEA. In the meeting, it was decided to send a team of officers from CEA, representative from PGCIL and PKTCL for the measurement of induced voltage at site and HPSEB ltd. to coordinate with the team for the above mentioned measurement.

The proposed measurement of induced voltage at site as mentioned above shall be carried out on 05.04.2018 as proposed by PKTCL. In this regard three officers from CEA are being deputed by Chief Engineer (CEI), CEA. Shri Sunil Kumar Jain, Dy. Director (RIO-North) would be coordinating officer from CEA. Details of the officers from CEA are given below. It is requested to PGCIL and HPSEB to depute their officers for the proposed measurement on 05.04.2018 and send their contact details to coordinating officer at the earliest. Further, HPSEB is requested to coordinate with the team for the cooperation during above measurement.

Detail of CEA Officers:

1. Shri Sunil Kumar Jain, Dy. Director (Contact No. 9718784017)
2. Shri Santosh Kumar, Dy. Drector (Contact No. 08860754509)
3. Shri Mukul Kumar, Assistant Director, CEI (Div.), CEA

Yours faithfully,
P. Khichi 26/3/18
(Prakash Khichi)
Director(RIO-North), CEA

Copy for information to:
1). Chief Engineer, Chief Electrical Inspectorate Division, CEA

Annexure - I

Investigation Report of problems being faced by villagers due to induced voltage from 400 kV D/C Parbati-Koldam Transmission line of PKTCL in Sub –Division Gohar, Distt. Mandi(H.P.)

1. Background

Special Secretary (Power) to the Govt. of Himachal Pradesh vide letter No. MPP-D(1)-3/2017 dated 19.08.2017 addressed to CEA raised the issue regarding problems being faced by villagers of Gohar Sub- Division of Mandi District in Himachal Pradesh due to induced voltage from 400kV D/C Parbati-Koldam transmission line of Parbati Koldam Transmission Co. Ltd (PKTCL). A meeting was taken by Chief Engineer (CEI), CEA with representatives from HPSEBL, PKTCL, PGCIL and RIO(North), CEA to discuss the problems being faced by villagers of Gohar Sub- Division on 15.11.2017.

In the meeting, it was decided to send a team of officers from CEA, representative from PGCIL and PKTCL for physical verification and measurement of induced voltage / electric field at the sites as mentioned in the Investigation Report submitted by the Committee headed by Chief Engineer, Electrical System, HPSEBL. Further, HPSEBL was requested to coordinate with the team for above mentioned measurements. The following three officers from CEA were nominated for the site verification and measurements:

1. Sunil Kumar Jain - Deputy Director(RIO-N),CEA
2. Santosh Kumar - Deputy Director(CEI), CEA
3. Mukul Kumar - Assistant Director(CEI),CEA

2. Electric Field due to transmission lines and its measurement

2.1 Introduction

A power transmission line during its operation emits electric and magnetic field. The strength of the electric and magnetic field depends on their operating voltage and current flowing (line loading) through the line. Equipment operating at high voltage produces comparatively stronger electric fields than the equipment operating at low voltage. Similarly, highly loaded lines produce stronger magnetic field than lightly loaded lines. The electric and magnetic field strength at any point is inversely proportional to square of the distance from the source.

When the exposure levels of electric field and magnetic field generated by HV/EHV substation equipment and transmission lines in their vicinity exceed specified limits, they are likely to have adverse effects on human beings, plants, and animals. Human beings or animals coming in direct contact with electrically isolated objects lying below the HV/EHV equipment or transmission line would experience shocks, which at times may be fatal. Therefore, it is necessary to keep these field levels in the vicinity of HV/EHV equipment & lines within limits. (ROW)

2.2 Exposure limits of Electric Field

Electric field is generated by electric charges. The electric field at any point represents the force exerted on the electric charge due to one another. The strength of an electric field depends on the voltage associated with these charges. The electric field is present around the equipment/conductor due to its operating voltage. High voltage equipment & lines produce comparatively stronger electric fields than low voltage equipment & lines. The field reduces if the equipment is grounded/external conductive objects are present nearby. The magnitude of the AC electric field is expressed in terms of Volts per meter or kV per meter (kV/m).

The electric field generated by the lines is of the same frequency as that of operating voltage of line. The factors which primary influence the electric field strength beneath an overhead transmission line are given below:

a. Actual (rather than the nominal) voltage on the line
b. Height of the conductors above ground (which is influenced considerably by the ambient temperature and heating caused by the current passing through the conductor).
c. Geometric configuration of phase and ground conductor on the towers, and in the case of two circuits in proximity, the relative phase sequencing
d. Proximity of the grounded metallic structure of the tower
e. Proximity of other tall objects (trees, fences, etc.)
f. Distance of point of measurement of electric field from the conductor.
g. Height above ground at the point of measurement
h. Atmospheric conditions (Temperature, humidity, wind speed etc.

International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines are followed in India for designing of transmission line. The electric field continuous exposure limits for general public recommended by ICNIRP are 5kV/m.

2.3 Instrument used (Digital Electric Field Meter)

The Instrument used for the measurement was Digital Electric Field Meter. It is a free body type which had been designed, developed and fabricated in CPRI. The meter measures the power frequency induced charge between two hemispherical electrodes of an isolated conductive body in an Electric field. The incident field on the meter electrodes is directly proportional to kV/m. The free body probe is suitable for survey type measurements. It is portable and does not require a known ground reference. The incident charge Q across the electrodes is directly proportional to the voltage gradient. That is, Q = C V, where C is capacitance of the medium. The Electric field meter has a measurement uncertainty of ±10%.

3. Measurements and Observations

The team visited the affected sites on 05.04.2018 and took several measurements and discussed the problems being faced by the affected villagers.. The measurement of electric field due to 400 kV double circuit Parbati Koldam transmission line, vertical and horizontal clearances from the structures at affected sites were carried out.

All the measurements of electric field were carried out at 1 meter height from the ground level as per IEEE standard 644-1994 guidelines and also, at 1.8 meter from the ground (i.e. at normal human height) to study the effective field intensity levels on human beings. The measurements were carried out in the clear sky weather during 1100 Hrs to 1600 Hrs. The line loading during the period is given in the Table below:

Time / Parameters	1100 Hrs	1300 hrs	1500 hrs	1600 hrs
Circuit-1 :Line voltage(kV)	416	417	416	416
Circuit-1 :Line loading(MW)	5	28	31	21
Circuit-2 :Line voltage(kV)	417	418	417	417
Circuit-2 :Line loading(MW)	16	36	28	19

All sites were on altitudes ranging between 1500m-1700m above MSL.

The site-wise details of the various measurements, observations and conclusions are given below:

(i) Site-1 (Village Saroa)

In village Saroa, it was observed that house of Shri Tulsi Ram was near to tower No. 88 (Construction location No. 82-83) of 400kV transmission line. The various observations taken are as under:-

a. Vertical and Horizontal Clearances

The minimum vertical and horizontal clearance between lowest and nearest conductor of 400kV transmission line and at the edge of the slab/roof of the house are 13.6m and 2.6m respectively. The ground clearance of the lowest conductor is 20m.

b. Electric field measurement

- Electric Field observed at 1 metre height from the roof top surface and horizontally at the nearest point on the rooftop to the nearest conductor was 6.1 kV/m.
- Electric Field observed at 1.8 metre height from the roof top surface and horizontally at the nearest point on the rooftop to the nearest conductor was 5.3 kV/m.

The above observations are summarized below:

Clearances (m) observed from the nearest and lowest conductor of the transmission line and at the edge of the slab/roof of the house *		Minimum clearances (m) requirement as per Reg. 61 of CEA Safety Regulations		Electric Field at 1m height from the roof top surface and horizontally at the nearest point on rooftop to the nearest conductor. (kV/m)	Electric Field at 1.8m height from the roof top surface and horizontally at the nearest point on rooftop to the nearest conductor. (kV/m)
Vertical	Horizontal	Vertical	Horizontal		
13.6	2.6	7.3	5.6	6.1	5.3

* without considering maximum deflection due to sag/wind, etc.

c. Observations

The minimum vertical and horizontal clearances stipulated for 400kV transmission line from any part of the building required as per Central

Electricity Authority (Measure related to Safety and Electric Supply) Regulation 2010(as amended), is 7.3m and 5.6m respectively. In this case minimum vertical clearance as specified in the regulation is being met but horizontal clearance from the nearest conductor is not being met. The Right of Way (RoW) requirement for 400kV transmission line which is 46m (23 m on each side from centre of tower) has not been maintained.

The level of electric field values measured at 1m and 1.8m from rooftop surface and horizontally nearest point on rooftop to the conductor are 6.1kV/m and 5.3 kV/m respectively. The electric field values are higher as compare to ICNIRP values of 5kV/m, due to which static charge accumulation is high on the metallic body, which could conceivably deliver a perceptible shock to a person.

(ii) Site-2 (Village – Sainji)

In village Sainji, it was observed that house of Shri Khindu Ram was near to tower No. 97 (Construction location No. 90-91) of 400kV transmission line. The roof top of the house was covered with CGI sheets in the half portion underneath the line conductors. The earthing of the CGI Sheet rooftop was found to be done at multiple points. The various observations taken at the site are as under:-

a. Vertical and Horizontal Clearances

The minimum vertical clearance between lowest conductor of 400kV transmission line and the rooftop of the house are 7.9m and the house is beneath the transmission line conductor. The ground clearance of the lowest conductor is 11.6m.

b. Electric field measurement

- Electric Field observed at 1 metre height from the roof top surface and horizontally at the nearest point on the rooftop to the nearest conductor was 1.4 kV/m.
- Electric Field observed at 1.8 metre height from the roof top surface and horizontally at the nearest point on the rooftop to the nearest conductor was 2.2 kV/m.

The above observations are summarized below:

Clearances (m) observed from the nearest and lowest conductor of the transmission line and at the edge of the slab/roof of the house *		Minimum clearances (m) requirement as per Reg. 61 of CEA Safety Regulations		Electric Field at 1m height from the roof top surface and horizontally at the nearest point on rooftop to the nearest conductor. (kV/m)	Electric Field at 1.8m height from the roof top surface and horizontally at the nearest point on rooftop to the nearest conductor. (kV/m)
Vertical	Horizontal @	Vertical	Horizontal		
7.9	---	7.3	5.6	1.4	2.2

* Without considering maximum deflection due to sag/wind, etc.
@ Transmission line conductor passes over the house.

c. Observations

The minimum vertical and horizontal clearances stipulated for 400kV transmission line from any part of the building required as per Central Electricity Authority (Measure related to Safety and Electric Supply) Regulation 2010(as amended), is 7.3m and 5.6m respectively. In this case minimum vertical clearance as specified in the regulation is being met but horizontal clearance is not being met as conductor passes over the house. The Right of Way (RoW) requirement for 400kV transmission line which is 46m (23 m on each side from centre of tower) has not been maintained.

The level of electric field values measured at 1m and 1.8m from rooftop surface and horizontally nearest point on rooftop to the conductor are 1.4kV/m and 2.2 kV/m respectively. The electric field values are lower as compare to ICNIRP values of 5kV/m since earthing of the CGI sheet rooftop has been done. However, in the static charge accumulation may be high on the metallic body in absence of earthing, which could conceivably deliver a perceptible shock to a person.

(iii) Site-3 (Village – Bahari)

In village Bahari, it was observed that house of Shri Beli Ram was near to tower No. 129 (Construction location No. 107) of 400kV transmission line. The roof top of the house was covered with CGI sheets in the half portion underneath the line conductors. The earthing of the CGI Sheet rooftop was found to be done at multiple points. The various observations taken at the site are as under:-

a. Vertical and Horizontal Clearances

The minimum vertical clearance between lowest conductor of 400kV transmission line and at the edge of the slab of the house is 8.6m. The house is in close proximity of the transmission line conductor.

b. Electric field measurement

- Electric Field observed at 1 metre height from the roof top surface and horizontally at the nearest point on the rooftop to the nearest conductor was 6.3 kV/m.
- Electric Field observed at 1.8 metre height from the roof top surface and horizontally at the nearest point on the rooftop to the nearest conductor was 3.9 kV/m.

The above observations are summarized below:

Clearances (m) observed from the nearest and lowest conductor of the transmission line and at the edge of the slab/roof of the house *		Minimum clearances (m) requirement as per Reg. 61 of CEA Safety Regulations		Electric Field at 1m height from the roof top surface and horizontally at the nearest point on rooftop to the nearest conductor. (kV/m)	Electric Field at 1.8m height from the roof top surface and horizontally at the nearest point on rooftop to the nearest conductor. (kV/m)
Vertical	Horizontal @	Vertical	Horizontal		
8.6	---	7.3	5.6	6.3	3.9

* Without considering maximum deflection due to sag/wind, etc.
@ House is in close proximity from the transmission line conductor.

c. Observations

The minimum vertical and horizontal clearances stipulated for 400kV transmission line from any part of the building required as per Central

Electricity Authority (Measure related to Safety and Electric Supply) Regulation 2010(as amended), is 7.3m and 5.6m respectively. In this case minimum vertical clearance as specified in the regulation is being met but horizontal clearance is not being met as conductor passes in close proximity from the house. The Right of Way (RoW) requirement for 400kV transmission line which is 46m (23 m on each side from centre of tower) has not been maintained as specified by Ministry of Power , Government of India notification No. 3/7/2015-Trans dated 15.10.2015.

The level of electric field values measured at 1m and 1.8m from rooftop surface and horizontally nearest point on rooftop to the conductor are 6.3kV/m and 3.9 kV/m respectively. The electric field values are higher as compare to ICNIRP values of 5kV/m. These values are influenced due to presence of exposed metallic rods at the roof top slab.

4. Remedial Measures against Induced voltages /currents due to induced electric field

1. Electromagnetic & Electrostatic fields are always present near the transmission lines. In the present case, the proximity of the structure result in the danger of shock by providing conductive path to the charge accumulated due to electric field. A perfect shield cannot be provided against the problem of electric shock, however, it can be reduced to some extent by providing and maintaining adequate, effective, and multiple and distinct earthings at all the affected structures /houses.
2. The horizontal clearance as per CEA (Measure relating to Safety and Electric Supply),2010 (as amended), between the nearest conductor and any part of such building i.e. 5.33 m for 400kV Transmission line shall be maintained.
3. As per CEA (Measure relating to Safety and Electric Supply)2010, an overhead line shall not cross over an existing building as far as possible and no building shall be constructed under an existing overhead line. Where an overhead line passes above or adjacent to any building or part of a building it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line, not less than 7.3m for 400kV line which need to be maintained.
4. Any Structure (whether permanent or temporary) such as buildings , storage sheds, fence parallel to the transmission line are not

permitted in the Right of Way Corridor as per Ministry of Power, Government of India Notification No. 3/7/2015-Trans dated 15.10.2015.

5. Further, it is to mention that any dispute arising may be dealt under the provisions of Section 67 & 68 of ELECTRICITY ACT, 2003 which are reproduced at Annex.

(Sunil Kumar Jain)	(Santosh Kumar)	(Mukul Kumar)
Dy. Director , CEA	Dy. Director , CEA	Assistant Director , CEA

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Annex

***Section* 67 (sub section 3-5) of Electricity Act,2003**

(3) A licensee shall, in exercise of any of the powers conferred by or under this section and the rules made thereunder, cause as little damage, detriment and inconvenience as may be, and shall make full compensation for any damage, detriment or inconvenience caused by him or by anyone employed by him.

(4) Where any difference or dispute [including amount of compensation under sub-section (3)) arises under this section, the matter shall be determined by theAppropriate Commission.

(5) The Appropriate Commission, while determining any difference or disputearising under this section in addition to any compensation under sub-section (3),may impose a penalty not exceeding the amount of compensation payableunder that sub-section.

***Section* 68 (sub section 5 & 6) of Electricity Act,2003**

(5) Where any tree standing or lying near an overhead line or where any structure orother object which has been placed or has fallen near an overhead line subsequentto the placing of such line, interrupts or interferes with, or is likely to interrupt orinterfere with, the conveyance or transmission of electricity or the accessibility ofany works, an Executive Magistrate or authority specified by the AppropriateGovernment may, on the application of the licensee, cause the tree, structureor object to be removed or otherwise dealt with as he or it thinks fit.

(6) When disposing of an application under sub-section (5), an Executive Magistrateor authority specified under that sub-section shall, in the case of any tree inexistence before the placing of the overhead line, award to the person interested inthe tree such compensation as he thinks reasonable, and such person mayrecover the same from the licensee.

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Hazards from Extra High Voltage Lines

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ABSTRACT

Almost in every part of India, a sprawling network of Extra-High-Voltage (EHV), High Voltage (HV) lines have sprung up associated with wide spread of distribution lines. These lines produce EMF and there are areas where EMF so generated is of high intensity as to cause great concern about the health of humans and live stock. This work deals with the measurement of Electro Magnetic Field (EMF) radiation levels by using NFA1000 ^{TM} device so as to locate the areas where levels of Electro Magnetic Field (EMF) have exceeded tolerable limits. Such surveys are essential to take steps to alleviate the short term and long term suffering of people who are exposed to Electro Magnetic Field (EMF) in such areas and also arrive at levels which have to be recommended as limiting values.

NOMENCLATURE

VHF	Very High Frequency
VLF	Very Low Frequency
HV	High Voltage
EHV	Extra High Voltage
EMF	Electro Magnetic Field
EHF	Extremely High Frequency
ELF	Extremely Low Frequency
HFVT	High Frequency Voltage Transients
T	Tesla
Hz	Hertz
mG	milligauss
Kv/m	kilovolts per meter
A	Ampere
kW	kilowatt
Hz	Hertz

1.0 INTRODUCTION

Electricity is very useful, convenient from of energy which is used throughout the world. It is clean, easy to switch on and off at our convenience and can be made to perform a variety of jobs of our needs and it can be made available all the time and even at remote places. In the beginning of electrical age there were a few generating stations and a few transmission times feeding power to cities and these lines were run along areas uninhabited or sparsely habitated and also the HV lines were terminated outside the cities. With more and more developments, the voltage levels of transmission lines have elevated, due to pressure on land people have started living close to transmission lines and substations. Thus they are exposed to EMF due to the power lines and substations and that too at higher levels of exposure. The figure 1 shows the electrical power flow.

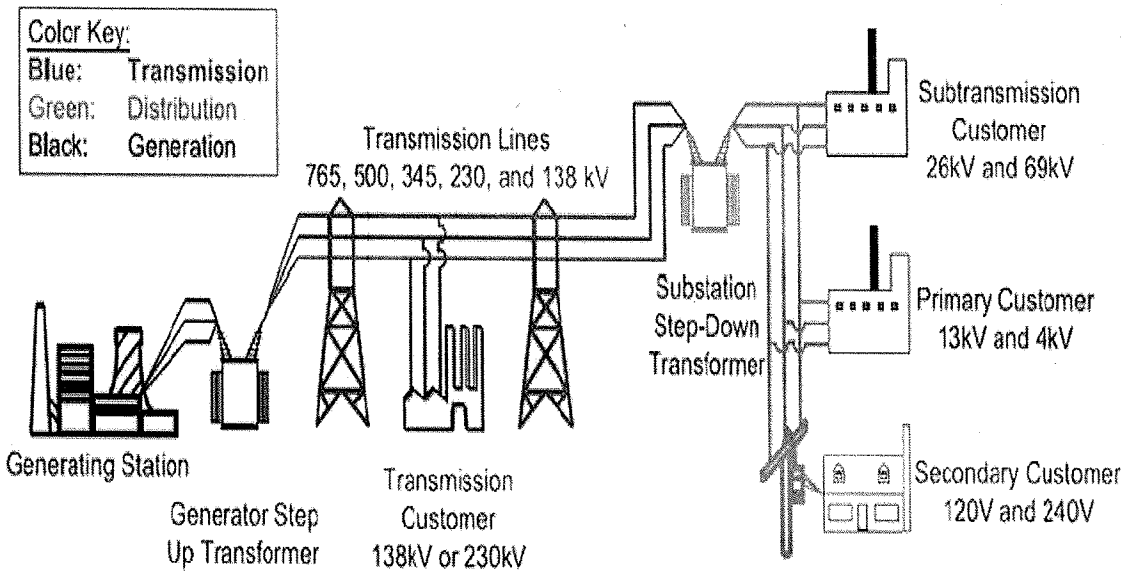

Figure 1 Generation and Transmission of Electric Power

Since the beginning of electrical age through the numerous advantages of using electrical energy became more and more apparent, at the same time the possible dangers associated with electricity was also realized. It was the electric shock that people may be subjected to when they come into contact with a live wire was paramount in the minds of authorities and general public. Precautions and adequate safety measures have been taken to prevent people from getting electric shock as long as they follow simple procedures in use of electricity. Failing to follow rules of use of electricity either by ignorance or by over confidence leads to electric shock. Also there have been cases where fire hazard has taken place in buildings, factories and even at homes due to electric short circuit. This is again due to improper wiring, using substandard materials, overloading the system etc... Which may lead to short circuit. Loose connections can lead to localized sparks and if flammable materials are in the vicinity of such sparks, fire can take place. Though the hazard from electric shock was much recognized and precautionary and safety measures were followed, what were not realized are the hazards due to electric and magnetic fields associated with the use of electricity [11]. As prosperity of people has increased, they are

using more and more equipments rum by electricity at homes, offices and factories. In the beginning electricity was used at homes to light a few lamps that too for a few hours during night. Then a typical home may be drawing a current of 1A or less. Nowadays, homes have connected load of 5kW and above and draw currents of 15A and above such currents flowing inside the homes create magnetic fields of levels 10 to 20 times what it was during a few decades ago. The case of offices and commercial places, malls are no different. Heavy currents are involved consequently elevated levels of magnetic fields are encountered. Though these facts are brought to notice of authorities they have not changed the allowable limits of electric and magnetic fields at low frequencies (i.e.. 50Hz and harmonics).

ICNIRP (International committee for Non-ionizing Radiation Protection) has given a guide line of field's exposure at 50 Hz to be limited to 1000 mg. this was recommended to avoid any possibility of electric shock to people exposed to EMF fields. This is still followed in India in-spite of overwhelming evidence of hazards of exposure to men and animals at much lower levels for longer duration. So there is an urgent need to make authorities and general public aware of the hazards of electric and magnetic fields at low frequencies so that reasonable levels based on the latest research studies is stipulated. This chapter deals with the nature of electric and magnetic fields, how they affect human health, and the levels of this fields limited by advanced countries.

To give an idea of electric and magnetic fields prevailing in our country, results of a survey conducted in and around Bangalore are included. According to ICNIRP there is no place on earth which is free from electric and magnetic fields. According to RCEP (Royal commission for environmental pollution) setting environmental threshold for safe electric and magnetic fields is very difficult. The really safe level of exposure to 50 Hz fields is zero. An after deliberating on the aspects cited above, levels for electric and magnetic fields, which are practical and reasonably safe as recommended by various researchers is included.

1.1 Nature of Electric and Magnetic fields

Whenever the voltage is applied to the conductor an electric field is produced around it. The conductor voltage affects the area surrounding the conductor as shown in figure 1.1. The strength of an electric field depends on two specifications — Applied voltage on the conductor and the distance from the conductor. The magnitude of an electric field is measured in kilo volts per metre.

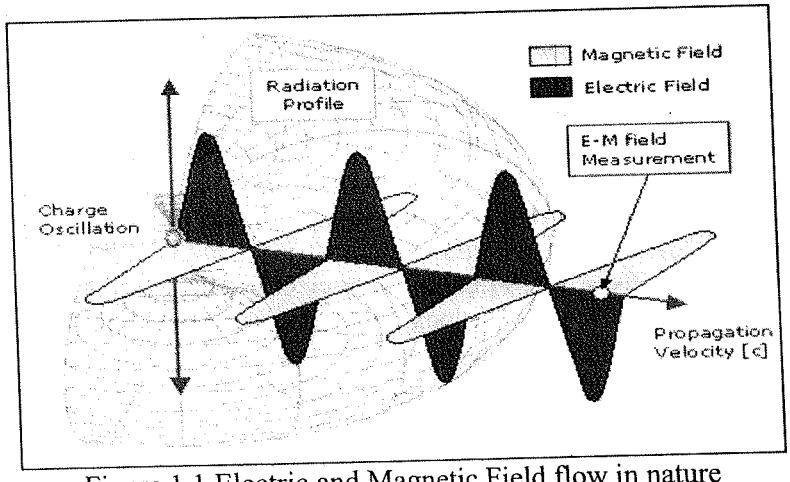

Figure 1.1 Electric and Magnetic Field flow in nature

1.1.1 Electric fields: whenever a source of electric voltage is there, then an electric field is associated with it all round. The intensity of the field is proportional to the voltage level and decreases according to inverse square law as we move away from the source.
Any electrical wire that is charged will produce an electric field. This field exists even when there is no current flowing, as long as the wire is held at a higher potential with respect to ground. The strength of electric field is measured as volts per meter (V/m) or in kilovolts per meter (kV/m). Electric fields are weakened by objects like trees, buildings and vehicles. Burying power lines can eliminate human exposure to electric field from this source.

1.1.2 Magnetic fields: magnetic fields result from the motion of the electric charge or current, such as when there is current flowing through a power line or when an appliance is plugged in and turned on. Appliances plugged in but not turned on do not produce magnetic fields. magnetic fields lines run in circles around the conductor (i.e.. produces magnetic induction on objects and induced currents inside human and animal bodies causing possible health effects and a multitude of interference problems) the higher the current, the greater the strength of the magnetic field. Magnetic fields are typically measured in Tesla (T) or more commonly, in gauss (G) and milligaus (mg). One Tesla equals 10,000 gauss and one gauss equals 1000 milligaus.

1.1.3 Electromagnetic field: The strength of an Electro Magnetic Field (EMF) decreases significantly with increasing distance from the source. Electric field part of an EMF can easily be shielded. As the strength of an electric field is proportional to the voltage, the field under a HV transmission line is greater than under a distribution line. Magnetic field strength, by contrast, is proportional to current in the lines, so that a low voltage distribution line with a high current load may produce a magnetic field that is as high as those produced by some high voltage transmission lines.

Electric field under a high voltage line is constant as the voltage in the line does not change but the magnetic field keeps on changing depending on the load current being carried by the line. In fact, electric distribution systems account for a far higher proportion of the population's exposure to magnetic fields than the larger and more visible high voltage transmission lines.

Magnetic field part of the EMF can penetrate stone, steel and human flesh. In fact, when it comes to magnetic fields, human flesh and bones has the same penetrability as air. Both fields are invisible and perfectly silent: people who live in an area with electric power, some level of artificial EMF is surrounding them. The magnetic field strength produced from a transmission line is proportional to load current, phase to phase spacing and the inverse square of the distance from the line. Many studies have been made to study the effect of different parameters on the produced magnetic field such as the distance from the line, the conductor height, line shielding, and the transmission line configuration and compaction. Extremely high voltages in EHV lines cause electrostatic effects where as short circuit currents and line loading currents are responsible for electromagnetic effects. The effect of these electrostatic fields is seen prominent with living beings like humans, plants, animals along with vehicles, fences and buried pipes under and close to the lines.

1.2 Line configuration and compaction

- Line compaction means bringing the conductors close together keeping the minimum (safe) phase to phase spacing constant. Keeping all the parameters the same and vary only the phase –

to-phase spacing. The magnetic field is proportional to the dimensions of the phase-to-phase spacing. Some studies have shown that increasing the distance between phases by increasing the height of the central phase conductor above the level of the other phase conductors leads to reduction of the peak value of the magnetic field. Reducing the phase-to-phase distance leads to the decrease of the magnetic field. This reduction between phases is limited by the electrical insulation level between phases.

- For single circuit lines, compaction causes a great reduction to the maximum magnetic field values. This reduction of magnitude field allows for lower conductor heights above the ground. This leads to transmit the same power on shorter towers thus a reduction in the cost is achieved.

- For double circuit lines, some studies showed that the use of optimum phase arrangement causes a drastic reduction to the maximum magnetic field values.

A detailed study and research is needed to establish the convincing evidence that exposure to extremely low frequency (50Hz) EMF emanated by HV lines is associated with detrimental health problems. In Indian cities there has not been a growth of power lines and distribution lines, many times there has been not in an orderly way. So there is necessity to study the EMF field in cities and locate high risk areas.

- Where further epidemiological studies may be undertaken to find the occurrences of field related health problems. In this direction a survey was made by electrical engineering department of Jain University and the highlights of which is included as a case study of a typical Indian city.

2. PRESENT SCENARIO

People living near HV power lines are subjected to electric and magnetic fields. Electric field produced directly related to the voltage level of the power line and to the distance of the people living close to it [14]. Magnetic field is related to the amount of current passing in the line. Though magnetic fields are employed in magnetic therapy they are of low intensity but when high intensity levels are present they can cause severe health problems [12].

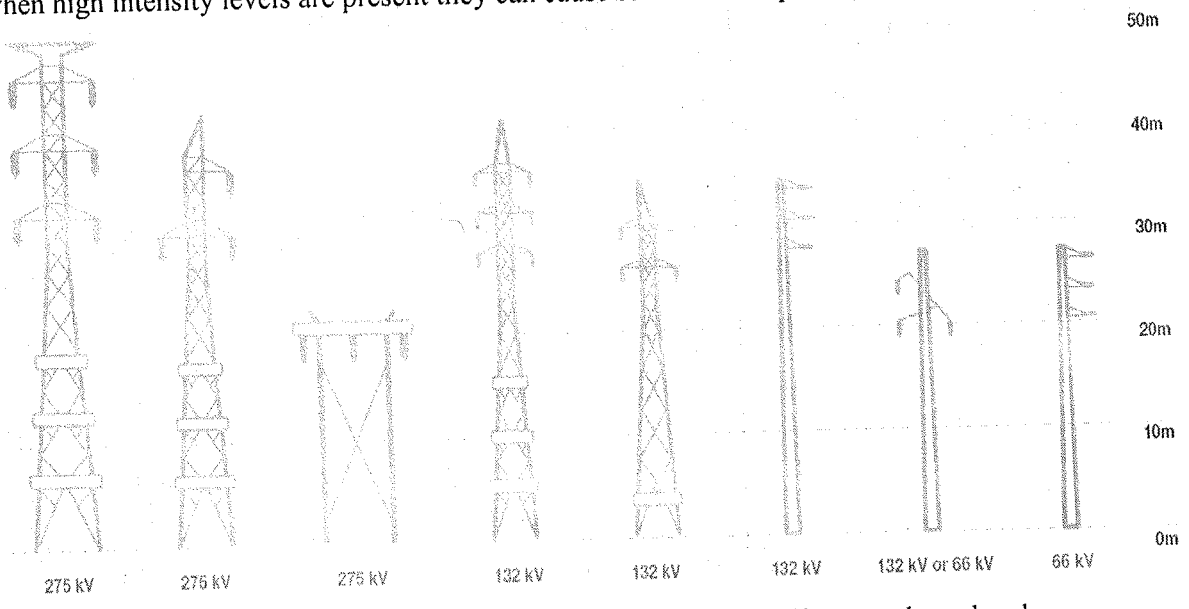

Figure 2 Extra-High-Voltage Transmission lines for different voltage level

In greater Bangalore EHV lines of 132 kV, 220 kV and 400 kV are running and residential areas have come up in the vicinity of these lines and surprisingly more such areas are coming up and getting closer to the lines and ROW. Figure 2 shows extra high voltage transmission lines for different voltage levels. As a first observation areas where buildings have come up under EHV lines and ROW are considered for measurements. IE rules, 1956, Rule 77(4) stipulates the minimum permissible ground clearance as follows. But one can see, though the lines are drawn to maintain the above clearances in Table 1, structures have come up close to EHV lines, the effective clearances have shrunk to a great extent causing serious concern [19]. Areas are found in bangalore to have housed buildings near or under HV lines. Such areas are high risk locations and so measurements have been made in such areas. Effects of EMF fields on human beings, live stock and plants over short term and long term effects.

TABLE 1 : Ground clearance with voltage level

Sl. No.	Voltage level	Ground clearance (m)
1.	≤ 33 kV	5.20
2.	66 kV	5.49
3.	132 kV	6.10
4.	220 kV	7.01
5.	400 kV	8.84

3.0 MEASUREMENTS OF EMF FIELD IN AND AROUND BANGALORE

The electricity is mainly generated at the remote locations of a country. The generated power is to be transmitted from remote location to the residential areas [1]. Therefore the generated power is transmitted through over head lines with support of the transmission towers. Since the first large scale generation of power and supply to general public by Edison in 1882, we have come a long way in achieving great progress in generation and utilization of electric power which has enormously increased the quality of human life and greatly responsible for industrial and commercial growth. This great beneficial progress is associated with some problems which have to be urgently addressed.

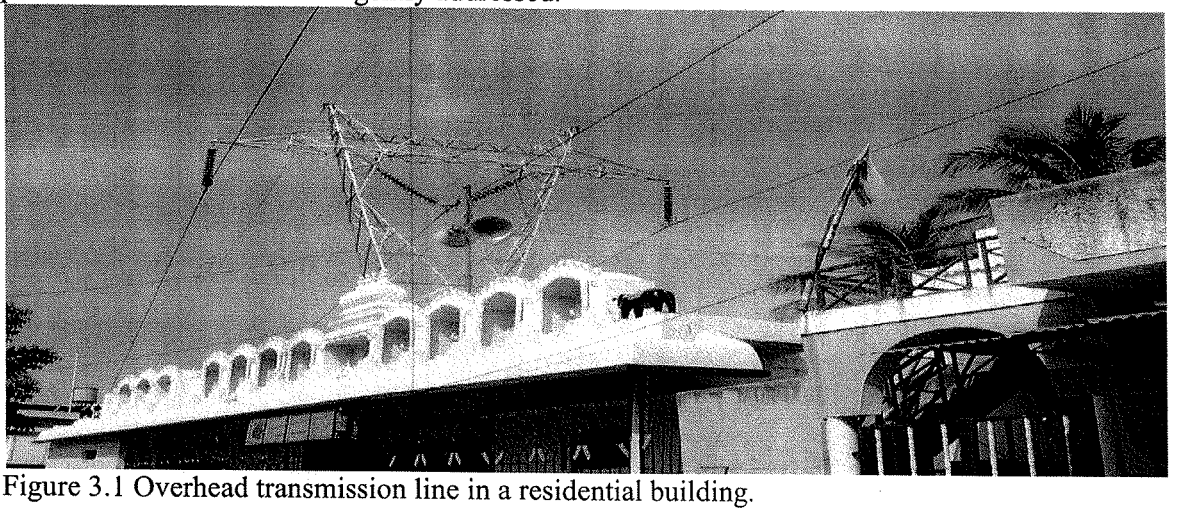

Figure 3.1 Overhead transmission line in a residential building.

For efficient transmission of power it has to be transmitted at high and EHV lines which produce EMF which is inheritable. Since last few decades, this was not considered as a problem as the HV lines were running through forest and agricultural land which were not habitated by people. But due to increase of population people have started living close to HV lines which is a matter of concern [2, 3] for example as shown in figure 3.1 and 3.2. There is no awareness among people about the ill effects of continuous exposure to EMF and many authorities also need to be appraised. In such a situation it is essential to take proper survey of the existing areas near HV lines in and around cities like Bangalore to locate areas which are exposed to dangerous levels of EMF [4, 5]. Also the paper enlists the health hazards due to exposure to EMF fields as published in various research publications and WHO.

A series of concentrated effort is required from academicians and medical fraternity to appraise the general public and authorities to create due awareness about the above pressing problem. The measurement made in this investigation and presented along with the related health risk is one such attempt in the above campaign [7, 17]. It may be realized that a lot of efforts by various agencies took several decades before the injurious health effect of smoking could be universally accepted and remedial measures being taken. Such efforts are needed to save people from injurious effects of exposure to dangerous levels of EMF by taking suitable remedial measures.

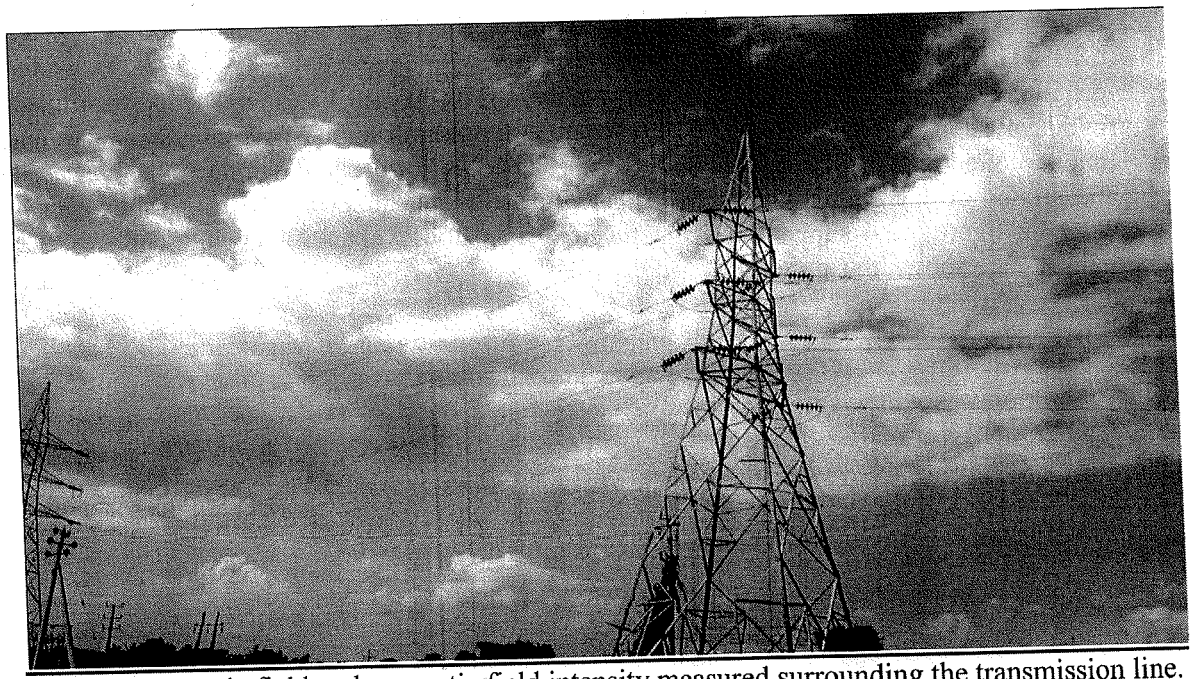

Figure 3.2 Electric field and magnetic field intensity measured surrounding the transmission line.

3.1 Methodology

This procedure is used to receive the signals from power lines to measure the levels of electric field (V/m) and magnetic fields (T) are shown in figure 3.1.1. The available radio frequency (RF) signals from 50 Hz to more than 2 kHz in free space were collected and recorded in the NFA1000 ™ device as shown in Fig 3.1.1. The radiation level present in the radio frequency signals is loaded to the NFA1000 ™ device which is analyzed by using NFA software. The survey covered around the transmission lines which are spread over in various parts of Bangalore. The survey was conducted thrice and the best readings were plotted using the software.

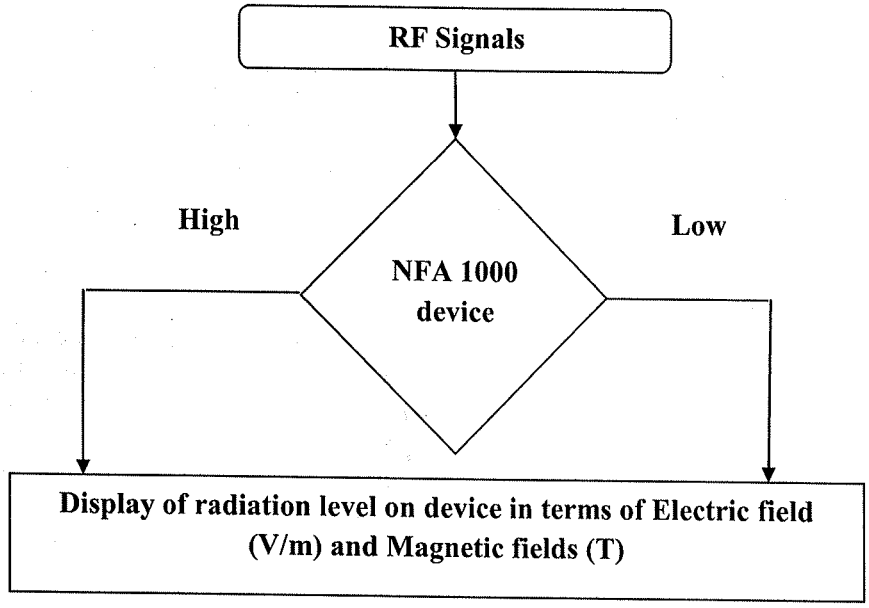

Figure 3.1.1 Measurement of radiation level

3.2 EMF fields measurements

In figure 3.2.1, shows the magnetic field intensity level of 220 kV line. The average magnetic field level is observed was 213.67 nT (2.136 mG) and the variation of the level in and around the line is plotted and in figure 3.2.2 shows the electric field intensity. Similarly the survey under and around 66 kV line conducted and the result 0.36 mG magnetic field are shown in figure 3.2.3. In figure 3.2.4 shows the magnetic field intensity level of 132kV line and electric field intensity are shown in figure 3.2.5.

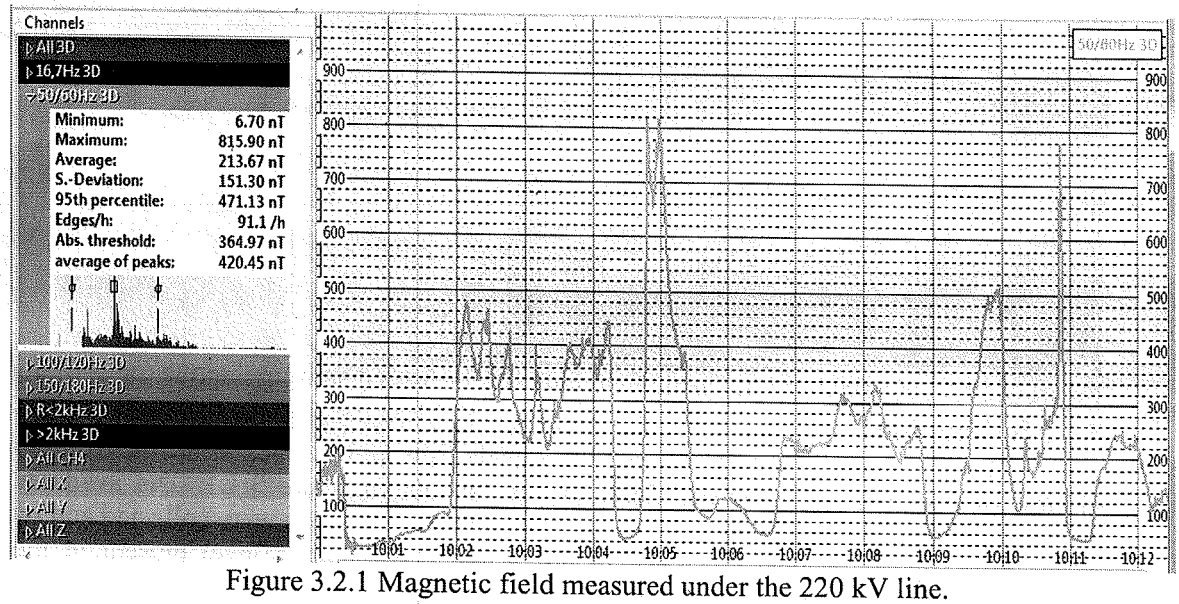

Figure 3.2.1 Magnetic field measured under the 220 kV line.

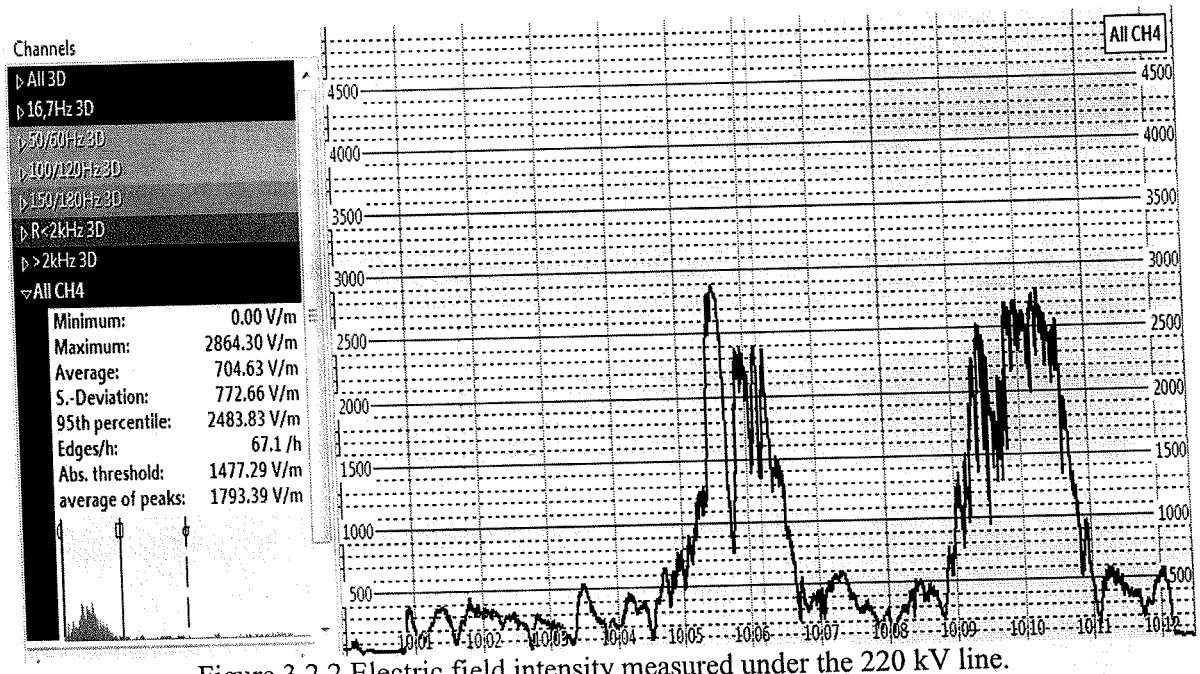

Figure 3.2.2 Electric field intensity measured under the 220 kV line.

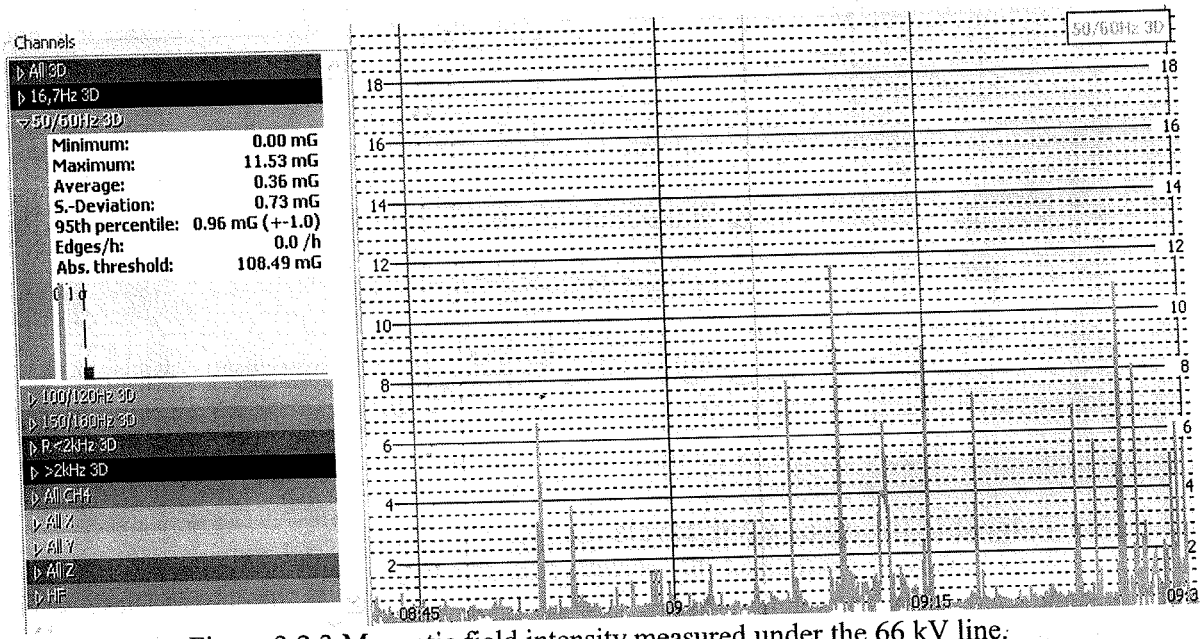

Figure 3.2.3 Magnetic field intensity measured under the 66 kV line.

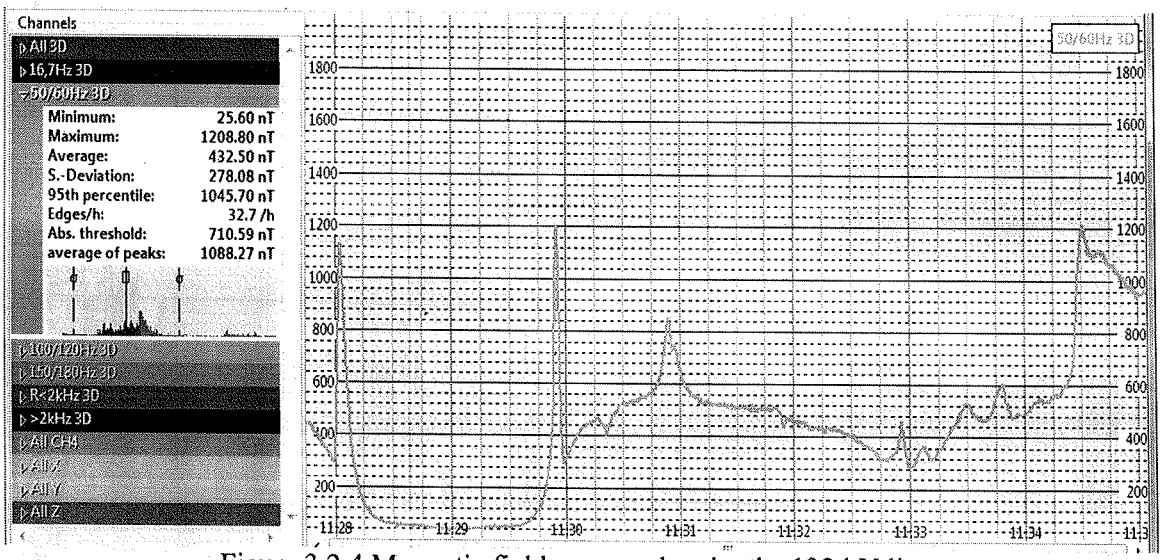

Figure 3.2.4 Magnetic field measured under the 132 kV line.

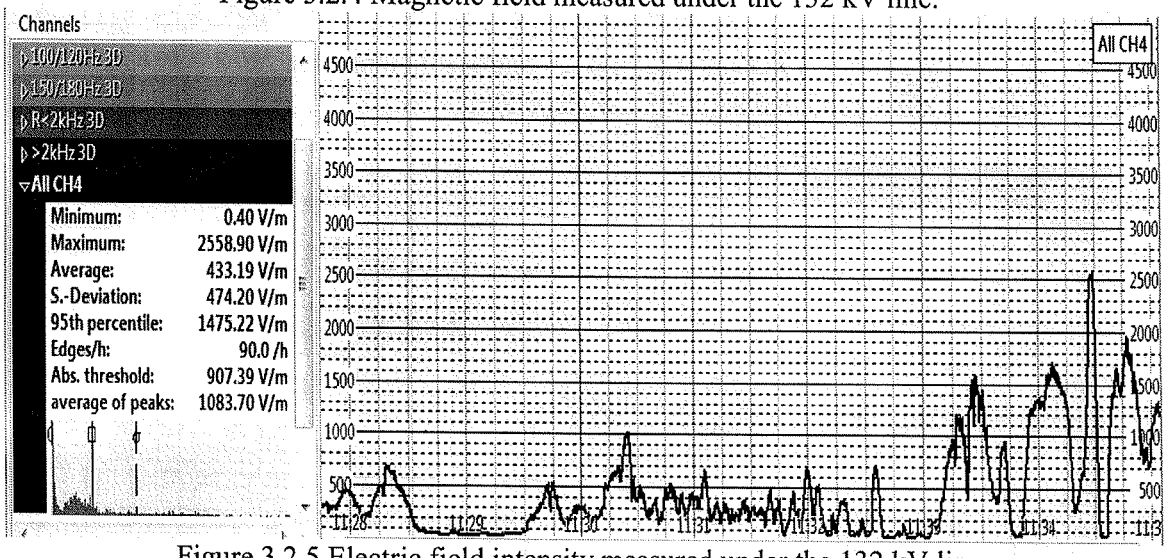

Figure 3.2.5 Electric field intensity measured under the 132 kV line.

3.3 Tolerable limits of EMF levels

In India its is stipulated that electric field intensity should not exceed 4.16 kV/m and magnetic intensity should not exceed 100 μT (1000 mG) in public areas. These levels are according to international commission on non – ionizing radiation protection (ICNIRP). These limits seem to be stipulated from the point of levels which may cause mild shocks [16, 17]. But the levels which may affect short term and long term health problems are much lower. In advanced countries the level EMF fields particularly magnetic field is contemplated to be fixed below 2 mG near residential areas, schools and hospitals.

4.0 HEALTH HAZARDS ON HUMAN BEINGS

The human body is composed of biological materials like blood, brain, lungs, muscle, skin etc. the permeability of human body is equal to permeability of air but within a human body different electromagnetic values at a certain frequency for different materials exists. The human body contains free electric charges (largely in ion-rich fluids such as blood and lymph), that

move in response to force exerted by changes on and currents flowing in nearby power lines. The processes that produce these body currents are called electric and magnetic induction.

In electric induction, charges on a power line attract or repel free charges within the body, since body fluids are good conductors of electricity, charges in the body move to its surface under the influence of this electric force. For example, a positively charged overhead transmission line induces negative charges to flow to the surfaces on the upper port of the body. Since the charge on power lines alternates from positive to negative many times each second, the charges induced on the body surface alternate also. Thus power-frequency electric fields induce currents in the body (eddy current) as well as charges on its surface.

The magnitude of surface charge and internal body currents that are induced by any gives source of power-frequency fields depends on many factors. These include magnitude of the charges and current in the source, the distance of the body from the source, the presence of other objects that might shield or concentrate the field and body posture, shape and orientation.

Where a person who is shielded from ground by some insulating material comes in close proximity to an over head transmission line, an electrostatic field is set in the body of human being, having a resistance of about 2000 ohms. When the same person touches a grounded object, it will discharge through his body causing a large amount of current to flow through the body. Discharge currents from 50-60Hz electromagnetic fields are weaker than natural currents in the body, such as those from electrical activity of the brain & the heart [9, 10]. For human beings the limit for undisturbed field is 15kV/m, to experience possible shock. Where designing a transmission lines this limit is not crossed, as long as a person takes care to keep minimum clearance from transmission lines [4, 5]. According to research and publications put out by the World Health Organization (WHO), EMF such as those from power lines can cause the following health problems.

4.1 Short term Health problems

1. Head ache
2. Fatigue
3. Anxiety
4. Insomnia
5. Prickling and /or burning skin
6. Rashes
7. Muscle pain

4.2 Long term Health problems

(1) Risk of damaging DNA: Our body acts like an energy wave broadcaster and receiver, incorporating and responding to EMFs. In fact, scientific research has demonstrated that every cell in your body may have its own EMF, helping to regulate important functions and keep you healthy. Strong artificial EMFs like those from power lines can scramble and interfere with your body's natural EMF, harming everything from your sleep cycles and stress levels to your immune response and DNA.

(2) Risk of Cancer: after hundreds of internationals studies, the evidence linking EMFs to cancers and other health problems is loud and clear. High voltage power lines are most dangerous culprits and other sources in the grid like transformers & substations are equally effective though to a lesser extent and even EMFs generated inside homes cannot be ignored [6].

(3) Risk of Neurodegenerative diseases: "Several studies have identified occupational exposure to low frequency EMF as a potential risk factor for neurodegenerative disease" (According to Epidemiology, 2003 Jul: 14(4): 413-9).

(4) Risk of miscarriage : there is |strong evidence that parental maximum magnetic field exposure above a certain level (possibly around 16mG) may be associated with miscarriage risk (As per epidemiology, 2002 jan,13(1)9-20).

(5) Child leukemia: It is observed all over the world that childhood leukemia has significantly increased from 1940 onwards when electricity supply increased to residents in cities and extended to rural area. The exposure of young children to power frequency EMF in schools, near transmission lines and at home to levels as low as 0.2mG can also lead to leukemia. Children in the age group 2 to 4 years are found to be vulnerable to this occurrence. Measured values of magnetic fields at home, at schools and near transmission lines show to be of the order of 1mG which is rather high for children to grow up [3].

For children the skull bones are not yet fully developed in the sense they are tender and magnetic field penetration will be higher [7]. The production of melatonin, a protective hormone is less and as their immune system is low. Thus they are more vulnerable. Statistically it has been overwhelmingly noticed both in Europe and America that childhood leukemia has been on the increase since the last war and it is attributed to exposure to EMF fields. Use of electric blanket by children has resulted in an increase number of cases of leukemia. Researchers in England have reported that children living within 650 feet of power lines had a 70% greater risk for leukemia than children living 2000 feet or more away (British medical journal June 2005).

4.3 EMF effects on Maintenance works

For providing continuous and uninterrupted supply of electric power to consumers, maintenance operations of power lines are after performed with systems energized or live as shown in figure 4.3. Thus the maintenance staff and others involved in electrical supply industry are exposed to magnetic fields of 0.2mG and above for long durations. Among such people it was noticed that suicide rate among them was 23% higher than normal population and it increased to 70% and above among those exposed to 1.1mG & above this shows that level of no effect is very close to zero 50 Hz magnetic field exposure [15].

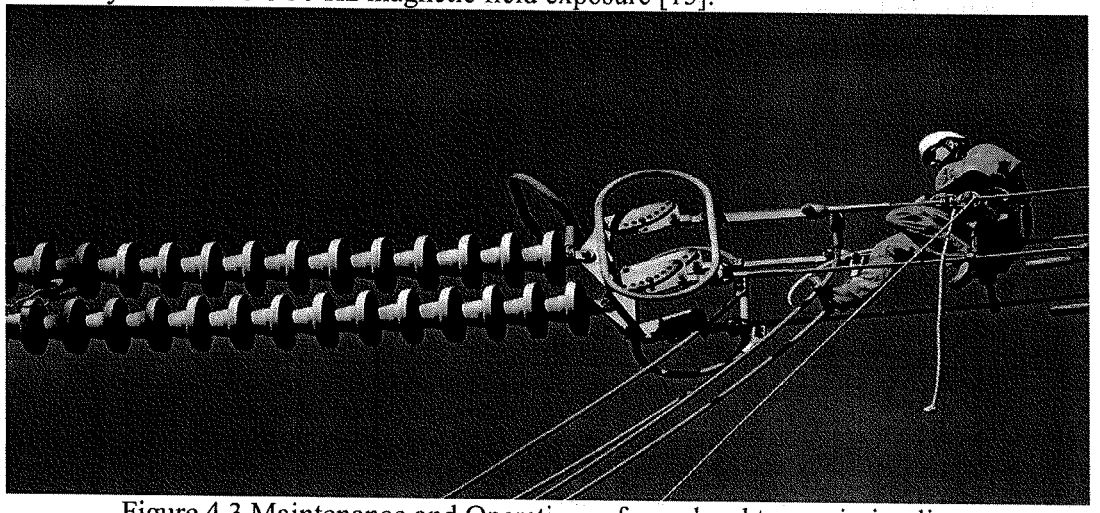

Figure 4.3 Maintenance and Operations of over head transmission lines

4.4 Step potential and touch potential

Transmission lines when subjected to faults or over voltages, insulators flash over and heavy current flows through the transmitting towers to ground. Under such cases, if a person touches a tower the potential between the points of touch to ground may be high and give a shock to the person who has touched as shown in figure 4.5.

Likewise when heavy current is passing from the towers to the ground there will be an electric field around the foot of the tower so if a person approaches a tower a voltage appears between his two feet called step potential which can give him a shock. If the touch potential or step potential is higher than 30v, the person experiences a shock. If cattle approaches a tower it is subjected to a greater value of step potential as the distance between front & hind legs in cattle are longer.

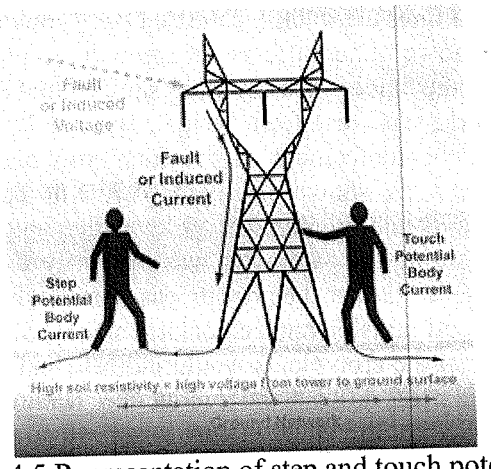

Figure 4.5 Representation of step and touch potentials

4.5 Effect on pacemakers

Under some circumstances voltages and currents from power lines, distribution lines and electrical devices can interfere with operation of some implanted cardiac pace makers as shown in figure 4.5. However no case where a HV line has harmed a pace maker patient has been reported [8, 9]. Still a person with a pacemaker in an electrical environment and the pacemaker begins to produce a regularly paced pulse that is not related to a normal heart beat, the person should leave the environment and consult a physician.

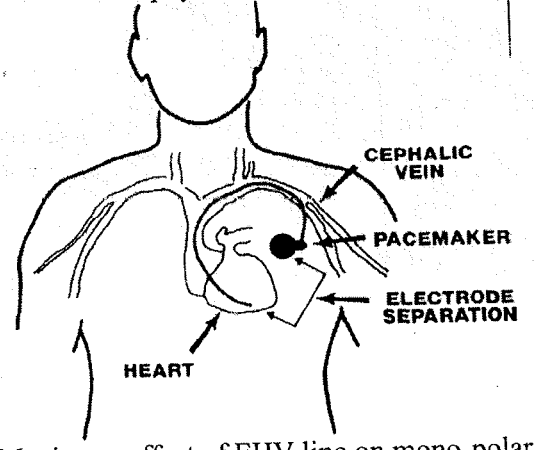

Figure 4.5 Maximum effect of EHV line on mono-polar cardiac pacemaker implant.

4.6 EMF effects on Animals

Many researchers have studied the effect of electrostatic field on animals. In order to do so they kept the cages of animals under high electrostatic field of about 30 kV/m (an order of extremely high field that may be experienced under power lines). The results of these experiments are shocking as animals which acquired charge during the above exposure, when they tried to drink water a spark started jumping from their nose to grounded water and hens who had acquired charge were unable to pick up grain because of the chattering of their beaks which also affected their growth[10].

4.7 EMF Effects on plant life

Most of the areas under HV power lines are agricultural and forest land. The voltage level of high power transmission lines are 400kv, 230kV, 110kV, 66kV etc. The electromagnetic field from such high voltage power lines affects the growth of plants [2]. From various studies conducted on growth of plants under such HV lines showed that growth characteristics like shoot length, root length, leaf area, and leaf fresh weight, specific leaf weight, shoot/root ratio, total biomass content and total water content of the four crop plants were reduced significantly compared to control plants as shown in figure 4.7. Similar trend were observed in the biochemical characteristics like chlorophyll.

Reduced growth and physiological parameter was primarily due to the effect of reduced cell division and cell enlargement. Further the growth was started which may be due to poor action of hormones responsible for cell division and cell enlargement [18]. It is concluded that the reduced growth parameters shown in the crop plants would indicate that the EMF has exerted a stress on the plants and this EMF stress affects the production leading to economic loss, so further research activities are needed to safe guard plants from EMF stress.

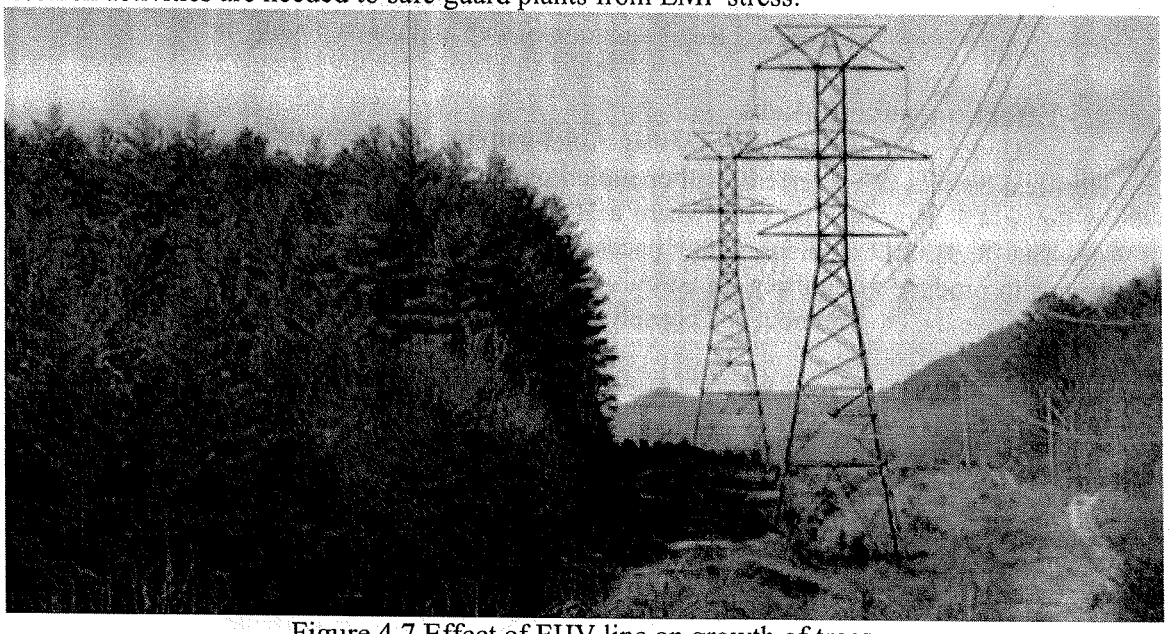

Figure 4.7 Effect of EHV line on growth of trees

4.8 Living and working safely around HV power lines

i) Use of ROW: Right of way which is a narrow strip of land below transmission lines is not a public property, it is acquired by power companies through easements from land owners so trespassing, collecting vegetation, cutting any plant by general public amounts to stealing and

can be prosecuted. It is the job of engineers and educated people to make people around aware of the status of ROW.

ii) General precautions: Avoid bringing yourself or any object you are holding too close to an overhead power line. As a general precaution when under a HV line never put you or any object higher than 14ft from the ground. Vehicles and large equipment should not extend more than 14ft in height such as harvesting machines, cranes etc.

iii) Nuisance shocks: which are experienced by touching metal objects even away from HV lines. Such objects include vehicles, fences, metal buildings or roofs and irrigation systems.

iv) Irrigation systems: While moving irrigation pipes under or near power lines, keep the equipment in a horizontal position to keep it away from overhead lines electricity can conduct through water so never allow irrigation system to spray a continuous stream directed towards the power line or tower.

Underground pipes, telephone cables and electrical cables should not be installed closer than 50ft to a HV tower as in figure 4.8. The grounding system of the tower is not visible and run up to 300ft along the ROW, so these systems have to be located before installing any underground utilities.
Fences are discouraged from locating in ROW as they can cause a potential safety hazard and an access problem. If electric fences were to be installed it can be done after consulting with the HV line authorities.

(v) Buildings located off ROW may collect an induced voltage. This voltage is often drained through the building plumbing, electrical service, metal sheeting or metal frame. If the voltage does not drain through the systems described, then it can result in a situation of nuisance shock. Large electrical supply companies recommend grounding metallic components on buildings near a power line when

- Within the building is written 100ft of the outside wire
- The building has more than 2000 square feet of metal surface and is within 100 to 150ft of the outside wire
- The building is used to store flammable materials and is within 250ft of the outside wire.

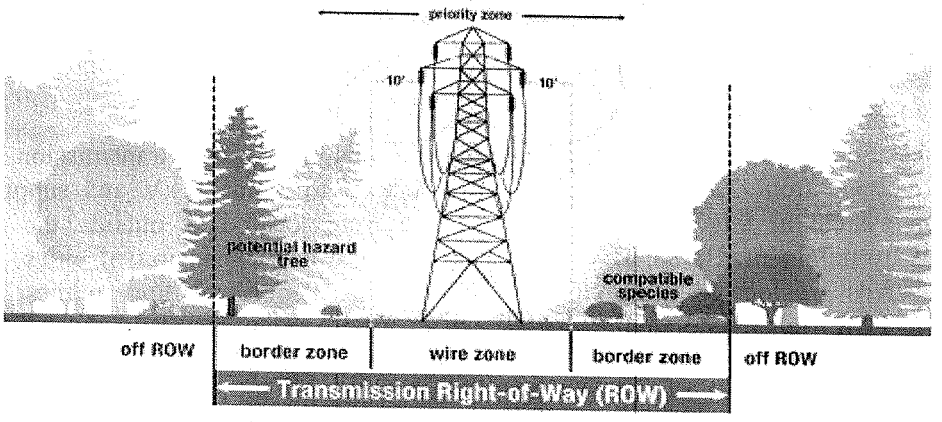

Figure 4.8 Safety zone for living beings

5.0 HIGH FREQUENCY VOLTAGE TRANSIENTS

These refer to harmonics and transients in the lower radio frequency spectrum, in the KHz range (approximately 1 to 100 KHz). Deviations from 50/60Hz sine wave are generally in the tower radio frequency spectrum and better described as radiofrequency transients or high frequency voltage transients (HFVT). HFVT can be produced in the power system due to lighting strokes, switching events and short circuits. Harmonics can also be introduced to the power system by electronic items that draw non-sinusoidal current from the power supply [17]. Such equipments can include computers, fax machines, dimmer switches and house hold appliances with electronic controls. HFVT can interact with electrical equipments and can damage them. Also long term exposure to EMF fields produced by HFVT can be harmful to human beings [16].

For electric fields in 3 kHz 100 kHz range unintentional stimulation of excitable tissues can occur when electric or magnetic fields are strong enough. There have been a limited number of studies published on health effects associated with HFVT. A review published in 2010 cited various methodological problems in the design of the studies and has recommended more in depth studies to be made before causal link between HFVT exposure and adverse health effects can be found. Electric and magnetic fields generated by HFVT on main circuits can be measured using standard radiofrequency and low frequency EMF measurement equipment.

5.1 Radio frequency interference from HV lines

HV lines are associated with corona and other effects which generate radiofrequency EMF. This can be observed when your car approaches a HV line the radio in the car develops disturbance. This radiofrequency waves generated near HV lines have adverse effect on communication system and their effect on human health has not been studied in detail though evidences point out that these are potential sources of health hazard.

5.2 Electricity problems under Distribution lines

Distribution lines are spread out and run in densely populated areas as they have to reach every customer. Though the voltage levels are less (220V to 11000V) they have been a cause for a number of accidents. Also as the currents in these lines are large, magnetic field produced can have adverse effect on human beings if they fail to follow the safe clearance distances as recommended. The clearance between a building and a medium voltage line is 2m horizontally and 3m vertically and these clearances must take into account the lines swinging in the wind and line sag. A medium-voltage line must never run above a permanent building, even with a 3m clearance.

5.3 EMF hazards in the vicinity of a substation

Substations receive power from generating stations through HV transmission lines, step down the voltage from 220kV the voltage from 220kV to about 11kV and supplies to the distribution system at this reduced voltage. These were located at outside the cities and surrounded by uninhabited area. Due to pressure on land and expansion of cities, nowadays residential areas are located quite close to substations. People residing in these areas are subjected to EMF fields generated at the terminals of the equipments in the substation. In HV lines, the lines which are subject to High voltage area at a safe height but the line when terminated at the equipments in substation, it is towered to the tip of the equipments. Thus the EMF field is quite close to the ground. So save distance should be measured in building residential houses close to substations.

5.4 Tolerable levels of EMF fields and methods to mitigate the hazards

For genotoxic substances RCEP (Royal commission on Environmental protection 1998) states that it is not possible to demonstrate that there are a threshold dose. This is also clearly true for electromagnetic fields and radiation. So the safe level of exposure to 50/60 Hz fields is zero. This is impossible, because in that case we have to dismantle entire electric system throughout the world. So we have to identity intensity levels of fields and mark them as worst, bad, tolerable, good and excellent. This has to take into account whether the people exposed are children, old people and also how long they are exposed. For example the fields at home, in schools, hospitals vulnerable sections are exposed for long periods. Here the levels should be excellent.

School and home environments should be assessed and where possible 90% of room space at head height, especially at the head position when sleeping or in school should be less than 0.2mG. Fields produced by the substation and power lines should not exceed this limit in residential, school or working environment

If the above limits cannot be maintained it is common practice to set an achievable management guideline that will produce a significant reduction in health effects. In India, there are no stipulated levels which should not be exceeded. In such a situation the guidelines recommended by international commission on Non-Ionizing Radiation Protection (ICNIRP) is to be followed. The reference levels according to ICNIRP are 5kV/m for electric fields and for magnetic fields 100μT (1000mG). This is very much high particularly regarding magnetic fields. Modern researches suggest a threshold level of 1mG for magnetic fields and lower levels of 0.2 to 0.5mG at sensitive place like schools & hospitals etc. There is an urgent need to educate the general public and make them aware of the hazards from higher field levels of EMF. Also many precautions to be taken as follows to be made known

1. Observe clearances an stipulated from HV lines and distribution lines
2. Do not construct any building or structure under distribution lines
3. Residential houses should not be built close to substations
4. Inside residences the magnetic fields can be got measured and limit the equipments to be used at a time so that tolerable limits of magnetic fields are maintained.
5. Where children sleep, electric appliance switched on at the head level to be avoided also near the head & behind the wall at head level no appliance switched on to be used.
6. Children should not be allowed to use electric blanket

In areas where electromagnetic fields are noted to be high due to power lines there are several methods as follows to reduce the field. Electric field can be reduced by shielding the wire but it is more complex to reduce the magnetic field. Regarding line shielding for magnetic field mitigation, there are two basic methods.

- Passive magnetic field mitigation uses rigid magnetic shielding with ferromagnetic and highly conductive materials and the use of such passive shield wires installed near transmission lines that generate opposing cancelation fields from electromagnetic induction
- Active magnetic field mitigation uses electronic feed back to sense a varying 50Hz magnetic field, then generates a proportionally opposing cancellation field within a defined area (room or building) surrounded by cancellation coils. Ideally, when two opposing 180 degrees out of phase magnetic fields of equal magnitude intersect, the resultant magnetic field is completely cancelled. This technology has been demonstrated to be practical but not applied very much.

5.5 Mitigation of electric and magnetic fields

Where the lines cannot be shifted or residential buildings have come up near the lines and the areas have become high risk areas there are certain steps to mitigate the risks by reducing the levels of the field. For electric field it is easy by providing a conducting shield around the conductor. For magnetic field there are several methods though complex and expensive. Passive Magnetic field mitigation includes rigid magnetic shielding with ferromagnetic and highly conductive materials. Active magnetic field mitigation uses electronic feed back to sense 50 Hz magnetic field then generates proportionally apposing (null), cancellation field within a defined area (building). Line configuration and compaction can be adopted where the distance between the phases is reduced (Keeping the minimum safe spacing).

6. CONCLUSION

The survey conducted in and around metropolitan city shows there are some high risk areas. For example in figure 3.23 area shows the maximum level of magnetic field, which is for lower than stipulated but higher than what the researchers are advocating. There is over whelming evidence as per researchers that there is health risk at EMF filed levels as low as 2 to 5 mG. But the WHO feels that there is no conclusive and convincing to link EMF related diseases to low levels of radiation so there is a pressing need to conduct large scale survey of residential areas in large cities, locate high risk areas and take health (Particularly mental health) check up to gather more and more evidence to link up EMF field levels and health hazards in a convincing way.

In this direction the survey has been done in metropolitan city and some of the high risk areas are indentified for further work and follow up studies by health organizations / authorities. Where the risk areas exist and shifting of lines is difficult, mitigation efforts to be taken as suggested. These will cause health hazards even at low intensity, when living beings are exposed for longer duration, especially children and old people. Hence it is concluded that to avoid high density radiations area from living beings.

FUTURE WORK

There are many transmission lines in and around Bangalore which is likely to cause greater concern for the area in the vicinity where people are habituated such studies need to be done, also with the co-operation of a hospital a survey of the people living in the risky area can be conducted along with radiation measurement for a better study of the hazard involved. This may help in arriving at a realistic safe level of magnetic fields that is tolerable as the maximum level stipulated in India is 100 μT seems to be very high and a detailed studies are required to arrive at a lower limit which is tolerable.

ACKNOWLEDGEMENT

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https://electricalnotes.wordpress.com/2011/04/22/minimum-electrical-clearance-2/,Last accesses on June 8, 2018.

SAFETY PROVISIONS IN THE ELECTRICITY ACTS AND RULES

The Indian Electricity (IE) Rules, 1956 was made under section 37 of the Indian Electricity Act, 1910 and redefined after enactment of The Electricity Act, 2003. CEAR namely Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 came into effect from 20th September 2010, in place of The Indian Electricity Rules, 1956.

IE rules mainly dealt with

- Appointment of inspectors & their duties
- Licensing provisions.
- General safety requirements
- Conditions relating to supply and use of energy.
- Electric supply lines and systems for LV & MV
- Electric supply lines and systems for HV & EHV.
- Overhead lines, underground cables and generating stations
- Electric traction.
- Precautions in mines & oil fields

IMPORTANT STATUTORY SAFETY PROVISIONS

- In every registered factory, where more than 250 KW of electrical load is connected, there **SHALL BE A PERSON** authorized by the management for ensuring the safety provisions laid under the Act and the rules made there under,
- Shall periodically inspect such installation.
- Get them tested & keep a record
- Records shall be made available to the Inspector [or any officer of a specified rank and class appointed to assist the Inspector
- All suppliers of electricity including generating companies, transmission companies and distribution companies shall appoint **A SAFETY OFFICER** for proper observance of safety measures in their organization in construction, operation and maintenance of power station, sub-station, transmission and distribution lines
- No person shall be authorised under sub-rule (1) unless he is **COMPETENT** to perform the duties assigned to him and **POSSESSES** either an appropriate certificate of competency or permit to work.
- Adequate ratings of the Electrical Installation ,Mechanical Strength, as per Indian Standards.- All electric supply lines and apparatus shall be of sufficient ratings for power, insulation and

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estimated fault current and of sufficient mechanical strength, for the duty which they may be required to perform under the environmental conditions of installation, **and shall be constructed, installed, protected, worked and maintained in such a manner as to ensure safety of human beings, animals and property.**

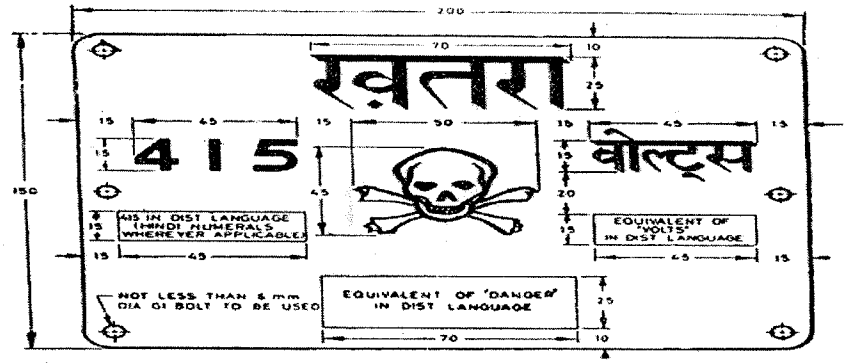
- Isolating **(CUT OUT)** arrangement by supplier
- Identification system of earth and Earth Neutral conductor
- Earthing system.
- Inaccessibility of bare conductors.

  (a) Ensure that they are inaccessible;

  (b) Provide in readily accessible position switches for rendering them dead whenever necessary

  (c) Take such other safety measures as are considered necessary by the Inspector.

- Danger Notice. (sign of skull and bones) Permanently in a conspicuous position
- Handling of electric supply lines and apparatus-
  - To discharge electrically such conductor or apparatus.
  - Gloves, rubber shoes, safety belts, ladders, earthing devices, helmets, line testers, hand lines etc.
  - Authorised person.
- Distinction of different circuits.(Permanent nature)
  - Ensure by means of indication of a permanent nature that the respective circuits are readily distinguishable from one another (By numbering).
  - The owner of the every installation including sub-station, double pole structure, four pole structure or any other structure having more than one feed, shall ensure by means of indication of a permanent nature, that the installation is readily distinguishable from other installations



NOTE 1 — All letterings should be centrally spaced.
NOTE 2 — The dimensions for the words in district language are mainly for guidance, however, care should be taken to space them centrally between the edges and the area of the skull and bones.
NOTE 3 — The location of the fixing holes shall be left to the choice of the user.
NOTE 4 — The corners of the plates should be rounded off.

All dimensions in millimetres.

- Prevention of accidental charge
    - The owners of all circuits and apparatus shall so arrange them that there shall be no danger of any part thereof becoming accidentally charged to any voltage beyond the limits of voltage for which they are intended.
- Protection equipment, Fire buckets, First aid box ,Gas mask (5MW & Above) etc.
    - Fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires, in addition to fire extinguishers suitable for dealing with electric fires, shall be conspicuously marked and kept in all generating stations, enclosed sub-stations and switch stations in convenient situation. The fire extinguishers shall be tested for satisfactory operation at least once a year and record of such tests shall be maintained.
    - First-aid boxes or cup boards conspicuously marked and equipped with such contents as the State Government may specify shall be provided and maintained in every generating station, enclosed sub-station and enclosed switch station so as to be readily accessible during all working hours. All such boxes and cupboards shall, except in the case of unattended sub-stations and switch stations, be kept in charge of responsible persons who are trained in first-aid treatment and one of such person shall be available during working hours.
    - Two or more gas masks shall be provided conspicuously and installed and maintained at accessible places in every generating station with capacity of 5 MW and above and enclosed sub-station with transformation capacity of 5 MVA and above for use in the event of fire or smoke. Provide that where more than one generator with capacity of 5 MW and above is installed in a power station, each generator would be provided with at least two separate gas masks in accessible and conspicuous position.
- Instructions for restoration of persons suffering from electric shock
    - Instructions, in English or Hindi and the local language of the district and where Hindi is the local language, in English and Hindi for the restoration of persons suffering from electric shock, shall be affixed by the owner in a conspicuous place in every generating station, enclosed sub-station, enclosed switch-station and in every factory as defined in clause (m) of section 2 of the Factories Act, 1948 (63 of 1948) in which electricity is used.
    - The owner of every generating station, enclosed sub-station, enclosed switch-station and every factory or other premises to which this rule applies, shall ensure that all authorized persons employed by him are acquainted with and are competent to apply the instructions
    - In every manned high voltage or extra-high voltage generating station, substation or switch station, an artificial respirator shall be provided and kept in good working condition.
- Precautions to be adopted by consumers, owners, occupiers, electrical contractors, electrical workmen and suppliers:-

- All electrical installation works shall be carried out by a person holding certificate of competency and by a person holding a permit issued or recognized by the State Government.
- No electrical installation work which has been carried out in contravention of sub-rule(1) UNAUTHORIZED PERSON shall not be energized or connected to the works of any supplier.

- Periodical inspections and testing of Equipments
  - Installation shall be periodically inspected and tested at intervals not exceeding five years either by the Inspector or any officer appointed to assist the Inspector or by the supplier as may be directed by the State Government in this behalf or in the case of installations belonging to, or under the control of the Central Government.
- Testing of consumer's installation
  - Upon receipt of an application for a new or additional supply of energy and before connecting the supply or reconnecting the same after a period of six months, the supplier shall inspect and test the applicants' installation.
- Installation and Testing of Generating Units
  - Installation and Testing of Generating Units- Where any consumer or occupier installs a generating plant, he shall give a thirty days' notice of his intention to commission the plant to the supplier as well as the Inspector.
- Precautions against leakage before connection.
  - High Voltage Equipments installations
    - High Voltage Equipments shall have the IR value as stipulated in the relevant Indian Standard.
    - At a pressure of 1000 V applied between each live conductor and earth for a period of oneminute the insulation resistance of HV installations shall be at least 1 Mega ohm or as specified by the 1 [Bureau of Indian Standards] from time to time.
- Supply and use of energy
  - A linked switch with fuse(s) or a circuit breaker by low and medium voltage consumers.
  - A linked switch with fuse(s) or a circuit breaker by HV consumers having aggregate installed transformer/apparatus capacity up to 1000 KVA to be supplied at voltage upto 11 KV and 2500 KVA at higher -voltages (above 11 KV and not exceeding 33 KV).
  - A circuit breaker by HV consumers having an aggregate installed transformer/apparatus capacity above 1000 KVA and supplied at 11 KV and above 2500 KVA supplied at higher voltages (above 11 KV and not exceeding 33 KV).
  - A circuit breaker by EHV consumer ; Provided that where the point of commencement of supply and the consumer apparatus are near each other one linked switch with fuse(s) or circuit breaker near the point of commencement of supply as required by this clause shall be considered sufficient for the purpose of this rule;
- Provisions applicable to medium, high or extra-high voltage installations
  - All conductors (other than those of overhead lines) shall be completely enclosed in mechanically strong metal casting or metallic covering.

- All metal works, enclosing, supporting or associated with the installation, other than that designed to serve as a conductor shall be connected with an earthing system.
- Every switchboard shall comply with the following provisions, namely: -
  - A clear space of not less than 1 metre in width shall be provided in front of the switchboard
  - If there are any attachments or bare connections at the back of the switchboard, the space (if any) behind the switchboard shall be either less than 20 centimetres or more than 75 centimetres in width, measured from the farthest outstanding part of any attachment or conductor
  - If the space behind the switchboard exceeds 75 centimetres in width, there shall be a passage-way from either end of the switchboard clear to a height of 1.8 metres.

OTHER PROVISIONS

ELECTRIC SUPPLY LINES, SYSTEMS AND APPARATUS FOR LOW AND MEDIUM VOLTAGES

- Test for resistance of insulation.
  - Where any electric supply line for use at low or medium voltage has been disconnected from a system for the purpose of addition, alteration or repair, such electric supply line shall not be reconnected to the system until the supplier or the owner has applied the test prescribed under rule 48.
  - The provision of sub-rule (1) shall not apply to overhead lines except, overhead insulated cables unless the Inspector otherwise directs in any particular case.
- Connection with earth.
  - Neutral conductor of a phase, 4 wire system and the middle conductor of a2 phase, 3-wire system shall be earthed by not less than two separate and distinct connections with a minimum of two different earth electrodes of such large number as may be necessary to bring the earth resistance to a satisfactory value both at the generating station and at the sub-station. The earth electrodes so provided, may be interconnected to reduce earth resistance. It may also be earthed at one or more points along the distribution system or service line in addition to any connection with earth which may be at the consumer's premises.]
  - The frame of every generator, stationary motor, portable motor, and the metallic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or controlling energy and all medium voltage energy consuming apparatus shall be earthed by the owner by two separate and distinct connections with earth.

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- Earth leakage protective device
  - The supply of Energy to every electrical installation other than low voltage installation below 5 KW and those low voltage installations which do not attract provisions of section 30 of the Indian Electricity Act, 1910, shall be controlled by an earth leakage protective device so as to disconnect the supply instantly on the occurrence of earth fault or leakage of current.

- Approvals by Inspector-
  - Before making an application to the Inspector for permission 1[to commence or recommence supply after an installation has been disconnected for one year and above] at high or extra-high voltage to any person, the supplier shall ensure that the high or extra-high voltage electric supply lines or apparatus belonging to him are placed in position, properly joined and duly completed and examined. The supply of energy shall not be commenced by the supplier unless and until the Inspector is satisfied that the provisions of rules 65 to 69 both inclusive have been complied with and the approval in writing of the Inspector have been obtained by him.

OVERHEAD LINES, UNDER GROUND CABLES AND GENERATING STATIONS

- Material and strength-
  - All conductors of overhead lines other than those specified in sub-rule (1) of rule 86 shall have a breaking strength of not less than 350 kg.
  - Where the voltage is low and the span is of less than 15 metres and is on the owner's or consumer's premises, a conductor having an actual breaking strength of not less than 150 kg may be used.
  - Joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation. The ultimate strength of the joint shall not be less than 95 per cent of that of the conductor, and the electrical conductivity not less than that of the conductor.
- Clearance above ground of the lowest conductor

OVER HEAD LINES ALONG ANY STREET	Meter
FOR LOW AND MEDIUM VOLTAGE LINES	5.5
FOR HIGH VOLTAGE LINES	5.8
ELSEWHERE THAN ALONG OR ACROSS ANY STREET SHALL BE NOT LESS THAN-	
UP TO AND INCLUDING 11,000 VOLTS, IF BARE	4.6
LINES UP TO AND INCLUDING 11,000 VOLTS, IF INSULATED	4.0
FOR HIGH VOLTAGE LINES ABOVE 11,000 VOLTS	5.2

For extra-high voltage lines the clearance above ground shall not be less than 5.2 metres PLUS 0.3 metre for every 33,000 volts or part thereof by which the voltage of the line exceeds 33,000 volts

- Clearances from buildings of high and extra-high voltage lines

ABOVE OR ADJACENT TO ANY BUILDING OR PART (VERTICAL)	Meter
For High Voltage Lines Up to And Including 33,000 Volts	3.7
For Extra-high Voltage 33,000 V Lines (+ 0.30 Metre For Every Additional 33,000 Volts Or Part Thereof)	3.7+
For High Voltage Lines Up to And Including 11,000 Volts	1.2
HORIZONTAL CLEARENCES	
For High Voltage Lines Above 11,000 Volts And Up To And Including 33,000 Volts	2.0
For Extra-high Voltage Lines (Metres Plus 0.3 Metre For Every Additional 33,000 Volts For Part Thereof.)	2.0+

- Maximum interval between supports (65 meter. for low and medium voltage)
- Guarding-
  - Every guard-wire shall be connected with earth at each point at which its electrical continuity is broken.
  - Every guard-wire shall have an actual breaking strength of not less than 635 kg and if made of iron or steel, shall be galvanised.

Minimum clearances in metres between lines crossing each other

Sl. No.	Nominal System Voltage	11-66 KV	110-132KV	220 KV	400 KV	800 KV
1.	Low & Medium	2.44	3.05	4.58	5.49	7.94
2.	11-66 KV	2.44	3.05	4.58	5.49	7.94
3.	110-132 KV	3.05	3.05	4.58	5.49	7.94
4.	220 KV	4.58	4.58	4.58	5.49	7.94
5.	400 KV	5.49	5.49	5.49	5.49	7.94
6.	800 KV	7.94	7.94	7.94	7.94	7.94

- Safety and protective devices
  - Every overhead line, erected over any part of street or other public place or in any factory or mine or on any consumers' premises shall be protected with a device approved by the Inspector for rendering the line electrically harmless in case it breaks.

- The owner of every high and extra-high voltage overhead line shall make adequate arrangements to the satisfaction of the Inspector to prevent unauthorised persons from ascending any of the supports of such overhead lines which can be easily climbed upon without the help of a ladder or special appliances.

- Protection against lightning
  - The owner of every overhead line which is so exposed as to be liable to injury from lightning shall adopt efficient means for diverting to earth any electrical surges due to lightning.

  - The earthing lead for any lightning arrestor shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the lightning- arrestor to a separate earth electrode and/or junction of the earth mat already provided for the high and extra-high voltage sub-station subject to the avoidance of bends wherever practicable.
- Unused overhead Lines
  - Where an overhead line ceases to be used as an electric supply line, the owner shall maintain it in a safe mechanical condition in accordance with rule 76 or shall remove it.

  - Where any overhead line ceases to be used as an electric supply line, an Inspector may, by a notice in writing served on the owner, require him to maintain it in a safe mechanical condition or to remove it within fifteen days of the receipt of the notice

PROVISION OF PENALTY ON BREACH OF ACTS AND RULES

In case any complaint is filed before the Appropriate Commission by any person or if that Commission is satisfied that any person has contravened any provisions of this Act or rules or regulations made thereunder, or any direction issued by the Commission, the appropriate Commission may after giving such person an opportunity of being heard in the matter, by order in writing, direct that, without prejudice to any other penalty to which he may be liable under this Act, such person shall pay, by way of **penalty, which shall not exceed one lakh rupees for each contravention and in case of a continuing failure with an additional penalty which may extend to six thousand rupees for every day** during which the failure continues after contravention of the first such direction.

Punishment

Punishment for non-compliance of orders or directions.

Whoever, fails to comply with any order or direction given under this Act, within such time as may be specified in the said order or direction or contravenes or attempts or abets the contravention of any of the provisions of this Act or any rules or regulations made thereunder, shall be punishable with **imprisonment for a term which may extend to three months or with fine, which may extend to one lakh rupees,** or with both in respect of each offence and in the case of a continuing failure, with an additional fine which may extend to five thousand rupees for every day during which the failure continues after conviction of the first such offence.

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Dalbergia latifolia

Assessment by: Lakhey, P., Pathak, J. & Adhikari, B.

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Taxonomy

Kingdom	Phylum	Class	Order	Family
Plantae	Tracheophyta	Magnoliopsida	Fabales	Fabaceae

Scientific Name: *Dalbergia latifolia* Roxb.

Common Name(s):

- English: Bombay Blackwood, Indian Rosewood, Indonesian Rosewood, Malabar Rosewood
- French: Palisandre De L'Inde
- Indonesian: Sonobrits, Sonokeling, Sonosungu

Taxonomic Source(s):

Board of Trustees, RBG Kew. 2020. Plants of the World Online Portal. Richmond, UK Available at: http://www.plantsoftheworldonline.org.

Assessment Information

Red List Category & Criteria: Vulnerable A1cd ver 3.1

Year Published: 2020

Date Assessed: August 1, 2020

Justification:

This tree species has a history of over-exploition for its valuable timber throughout its range causing decline in its wild population. Various national level legislation have since been implemented for the conservation of this species. Further, inclusion of this all *Dalbergia* spp. in CITES appendix II has further ensured its conservation through the trade regulation. However, due to its slow growth rate and long rotation cycle, the declined population is yet to recover to its original level. Although the reduction in its population has thought to have ceased, threats to this species exists on the account of its high commercial timber value and slow regeneration rate. Hence, this species is continued to be assessed as Vulnerable.

Previously Published Red List Assessments

1998 – Vulnerable (VU)
https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T32098A9675296.en

1998 – Not Threatened (NT)

Geographic Range

Range Description:

This species is native to India, Nepal, Bangladesh, Myanmar, Java, and Indonesia. It has been reported from west to east Nepal. It has been reported as occurring in Sylhet district of Bangladesh. The distribution range also includes Java and Indonesia (Plants of the World Online 2020). However, the

information of the conservation status, management and trade of *Dalbergia latifolia* in Indonesia prepared by CITES Management Authority and Scientific Authority of Indonesia in 2017 indicates it as introduced species in that country. The estimated extent of occurrence (EOO) is 9,313,133 km^2.

Country Occurrence:

Native, Extant (resident): India (Andhra Pradesh, Karnataka, Sikkim, Tamil Nadu, Uttar Pradesh); Indonesia (Jawa); Myanmar; Nepal

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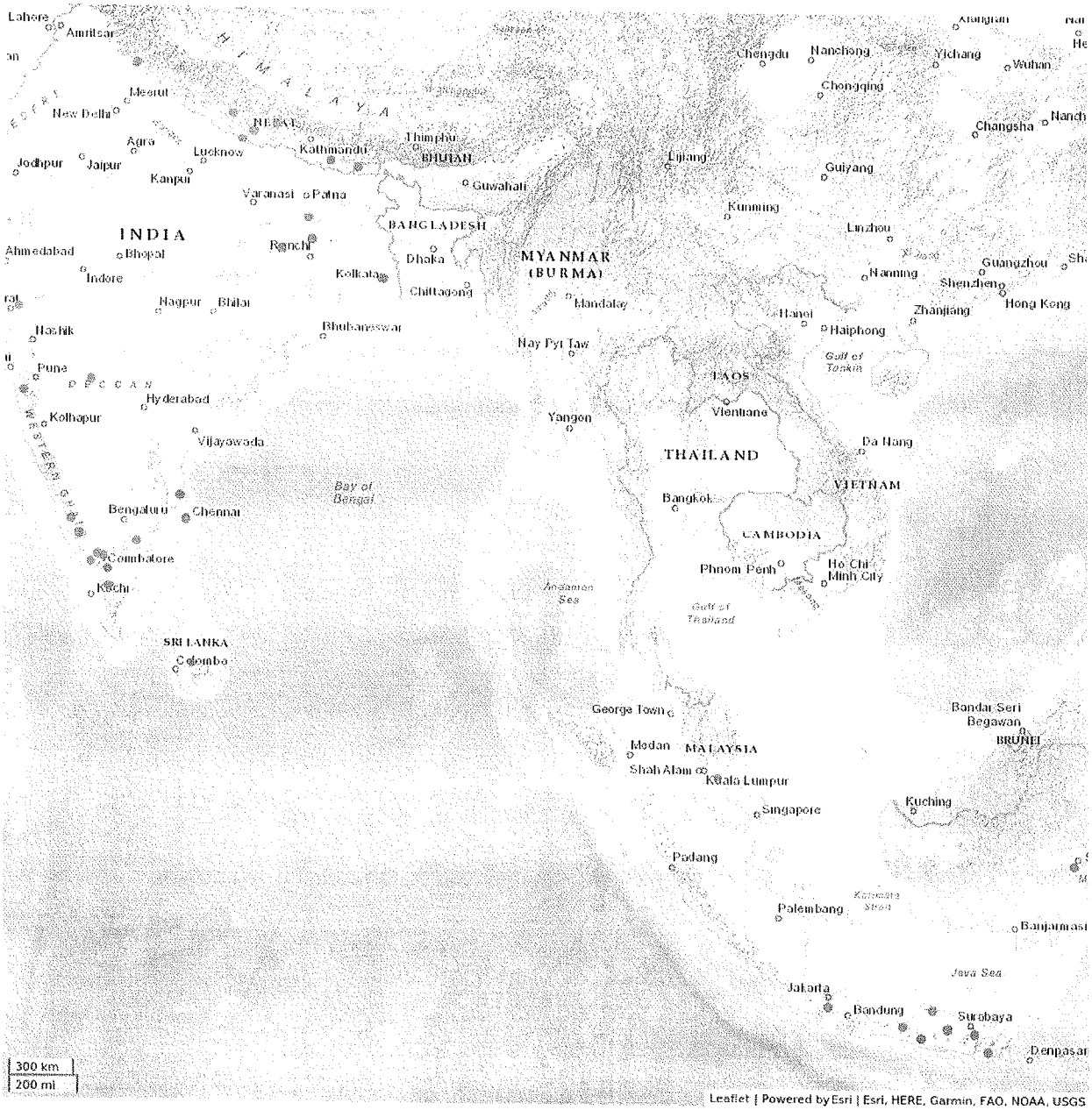
Distribution Map

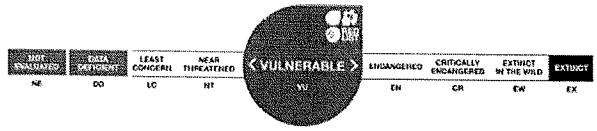


Legend

EXTANT (RESIDENT)

Compiled by:

RBGE 2020



The boundaries and names shown and the designations used on this map do not imply any official endorsement, acceptance or opinion by IUCN.

RED LIST

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Population

Specific information on sub-populations across the range is lacking. In Nepal this species is rare in and localized to a few localities. Based on historic deforestation it is thought that there has been at least 50% population decline for this species in Nepal. In India reports from states where this species was once common indicated continued decline over the last ten years. The high demand of desirable rose wood timber produced from this species, coupled with slow growth rate, long rotation, and decrease in natural habitat has resulted in drastic decline of its population throughout its range (Barber and Winfield 2019).

Current Population Trend: Decreasing

Habitat and Ecology (see Appendix for additional information)

This species is large tree that can grow up to 40 m tall, and occurs in evergreen or deciduous tropical or sub-tropical forests with deep, well-drained and moist soils, within an elevational range of 300 to 1,000 m asl.

Systems: Terrestrial

Use and Trade

This species is highly ultilised as a timber species and is renowned for the colour and fragrance of its wood. It is particularly prized for making musical instruments (e.g. guitars), furniture, veneer, flooring, plywood, carvings, and moulding. In Nepal it is grown in plantations in national and community forests. This species is included in China's 2000 National Hongmu Standard (EIA 2016) and is used for making Hongmu furniture.

Threats (see Appendix for additional information)

The timber of this species is of high commercial value and wild subpopulations are widely overexploited. This species has seen widespread harvesting in the past, but now is protected under Forest Acts in both India and Nepal. Nevertheless, the tropical forests in which is grows have suffered from continued deforestation across its range due to human settlement and agriculture. Although this species is grown in commercial plantations, its slow growth rate and long rotation period make it difficult for plantations to meet demand for the timber.

Conservation Actions (see Appendix for additional information)

This species was previously assessed as Vulnerable on the IUCN Red List in 1996 and is listed on Appendix II of CITES in 2017. The species is protected under the Indian Forest Act, with the export of logs or sawn timber being banned. In Nepal, this species is listed under the Forest Act, 1993 Article 70 and its felling, transportation and export is banned for all commercial purposes. In Nepal, the majority of subpopulations that remain, occur in protected areas. It is included in management plans of the forests in which it occurs. It has been recorded to occur in 14 *ex situ* conservation collections worldwide (BGCI PlantSearch 2019). It is grown in botanic gardens within Nepal and seed orchards have been established to preserve genetic material and to produce propagules.

Credits

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Assessor(s): Lakhey, P., Pathak, J. & Adhikari, B.

Reviewer(s): Watson, M.

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Citation

Lakhey, P., Pathak, J. & Adhikari, B. 2020. *Dalbergia latifolia*. *The IUCN Red List of Threatened Species* 2020: e.T32098A67777757. https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T32098A67777757.en

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External Resources

For Supplementary Material, and for Images and External Links to Additional Information, please see the

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Red List website.

Appendix

Habitats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Habitat	Season	Suitability	Major Importance?
1. Forest -> 1.6. Forest - Subtropical/Tropical Moist Lowland	-	Suitable	-

Plant Growth Forms

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Plant Growth Form
TL. Tree - large

Use and Trade

(http://www.iucnredlist.org/technical-documents/classification-schemes)

End Use	Local	National	International
Other household goods	No	Yes	Yes
Handicrafts, jewellery, etc.	No	Yes	Yes
Establishing ex-situ production *	No	Yes	No

Threats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Threat	Timing	Scope	Severity	Impact Score
5. Biological resource use -> 5.3. Logging & wood harvesting -> 5.3.2. Intentional use: (large scale) [harvest]	Past, unlikely to return	-	-	Past impact

Conservation Actions in Place

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Action in Place
In-place land/water protection
Occurs in at least one protected area: Yes
In-place species management
Subject to ex-situ conservation: Yes

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Additional Data Fields

Distribution
Estimated extent of occurrence (EOO) (km^2): 9313133
Lower elevation limit (m): 300
Upper elevation limit (m): 1,000
Habitats and Ecology
Generation Length (years): 80

The IUCN Red List Partnership

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The IUCN Red List of Threatened Species™ is produced and managed by the IUCN Global Species Programme, the IUCN Species Survival Commission (SSC) and The IUCN Red List Partnership.

The IUCN Red List Partners are: Arizona State University; BirdLife International; Botanic Gardens Conservation International; Conservation International; NatureServe; Royal Botanic Gardens, Kew; Sapienza University of Rome; Texas A&M University; and Zoological Society of London.

Trees Details on Right Of Way (ROW) -(Line Corridor) - 46 Meters

Sr No	Tree Name English	Tree Name Tamil	Scientific Species Name	World Conservation (IUCN-)Species Current Status	Total Trees	Maximum Height Can Grow (Meters)	
1	Indian Rosewood	Yeeti	**Dalbergia Latifolia**	Red List Vulnerable	251	40 Meters	
2	Mahogany	Mahogany	**Swietenia Mahagoni**	Red List-Near Threatened Species	220	20 Meters	
3	Forest Neem	Malai Vembu	**Melia Dubia**	Not Evaluated	129	25 Meters	
4	Teak	Thekku	**Tectona Grandis**	Not Evaluated	56	40 Meters	
5	Indian Kino Tree	Vengai	**Petrocarpus Marsupium**	Red List of Threatened Species-Vulnerable	36	33 Meters	
6	White Teak Wood Tree	Kumil Teak	**Gmelina Arborea**	Least Concern	19	30 Meters	
7	Ear-Leak Acacia	Kathi Savukku	**Acacia Auriculiformis**	Least Concern	14	30 Meters	
8			**Other Trees**		20		
Total Trees					742		

IUCN- International Union for Conservation of Nature

Trees standing outside the Right of Way in land owned by Mr. Jayakumar and adjacent contiguous land owned by his brother K.Kamaraj are about (Totally about 12 acres of Land) 6200 in numbers.

Trees are Indian Kino , Red Sanders, Rosewood,

Sr No	Tree Name English	Tree Name Tamil	Scientific Species Name	World Conservation (IUCN-)Species Current Status
1	Indian Rosewood	Yeeti	**Dalbergia Latifolia**	Red List Vulnerable
2	Mahogany	Mahogany	**Swietenia Mahagoni**	Red List-Near Threatened Species
3	Forest Neem	Malai Vembu	**Melia Dubia**	Not Evaluated
4	Teak	Thekku	**Tectona Grandis**	Not Evaluated
5	Indian Kino Tree	Vengai	**Petrocarpus Marsupium**	Red List of Threatened Species-Vulnerable
6	White Teak Wood Tree	Kumil Teak	**Gmelina Arborea**	Least Concern
7	Ear-Leak Acacia	Kathi Savukku	**Acacia Auriculiformis**	Least Concern
8	Red Sanders	Senchandanam	**Pterocarpus Santalinus**	Red List- Endangered Species
9	Belleric Myrobalan	Thandri	**Terminalai Belliricia**	Least Concern
10	Sandalwood	Chandanam	**Santalum Album**	Red List -Vulnerable
11	North Indian Rosewood	Sissoo	**Dalbergia Sissoo**	Least Concern

Other Trees include Sappan Wood, Mausari Tree, Indian Black berry, Manja Kadambai and Few hundred different fruit trees.

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Power Grid - Tower Details

Tower No	Total Height	Lowest Conductor Height-at the Tower site- Without Sag	Lowest Conductor Height-In between Towers- Without Sag	Clearance Between Trees and Lowest Conductor if the Tree Grows			
				Tree Height 10 Meters	Tree height 20 Meters	Tree Height 30 Meters	Trees Height 40 Meters
T144/4 Kumar Land		27 M	In between 27 and 34 Meters	17 M	7 M	No Clearance	No clearance
T144/5 Mallika Land - New Tower		34 M		24 M	14 M	4 M	No Clearance

Present Clearance as per Power Grid Letter is about 17.5 M without calculating Insulator Height and Sag at Tower 144/4 End.

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Initial Environmental Examination

June 2017

IND: Green Energy Corridor and Grid Strengthening Project
(400 kV AC power transmission systems associated with HVDC terminal stations at Pugalur, Tamil Nadu)
Main Report

Prepared by Power Grid Corporation of India Limited for the Asian Development Bank.

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Page: 35 - flash floods

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Last page mini biography

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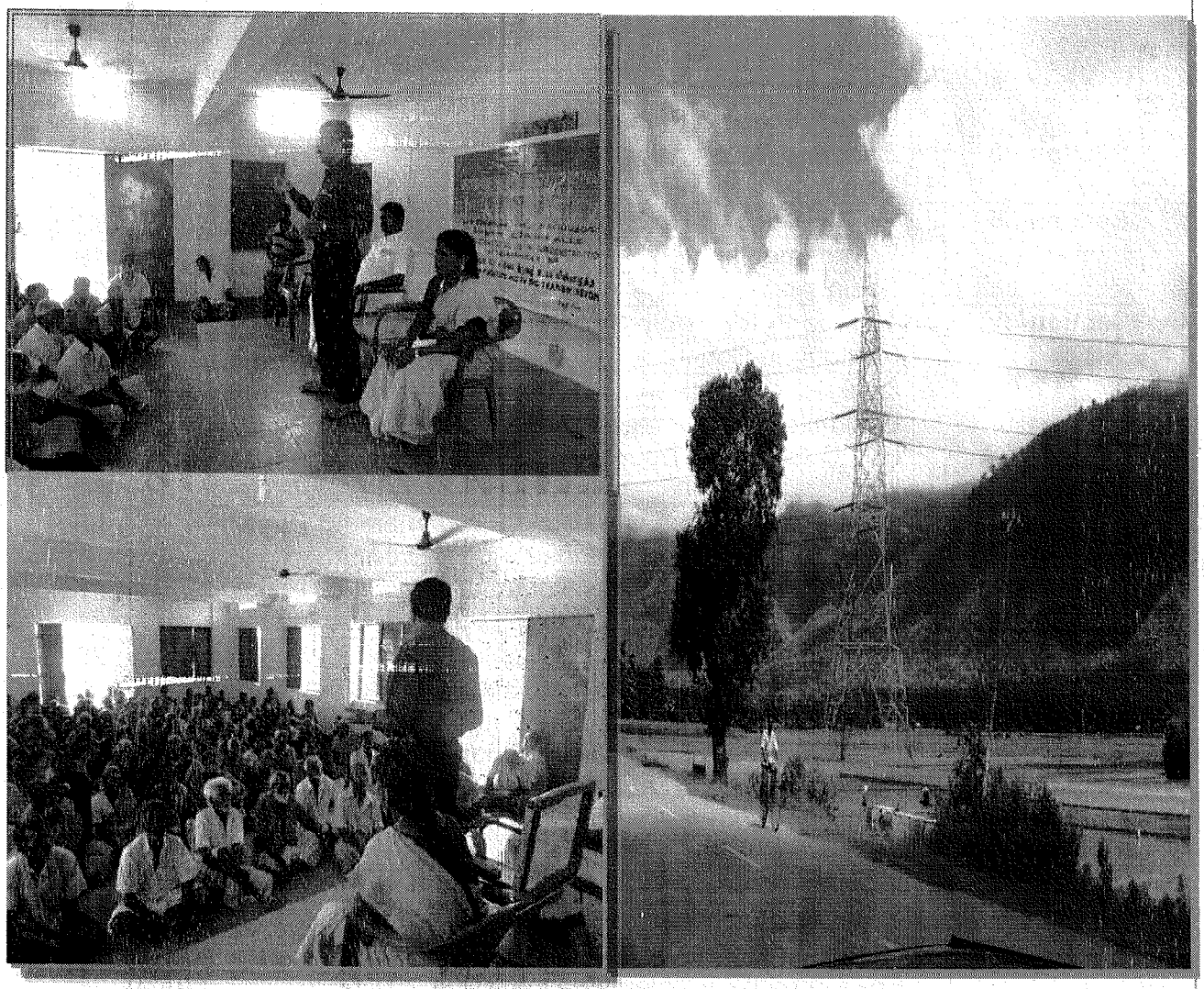
INITIAL ENVIRONMENT EXAMINATION REPORT (IEER)
FOR
AC SYSTEM STRENGTHENING AT PUGALUR END



ENVIRONMENT AND SOCIAL MANAGEMENT

POWER GRID CORPORATION OF INDIA LTD.

(A GOVERNMENT OF INDIA ENTERPRISE)

CONTENTS

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2	Annexure- 2	Tree / crop Compensation Procedure
3	Annexure -3	CEA Gazette Notification for Electrical Safety
4	Annexure -4	Safety Plan
5	Annexure -5	Health, Safety & Environment Conditions in Contract Document
6	Annexure -6	Health & Safety Checklists
7	Annexure -7	Report of PTI on EMF
8	Annexure -8	Procedure of Public Consultation
9	Annexure -9	Details of Public Consultation
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EXECUTIVE SUMMARY

This Initial Environmental Examination Report (IEER) of the proposed Transmission System Strengthening Project (the Project) in Tamil Nadu State has been carried out in accordance with the Environmental and Social Policy and Procedures (ESPP) of POWERGRID. It also fulfills the provisions of the Asian Development Bank's Safeguard Policy Statement (SPS). The proposed Project is a subset of POWERGRID's "HVDC Bi-pole Link between Western Region (Raigarh, Chhattisgarh) and Southern Region (Pugalur, Tamil Nadu) – North Trichur (Kerala)", which comprises three related schemes to expand the interstate transmission network in western and southern India. These schemes are:

- Scheme 1: +800 kV HVDC link from Raigarh (Chhattisgarh, Western Region) to Pugalur (Tamil Nadu, Southern Region).
- Scheme 2: 400 kV transmission segments from Pugalur to 5 other grid substations in Tamil Nadu state, and
- Scheme 3: +320 kV HVDC link from Pugalur (Tamil Nadu) to Trichur (Kerala).

The objective of the Project is to enhance the capacity of the electricity supply in the Southern Region of India. The impact of the Project will be increased availability and sustainability of power supply in India. Schemes 1 and 3 have been the subject of environmental and social assessment consistent with POWERGRID's ESPP and ADB's Safeguard Policy Statement, 2009. This has included preparation of IEERs and CPTDs. POWERGRID has requested financing from ADB and the Asian Infrastructure Investment Bank (AIIB) for the 400 kV transmission lines included in Scheme 2 (the related substations are being funded by ADB). The AIIB has agreed to the application of ADB's SPS, which the AIIB has found to be materially consistent with its Environmental and Social Policy and Environmental and Social Standards, and which has appropriate monitoring procedures in place.

The Project components will include construction of about 619 km of new 400 kV double circuit (D/C) transmission lines (in 5 segments) and 16 nos. of 400 kV line bays at existing substations for terminating 400 kV (quad) D/C lines. The Project components are located in the Southern part (Tamil Nadu State) of India. The alignment of the transmission line does not pass through any environmentally sensitive protected area (such as national parks or wildlife sanctuaries). However, about 5 km length of the proposed alignment of the Pugalur–Thiruvalam line passes through forest area. The rest of the alignment passes through agriculture and open areas. Terrain is plain to hilly.

The Project is classified as Category B under the provisions of ADB's SPS. Accordingly, this IEER has been prepared to meet ADB's requirements. This IEER includes an Environmental Management Plan (EMP) for project implementation and monitoring.

As a responsible corporate entity, POWERGRID pays maximum attention to the environmental and social safeguards associated with its operations. To address the environmental and social issues related to its power transmission projects, POWERGRID has developed its corporate ESPP based on the principles of avoidance, minimization, and mitigation. The current ESPP was developed and finalized through a multi-stakeholder and participatory consultation process, including the World Bank. The World Bank's Safeguards Diagnostic Review in 2008 concluded that POWERGRID's ESPP was fully equivalent to World Bank safeguard policies for Environmental

Assessment, Natural Habitats, Forests, Physical Cultural Resources, Involuntary Resettlement and Indigenous Peoples.[1]

Transmission line projects are considered environmentally clean and are exempted by the Ministry of Environment, Forests and Climate Change (MoEF&CC) from the requirements of the Environment (Protection) Act, 1986. However, when transmission projects pass through forest land, clearance must be obtained from relevant authorities under the Forest (Conservation) Act, 1980.

Under the Forest (Conservation) Act, 1980, prior approval from the Regional Offices of MoEF&CC shall be obtained for affected areas classified as forest that will be traversed by the transmission line after detailed survey and finalization of route through the forest area in consultation with local forest authorities. In this case, most of the forests that will be traversed by the transmission line routes are plantations along the road and canal crossings and are already degraded.

Local communities and stakeholders including women's groups were involved in the process of environmental assessment through on-site discussions. Formal public consultations in the Project areas were conducted in the months of May and June 2016 and will continue throughout the Project cycle. As the Project will not have any significant environmental and social impacts, local communities support the Project. The grievance redress mechanism will function according to POWERGRID's ESPP procedures, which are consistent with multilateral banks such as the World Bank and the relevant national regulations.

Environmental and social impacts associated with the Project components are restricted to the clearing and maintenance of the right-of-way (RoW). With the development of innovative tower design being implemented by POWERGRID, the RoW requirements for 400 kV D/C lines have been reduced from 52 m to 46 m. Even with ESPP and innovative design, some residual impacts cannot be entirely avoided, as about 23.0 hectares of land designated as forest land by the Government of India (GoI) will be affected by the Project components.

Potential impacts are mostly temporary. The routes of the transmission lines have been finalized so as to avoid any wildlife sanctuary or protected areas and other environmentally sensitive areas as well as settlement areas. Since the Bays extension work is proposed within the boundaries of the existing substations, there is no permanent land acquisition or physical displacement involved in the Project. Impacts are temporary in nature in terms of loss of crops and trees, and use of RoW, land below the transmission lines and footings of the towers. A draft Compensation Plan for Temporary Damages (CPTD) has been prepared to compensate these damages. This plan will be finalized following estimation of likely damages as part of detailed surveys, which will take place prior to execution of the work.

Best available technology and best management practices are built-in to the Project design. All Project components will be implemented and monitored in line with POWERGRID's ESPP, which is in line with ADB's SPS.

An EMP with cost estimates included in the budget as well as environmental and social monitoring plan is an integral part of this IEER. A semi-annual environmental monitoring report will be submitted to ADB and AIIB and will be disclosed publicly on the ADB and AIIB websites.

1 World Bank. Piloting the Use of Country Systems to Address Environmental Safeguard Issues at the Power Grid Corporation of India, Ltd., February 2009.

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SECTION – I : PROJECT DESCRIPTION

1.0 BACKGROUND

The Southern Region of the country is facing power deficit mainly due to (i) delay/deferment of anticipated generation projects and (ii) due to non-availability of gas for existing gas projects in Southern Region. As on date maximum power demand of Southern region is about 39000 MW and faces a deficit of about 3400 MW in spite of import capacity of about 4920 MW from NEW grid. As per 18th EPS of CEA the expected power demand of Southern region by the end of XII and XIII plan would be about 57,200 MW and 82,200 MW respectively. Envisaged generation addition indicates power transfer requirement to Southern Region is expected to increase in coming years particularly under certain scenarios. Therefore, in view of large deficit and requirement of transmission system to meet future requirements, the implementation of HVDC link has been proposed with a capacity of 6000 MW. Also, considering conservation of RoW problem in Kerala and dispersal of power beyond Pugalur, establishment of VSC (Voltage Source Converter) based 2000 MW HVDC link between Pugalur and North Thrissur (Kerala) has also been proposed. As decided during the standing committee meeting the project shall be built as three separate schemes as follows;

Scheme # 1 : Raigarh-Pugalur 6000 MW HVDC System;
Scheme # 2 : AC System strengthening at Pugalur end;
Scheme # 3 : Pugalur-Thrissur 2000 MW VSC Based HVDC System.

The scheme has been discussed and agreed in the 37th & 38th meeting of Standing Committee on Power System Planning in Southern Region held on 31st July, 2014 & 7th March, 2015 and in the 26th meeting of Southern Region Power Committee (SRPC) held on 20th December, 2014. Further, the scheme has been discussed and agreed in the Joint meeting of the Standing Committee on Power System Planning of Southern Region meeting and Western Region held on 20th April, 2015. Ministry of Power (MoP) vide letter dated 10/12/2014 has approved the implementation of the scheme by POWERGRID under compressed time schedule through regulated tariff mechanism. Further, the scheme has also been discussed and agreed in the 34th Empowered Committee Meeting on Transmission held on 13th April, 2015 for implementation of the scheme under regulated Tariff mechanism.

Scheme # 2 & Scheme # 3 should be in place before commissioning of 6000 MW Raigarh- Pugalur link (Scheme # 1).The issue of commissioning of Scheme1, 2 & 3 was again discussed in 39th meeting of standing committee of SR held on 28-29 December 2015, where it was agreed that the delivery schedule of scheme 2 & 3 should be kept or at least matching with that of scheme1. In case of any mismatch during execution of these schemes, their usefulness shall be discussed with CEA before their commissioning. Under the present project Scheme # 2: AC System strengthening at Pugalur end has been proposed.

POWERGRID has requested financing from Asian Development Bank (ADB) and the Asian Infrastructure Investment Bank (AIIB) for the 400 kV transmission lines included in Scheme 2 (the related substations are being funded by ADB). The AIIB has agreed to the application of ADB's SPS, which the AIIB has found to be materially consistent with its Environmental and Social Policy and Environmental and Social Standards, and which has appropriate monitoring procedures in place.

The Project is classified as Category "B" under the provisions of ADB's SPS. Accordingly, this IEER has been prepared to meet ADB's requirements. This IEER includes an Environmental Management Plan (EMP) for project implementation and monitoring.

1.1 PROJECT OBJECTIVE:

The objective of the project is to enhance capacity of electricity supply in Southern Region.

1.2 PROJECT JUSTIFICATION

Southern Region is facing power deficit which has arisen mainly due to – (i) delay/deferment of anticipated generation projects for example, Krishnapattam UMPP (4000 MW), Cheyyur UMPP(4000 MW), Udangudi TPS, IPP projects in Nagapatanam/ Cuddalore area (3000 to 4000 MW), Kundankulam APP (2000MW), Kalpakkam PFBR (500 MW), East coast project in Srikakulam (1320 MW), Gas based projects in Vemagiri (about 3000 MW) etc. and (ii) due to non-availability of gas for existing gas projects in Southern Region.

As on date maximum power demand of Southern region is about 39000 MW. As per 18th EPS of CEA the expected power demand of Southern region by the end of XII and XIII plan would be about 57,200 MW and 82,200 MW respectively. Hence power transfer requirement to Southern Region is expected to increase in coming years. Therefore, to facilitate the import of power to Southern region and considering the long distance, it has been proposed that power can be transferred over HVDC system along with the associated A.C Transmission system at 400 kV level. Accordingly, ±800 KV 6000 MW HVDC link with terminals at Raigarh & Pugalur along with VSC based 2000 MW HVDC link between Pugalur and North Trichur (Kerala) has been proposed. As decided during the Joint meeting of the Standing Committee on Power System Planning of Southern Region meeting and Western Region held on 20th April, 2015 the scheme is to be implemented as three separate schemes as discussed above.

The present report deals with transmission system to be implemented under Scheme-2 i.e. AC System strengthening at Pugalur end. The proposed system would help in direct supply to Tamil Nadu and Kerala relieving the tie line flow from NEW grid to Southern region and tie line flow between S1-S2. HVDC with its control features shall provide flexibility during operation and help in controlling the power flow on parallel AC lines and provide damping as and when need arises.

1.3 PROJECT HIGHLIGHTS

a)	Project Name	:	HVDC Bipole link between Western region (Raigarh, Chhattisgarh) and Southern region (Pugalur, Tamil Nadu)- North Thrissur (Kerala) - **Scheme # 2: AC System strengthening at Pugalur end.**
b)	Location	:	Southern Region
c)	Beneficiary States/UT	:	Tamil Nadu and Kerala
d)	Project Cost	:	Rs. 1929.39 Crores
e)	Commissioning Schedule	:	30 months from the date of Investment approval

1.4 PROJECT SCOPE & PRESENT STUDY

The present Initial Environment Examination Report (IEER) is a document developed to identify possible environmental and social issues associated with construction of 5 transmission lines & associated 16 nos. of line bays at different substation in Tamil Nadu State under Scheme # 2 of HVDC project. The IEER provides insight on possible environment & social issues and list management measures to minimize/mitigate them based on POWERGRID's Environment and Social Policy & Procedures (ESPP) and ADB's Safeguard Policy Statement, 2009(SPS). Following are scope of work covered under present IEER;

A. Transmission lines

1. Pugalur HVDC Station – Pugalur (Existing) 400kV (quad) D/c line – **55 km** approx.;
2. Pugalur HVDC Station – Arasur 400kV (quad) D/c line - **58 km** approx.;
3. Pugalur HVDC Station – Thiruvalam 400kV (quad) D/c line – **390 km** approx.; with 2x80 MVAR line reactor at Pugalur HVDC Station end and 2x63 MVAR line reactor at Thiruvalam 400kV end (existing 1x63 MVAR bus reactor shall be utilized as line reactor in one circuit and the second circuit shall have new 63 MVAR line reactor);
4. Pugalur HVDC Station – Edayarpalayam (TANTRANSCO) 400kV (quad) D/c line- **56 km** approx.;
5. Edayarpalayam (TANTRANSCO) Udumulpet 400kV (quad) D/c line- **56 km** approx..

B. Substations

1. 8 nos. of 400kV line bays at Pugalur HVDC Station for termination of 4 nos. of 400kV Quad lines. 2x80 MVAR line reactor at Pugalur HVDC Station end for Pugalur HVDC Station – Thiruvalam 400kV (quad) 400kV D/c line.
2. 2 nos. of 400kV line bays at Arasur for terminating Pugalur HVDC Station – Arasur 400kV (quad) D/c line
3. 2 nos. of 400kV line bays at Thiruvalam for terminating Pugalur HVDC Station – Thiruvalam 400kV (quad) D/c line along with line reactors as mentioned above.
4. 2 nos. of 400kV line bays at Pugalur (Existing POWERGRID stn) for terminating Pugalur HVDC Station – Pugalur (Existing) 400kV (quad) D/c line.
5. 2 nos. of 400kV line bays at Udumulpet for terminating Edayarpalayam – Udumulpet 400kV (quad) D/c line.

The proposed project activities include the survey for finalizing the route alignment and construction of above transmission lines and line bays at connecting substations. Lattice towers are erected on designated places using normal excavation and foundations, thereafter conductors are strung across these using manual/stringing machines.

The schematic showing the transmission grid of Southern Region highlighting the proposed line covered under the subject IEER is placed as **Exhibit - I.**

SECTION - II: BASELINE DATA

2.0 The proposed scheme is located Tamil Nadu State covering Coimbatore, Tirupur, Karur, Namakkal, Erode, Salem, Dharmapuri, Thiruvanamalai & Vellore districts. The basic environmental settings of the State and subproject districts in particular are discussed below:

2.1 TAMIL NADU:

Tamil Nadu is situated on the south eastern side of the Indian peninsula. It is bounded on the east by Bay of Bengal, in the south by the Indian Ocean, in the west by the states of Kerala and Karnataka and in the north by the Karnataka and Andhra Pradesh. Tamil Nadu has a geographic area of 130,058 sq. km, which constitutes 3.96% of the land area of the country. It lies between 08°04' N and 13°34' N latitude and 76°14'E and 80°21'E longitude.

Physiographically the state can be divided into two natural divisions: the eastern coastal plain and the hilly region along the north and the west. Along the whole length of the western part, at a distance from the sea varying from 80 to 160 km runs the range of the Western Ghats, a steep and rugged mass averaging 1220 meters above the sea level and rising to 2440 metres at the highest point. The slopes of the Western Ghats are covered with heavy evergreen forests. The Nilgiris and the Anamalai are the hill groups with the maximum height. The general land use pattern of the State is given in **Table 2.2**.

Table 2.2: Land use Pattern

Land use	Area in '000 ha	Percentage
Total Geographical area	13,006	
Reporting Area for land utilization	13,033	100.00
Forests	2,125	16.31
Not available for cultivation	2,672	20.50
Permanent Pasture & Grazing land	110	0.84
Land under misc. tree crops & groves	250	1.91
Culturable waste land	328	2.52
Fallow land & other than current fallows	1,696	13.01
Current fallows	1,308	10.04
Net area Sown	4,544	34.87

Source: Land use statistics, Ministry of Agriculture, GOI, 2012-13

Coimbatore district lies between 10°10"-11°30" N latitude and between 76° 40"-77°30" E longitude. It has an area of 7469 sq km and is bounded by the Nilgiris on the north, Erode district on the east, Dindigal district on the south and the State of Kerala on the west.

Tiruppur district has been carved out of Coimbatore and Erode districts in the year 2008. The district has total geographical area of 5186.34 sq km and lies between 11°06'27"N-11°10'75"N latitude and 77°20'23"E-77°33'98"E longitude. Tiruppur district is bounded by Coimbatore district in the west side, Erode district to the north and northeast side and Karur district in the east side and Dindigul district in the south east side and to the south side, it is surrounded by Idukki district of Kerala.

Karur district lies between 11°00'N-12°00'N latitude and 77°28'E-77°50'E longitude. The district has a total geographic area of 2895.57 sq. km. and is surrounded by Erode district in the east, Tiruchirapalli district in the west, Namakkal district in the north and by Dindigul district in the south.

Namakkal district was created by bifurcating the erstwhile Salem district and created in 1997. The geographical area of the district is 3363.35 sq km and lies between 11°13'-11°36'N latitude and 77°28'-78°30'E longitude. The district is bounded by Perambalur & Salem districts in the east, Erode district in the west, Salem district in the west & Karur district in the south.

Erode district lies on the extreme north of Tamil Nadu having geographical area of 5722 sq km and is located between 10°36'N-11°58'N latitude and 76°49'E-77°58'E longitude. The district is surrounded by Karnataka state in north-west, Coimbatore district in the west, Dindugal district and Karur District in the south and Salem and Namakkal district in the east.

Salem district is located between 11°14'N-12°53'N latitude and 77°44'E-78°50'E longitude with a total geographic area of 5237 sq kms. Salem District is bordered by the districts of Dharmapuri in the north, Erode in the west, Namakkal in the south, Perambalur in the south and south-east and Viluppuram in the east.

Dharmapuri district lies between 11°47'N-12°33'N latitude and 77°28'E-76°45'E longitude and has a geographic area of 9622 sq kms. The district is surrounded by Vellore, Villupuram and Thiruvannamalai districts in the east, by Erode district and the state of Karnataka in the west, by Andhra Pradesh and Karnataka state in the north and by Salem district in the south.

Tiruvannamalai came into existence as a separate district of Tamil Nadu on 30th Sept. 1989 by the bifurcation of the erstwhile North Arcot District. It is located between 11°55'N -13°15'N latitude and 78°20'E-76°45'E longitude and has a geographic area of 9622 sq km. The district is bounded on the north and west by Vellore District, on the south-west by Krishnagiri district, on the south by Villupuram district and on the east by Kanchipuram district.

Vellore district lies between 12° 15' -13° 15'N latitude and 78° 20' - 79° 50'E longitudes in Tamilnadu State. The geographical area of this district is 6077 sq km. It is bounded on north by Chittoor district of Andhra Pradesh, on the south by Thiruvannamalai district and on the west by Krishnagiri district, and on the east by Thiruvallr and Kanchipuram districts. The western parts of the district are endowed with pleasing hilly sceneries like Yelagiri Hills while the Eastern side of the District is mostly covered by rocky bases.

Climate:

The climate of Tamil Nadu is characterized as tropical with little variation in summer and winter temperatures. The hottest period is April-June, with the temperature rising up to 40°C. November-February is the coolest period with average temperature hovering around 20°C. Tamil Nadu gets its rain from North-East Monsoons between October and December. The average annual rainfall in Tamil Nadu ranges between 635-1905 mm. The coastal region of Tamil Nadu becomes uncomfortably warm and humid during summers; however, nights are cool and pleasant due to sea breezes.

Coimbatore district has a pleasant climate with mild winter and moderate summer. During summer, the maximum temperature goes up to 34.7°C, while minimum temperature hovers around 21°C. In winters, the recorded maximum and minimum temperatures are 32.2°C and 19.2°C respectively. Rainy season extends from September to November. Average annual rainfall is 61.22 cms.

Tirupur has a salubrious climate, which prevents temperature going to extreme levels. March, April and may are summer months. Temperature ranges from 29°C - 35°C,

which is much lower than the rest of Tamil Nadu. Monsoon season consisting of months of June, July and August is characterized by mild showers and a fall in temperature. The average annual rainfall of the district is 700 mm. September to January is considered as winter months. Maximum temperature during winter is 29°C, while minimum is 24°C. In the months of October and Early November, some rainfall occurs due to North-East Monsoon.

Karur district enjoys a tropical climate. The period from March to May is generally hot and dry. The mean maximum temperature ranges from 26.7 to 38.56 °C and the mean minimum temperature ranges from 18.7 °C to 29.3 °C. The district receives the rain under the influence of both Southwest and Northeast monsoons. The Northeast monsoon chiefly contributes to the rainfall in the district. Most of the precipitation occurs in the form of cyclonic storms caused due to the depressions in Bay of Bengal. The average annual rainfall over the district varies from about 620 mm to 745 mm.

Namakkal district also enjoys a tropical climate. The hot weather begins early in March, the highest temperature being felt in April and May. Weather cools down progressively from about the middle of June and by December. The district receives most of the precipitation in the form of cyclonic storms caused due to the depressions in Bay of Bengal. The Southwest monsoon rainfall is highly erratic and summer rains are negligible. The normal annual rainfall over the district varies from 640 mm to 880 mm.

Erode district in general is characterized with a scanty rainfall and a dry climate. The district has dry weather throughout the year except during the monsoon season. The hot weather begins early in March, the highest temperature being reached in April and May with temperature of 40°C. The district in general is characterized with a scanty rainfall and a dry climate. The normal annual rainfall over the district varies from about 575 mm to about 833 mm. The western part of the Erode district enjoys a salubrious climate because of the hilly region

Salem district enjoys a tropical climate. The weather is pleasant during the period from November to January. In the period June to November the afternoon humidity exceeds 60% on an average. The hot weather begins early in March, the highest temperature is being reached in April and May. From the middle of June and by December, the mean daily maximum temperature drops to 30.2°C, while the mean daily minimum drops to 19.2°C. The district receives the rain under the influence of both Southwest and Northeast monsoons. The normal annual rainfall over the district varies from about 800 mm to 1600 mm. The Normal Rainfall of the district during Southwest monsoon is 380 mm and during Northeast monsoon is 347 mm.

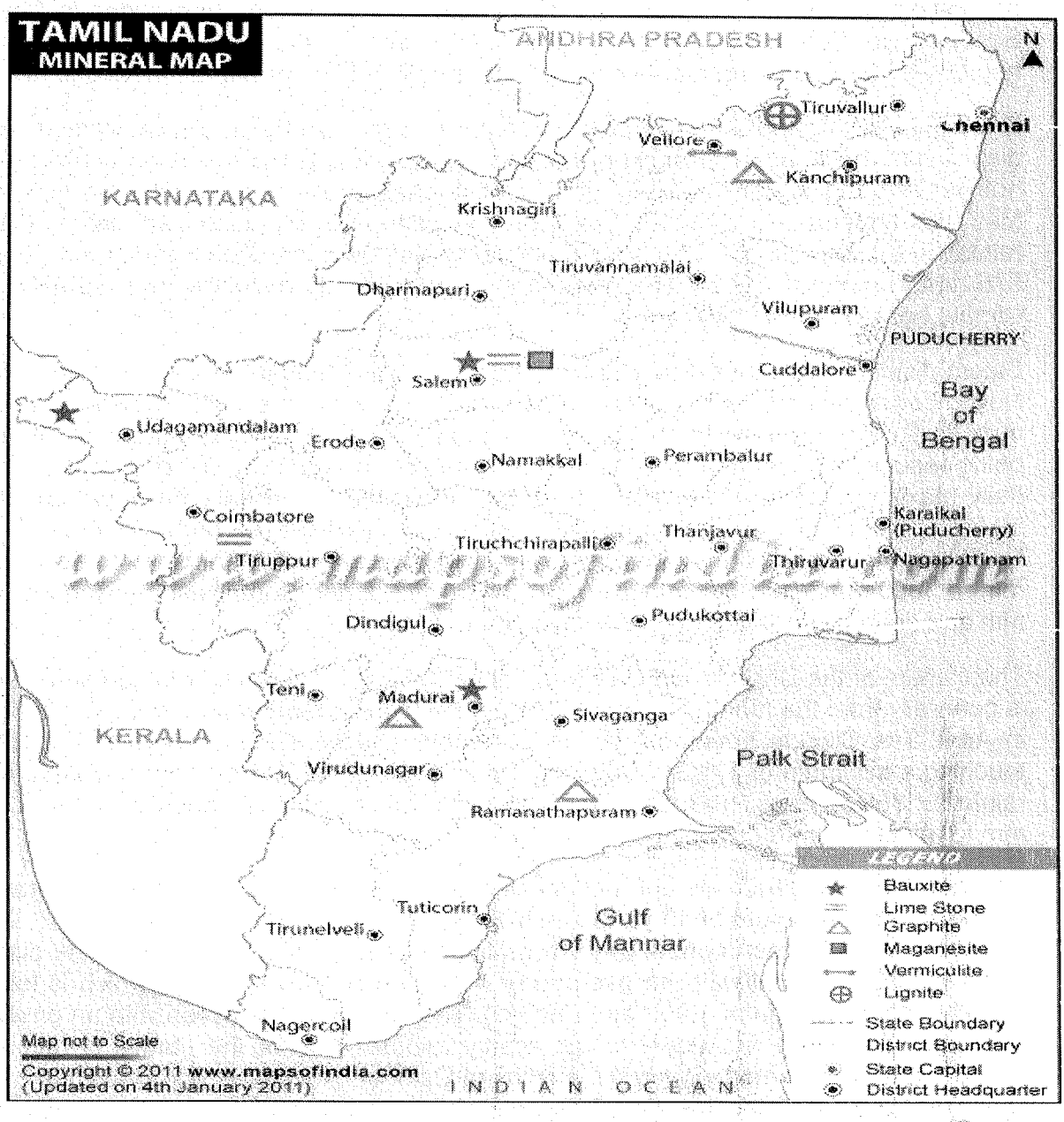
The climate of the Dharmapuri District is generally warm. The hottest period of the year is generally from the months of March to May, the highest temperature going up to 38°C in April. The Climate becomes cool in December and continuous so up to February, touching a minimum of 17° C in January. On an average the District receives an annual rainfall of 895.56 mm. The normal annual rainfall over the district varies from about 760 mm to about 910 mm.

Tiruvannamalai experiences hot and dry weather throughout the year. The temperature ranges from a maximum of 40 °C to a minimum of 20 °C. Like the rest of the state, April to June are the hottest months and December to January are the coldest. The district receives scanty rainfall with an average of 815 mm (32.1 in) annually, which is lesser than the state average of 1,008 mm (39.7 in). The southwest monsoon with an onset in June and lasting up to August brings scanty rainfall. Bulk of the rainfall is received during the northeast monsoon in the months of October, November and December. The average humidity of the town is 77% and varies between 67% to 86%. During the summer months of April to June, the humidity ranges from 47–63%.

Vellore district experiences a moderately tropical climate. Summer arrives in the month of April and persists till June. The days are hotter. Nights are relatively cooler with a sudden drop in temperature in the evening due to the sea breeze. Vellore experiences hot and dry weather throughout the year. During summer maximum temperature is 39.8°C and minimum is 29.4°C, During winter the maximum temperature is 27.3°C and minimum is 17.9°C. The average annual rainfall is 795mm, out of which Northeast monsoon contributes to 535mm and the Southwest monsoon contributed to 442mm. The bulk of the rainfall is received during the Northeast monsoon in October, November and December. The humidity ranges from 40%–63% during summer and 67%–86% during winter.

Minerals:

Tamil Nadu is the leading holder of country's resources of vermiculite, magnetite, dunite, rutile, garnet, molybdenum and ilmenite. The State accounts for the country's 81% lignite, 75% vermiculite, 69% dunite, 59% garnet, 52% molybdenum and 30% titanium minerals resources. Important minerals and their places of occurrence are given below:



S. N.	Mineral	Districts/Places of Occurrence
1	Bauxite	Dindigul, Namakkal, Nilgiris, Salem
2	Feldspar	Coimbatore, Dindigul, Erode, Kanchipuram, Karur, Namakkal, Salem, Tiruchirapalli
3	Fireclay	Cuddalore, Kanchipuram, Perambalur, Pudukottai, Sivaganga, Tiruchirapalli, Vellore, Villupuram
4	Granite	Dharmapuri, Erode, Kanchipuram, Madurai, Salem, Thiruvannamalai, Tiruchirapalli, Tirunelveli, Vellore, Villupuram
5	Graphite	Madurai, Ramnathapuram, Shivganga, Vellore
6	Gypsum	Coimbatore, Perambalur, Ramnathapuram, Tiruchirapalli, Thoothukudi, Virudhunagar
7	Lignite	Cuddalore, Thanjavur, Thiruvarur, Nagapattinam, Ramnathapuram
8	Limestone	Coimbatore, Cuddalore, Dindigul, Kanchipuram, Karur, Madurai, Nagapattinum, Namakkal, Perambalur, Ramnathapuram, Vellore,
9	Dunite	Salem
10	Lignite	Cuddalore, Thanjavur, Thiruvarur, Nagapattinum, Ramnathapuram
11	Vermiculite	Dharmapuri, Tiruchirapalli, Vellore
12	Garnet	Ramnathpuram, Tiruchirapalli, Tiruvarur, Kanyakumari, Thanjavur, Tirunelveli
13	Molybdenum	Dharmapuri, Dindigul, Vellore
14	Titanium	Kanyakumari, Nagapattinum, Ramnathapuram, Thiruvallur, Tirunelveli, Thoothukudi

Soil :

The major soil groups of Tamil Nadu are Red soil (62%), Black soil (12%), Laterite soil (3%) and Coastal soil (7%). As per USDA system of soil classification, the soils of Tamil Nadu are divided into six orders, out of which around 50% of total area of Tamil Nadu is occupied by Inceptisol followed by Alfisols, which occupy 30% of total state area. Vertisols cover around 7% of total state's area, Entisols cover 6% and Ultisols cover 1% of total area. Mollisols cover negligible area of Tamil Nadu.

The soils of Coimbatore district can be broadly classified into 6 major soils types viz., Red calcareous Soil, Black Soil, Red non-calcareous, Alluvial and Colluvial Soil, Brown Soil, and Forest Soil. About 60 per cent of the district is covered by red soils, of which red calcareous soil is predominant.

In Tirupur district, Black soils and Red soils are the major soil types. These two soil types occupy about 96% of total area, with rest 4% shared by other soils.

In Karur, Black soil is the predominant soil type in this district accounting for 35.51% followed by lateritic Soil for 23.85%. The other type of soil is sandy, coastal alluvium for 20.31%.

The soils of Namakkal district can be broadly classified into 5 major soils types viz., Red Soil, Black Soil, Brown soil, Alluvial and Mixed Soil. Major part of the district covered by Red Soil. Mixed soil is the second major soil type occurring in the districts.

The soils of Erode district can be broadly classified into 6 major soils types viz., Red calcareous soil, Red non calcareous soil, Black Soil, Alluvial and Colluvial soils, Brown soil and Forest soil. Major part of the district covered by red calcareous soils. They are mostly sandy to loamy and characterized by the hard and compact layer of lime.

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The soil type in Salem district is mostly Red soil, of which Non-Calcareous soil predominant occupying 66.3% of total area of the district. The next type is Red calcareous with 29.3 per cent followed by Black (3.8%) and Alluvial deposits (0.6%).

The soils of Dharmapuri district can be classified into i) Red Soil, ii) Red lateritic soil, (iii) Brown soil and iv) alluvial soil. The soils of the district are mostly in-situ in nature, lateritic, earthy and pale reddish in colour.

The predominant soil type found in Thiruvannamalai district is red loam. Different types of soils like ferrogeneous loamy and sandy loamy are also found extensively in the district. The others major soil types are laterite soil and black soil.

Soils of Vellore district can be classified into 1) Sandy soil 2) Sandy loam 3) Red loam 4) Clay 5) Clayey loam and 6) Black cotton soils. The predominant soil types found in Vellore district is red loam constituting 47.6 % of total geographical area. .

Water Resources:

a) Surface Water:

The total surface water potential of the state is 24864 Million Cubic Metres (MCM). There are 17 major river basins in the State with 61 reservoirs and about 41,948 tanks. Of the annual water potential of 46540 MCM, surface flows account for about half. The rivers of the state flow eastward from the Western Ghats and are entirely rain-fed. The 760 kms long Kaveri River is the longest river of Tamil Nadu. This river is popularly called the "Ganga of the South" or the "Dakshina Ganga" and divides the state in two halves. The other important rivers of the state are Palar, Cheyyar, Ponniyar, Meyar, Bhavani, Amaravati, Vaigai, Chittar and Tamaraparni, Noyil, Suruli, Gundar, Vaipar, Valparai and Varshali.

The major rivers in subprojects area districts are Kaveri, Palar, Ponnaiyar, Bhavani, Noyyal, Amaravathi, Aliyar, Vellar, Nallar etc..

b) Ground Water:

The utilizable groundwater recharge in the state is 22,423 MCM. The current level of utilization expressed as net ground water draft of 13,558 MCM is about 60 percent of the available recharge, while 8875 MCM (40 percent) is the balance available for use. Over the last five years, the percentage of safe blocks has declined from 35.6 per cent to 25.2 percent while the semi-critical blocks have gone up by a similar percentage. Over-exploitation has already occurred in more than a third of the blocks (35.8 percent) while eight blocks (2 percent) have turned saline. The water level data reveals that the depth of the wells ranges from an average of 0.93 metres in Pudukottai district to 43.43 metres in Erode. According to the Central Groundwater Board, there has been a general decline in groundwater level in 2003 due to the complete de-saturation of shallow aquifers.

The net groundwater availability for Coimbatore district is 792.874 MCM, whereas, existing Gross draft for all uses currently stands at 821.102 MCM, which indicates 104% groundwater development. The estimation of groundwater resources for the district has shown that out of 19 blocks, 11 blocks are overexploited and 4 blocks are under critical category.

The ground water scenario in Tirupur district also not good and requires attention. Out of 13 blocks of the district, 1 block falls in Over-Exploited category and 3 blocks fall in

critical category, while 8 blocks are categorized as Semi-critical. Only 1 block is falling under Safe category.

The annual replenishable ground water resources of Karur district stand at 321.45 MCM, while net annual Ground Water draft is 220.15 MCM, which corresponds to 68.5% ground water development. Out of 8 blocks of the district, 2 falls in Over Exploited category, while 2 others are categorized as semi critical.

In Erode district, the total quantity of annual replenishable ground water is 769.62 MCM, while net annual ground water draft is 1268.26 MCM. This indicates 135.29% development of ground water. Out of 20 blocks of the district, 3 are categorized as Over Exploited, 4 blocks as critical and 1 block as semi critical.

In Namakkal district, the total quantity of annual replenishable ground water is 493.51 MCM, while net annual ground water draft is 514.31 MCM. This indicates 104% development of ground water. Out of the 15 blocks of the district, 8 blocks are categorized as over exploited and 2 blocks are under critical category.

The net groundwater availability for Salem district is 855.12 MCM, whereas, existing gross draft for all uses currently stands at 1268.26 MCM, which indicates 148% groundwater development. The estimation of groundwater resources for the district has shown that out of 20 blocks, 14 blocks are overexploited and 1 block is under critical category.

Similarly, the net groundwater availability for Dharmapuri district is 496 MCM, whereas, existing gross draft for all uses currently stands at 737.69 MCM, which indicates 149% groundwater development. The estimation of groundwater resources for the district has shown that out of total 8 blocks, 7 blocks are overexploited and 1 block is under critical category.

In Thiruvannamalai district, the estimated total quantity of annual replenishable ground water is 1439.7 MCM, while net annual ground water draft is 1538.5 MCM which indicates 107% development of ground water. Out of the 18 blocks in the district, 8 blocks are categorized as over exploited, 2 blocks are in critical and 5 blocks are under critical category.

In Vellore district, the total quantity of annual replenishable ground water is 984.84 MCM, while net annual ground water draft is 1377.74 MCM which indicates 149% development of ground water. Out of the 20 blocks of the district, 16 blocks are categorized as over exploited and 1 blocks are under critical category.

Ecological Resources:

Forest: The recorded forest area is 22,877 sq. km which constitutes 17.59% of the geographic area of the State. According to legal status, Reserved Forests constitute 84.70% (20,293 sq km), Protected Forests constitute 7.9% (1,782 sq km) and Un-classed Forests constitute 3.50% (802 sq km) of the total forest area. Forest Map of Tamil Nadu is enclosed as **Map-1**. Tamil Nadu's forests are largely deciduous and thorn types and these two major types account for 87.30 % of the total forest area. Based on interpretation of satellite data, total forest cover is 23,844 sq. km which is 18.33% of State's geographical area. In terms of forest canopy density classes, the State has 2,948 sq. km of very dense forest, 10,199 sq. km of moderately dense forest and 10,697 sq. km of open forest.

The proposed transmission lines shall pass through 8 districts of Tamil Nadu having 4.17% and 35.17% respectively. Although forest involvements in the most of the lines are completely avoided through adopting careful route selection technique, some forest stretch (approx. 5 km, 23ha.) couldn't be avoided in case of 400kV Pugalur- Thiruvalam line due to geographical constraints. The details of forest resources available in the subproject area districts are as follows:

District	Geographic area	(Area in Sq. km)				% Forest cover
		Very Dense forest	Mod. Dense forest	Open forest	Total	
Coimbatore*	7,469	377	943	1,307	2,627	35.17
Erode*	8,209	485	1,285	651	2,421	29.49
Karur	2,901	0	34	87	121	4.17
Namakkal	3,413	54	211	309	574	16.82
Salem	5,235	130	479	826	1,435	27.41
Dharmapuri	9,622	271	1,436	1,573	3,280	34.09
Thiruvanamalai	6,191	174	493	632	1,299	20.98
Vellore	6,077	187	680	990	1,857	30.56

Source: Indian State of Forest Report, 2015
*** Tiruppur district was earlier part of Erode and Coimbatore districts***

Protected Areas:

The protected areas of Tamil Nadu extend to 6,708 km² constituting 5.16% of the geographic area and 29% of the recorded forest area. Tamil Nadu ranks 14th among all the States and Union Territories of India in terms of protected area. There are 14 Wildlife sanctuaries over 5,707.13 sq. km. and 14 bird sanctuaries over 173.34 sq. km., 5 National Parks over 827.63 sq. km., 4 Tiger Reserves, 4 Elephant Reserves and 3 Biosphere Reserves for in situ conservation of wild fauna and flora. There is one Conservation Reserve in Tamil Nadu. List of protected areas in subproject districts is given below:

Sl. No	Name of Protected Areas	Year of Establishment	Area (sq km)	District(s)
National Parks(NP)				
1.	Indira Gandhi (Annamalai)	1989	117.10	Coimbatore
Wildlife Sanctuaries(WLS)				
2.	Indira Gandhi (Annamalai)	1976	841.49	Coimbatore
3.	Satyamangalam	2008	524.35	Erode
4.	Vellode	1997	0.77	Erode
5.	Cauvery North	2014	504.33	Dharmapuri

As evident from the above list that five protected areas are located in the subproject districts. However, all these protected areas are completely avoided, while selecting the route of the proposed lines.

Wetlands:

The total wetland area of the state is estimated around 902534 ha. (including 18,294 small wetlands of size <2.25 Ha. each) which is 6.92% of the state's geographic area. Major wetland types are Lake/Pond (316091 Ha.), Tank/Pond (237613 Ha.), River/Stream (136878 Ha) and Reservoir/Barrage (56419 Ha). The districts where the present subprojects are envisaged have the wetlands coverage as below:

District	Geographical area (sq.km.)	Wetland area (Ha.)	% of total wetland area (Ha.)	% of district geographic area
Coimbatore*	7,469	8,070	0.89	1.08
Erode*	8,162	13,570	1.50	1.66
Karur	2,896	16,383	1.82	5.66
Namakkal	3,363	7,687	0.85	2.29
Salem	5,205	15,270	1.69	2.93
Dharmapuri	4,498	18,215	2.02	4.05
Thiruvanamalai	6,191	48,130	5.33	7.77
Vellore	6,077	32,640	3.62	5.37

Source: National Wetland Atlas
*** Tiruppur district was earlier part of Erode and Coimbatore districts***

However, none of these wetlands are getting involved/impacted in routing/RoW of proposed lines..

Human and Economic Development:

Tamil Nadu has achieved reasonable economic growth in past few years. With a population of around 7, 21,47,030 as per 2011 census, it is one of the populous states of India. The population density is 555 per square km, which is higher than the national average. The sex ratio of the state is healthy 996 females per 1000 males, which is better than the corresponding national figure. People belonging to Schedule Castes constitute around 20% of total population, whereas, share of people belonging to Schedule Tribes is a miniscule 1.1%. The state enjoys a reasonably good literacy rate of 80.09% which is better than National Average of 74.04%. The Human Development Index of the state is 0.570, which also compares favorably with national average of 0.467.

Agriculture is the main source of livelihood with around 5139832 ha. of area under cultivation. Paddy is the main crop. It is raised in three crops. The first crop is known as 'Kuruvali' (the short term crop) with a duration of three and a half to four months from June - July to Oct-Nov. The second crop called 'Thaladi' has a duration of 5 to 6 months Oct -Nov to Feb -March. Third is 'Samba '(the long term) crop and has a duration of almost 6 months from Aug to January. Chief sources of irrigation are the rivers tanks and wells. Other major food crops are jowar, ragi, bajra, maize and pulses. Cotton, sugarcane, coconut, tea and coffee as well as a number of horticultural products like bananas and mangoes are cash crops while ground nuts, sesame, sun flower are important oil seeds crops. Major Industries in Tamil Nadu are cotton, heavy commercial vehicles, auto components, railway coaches, power pumps, leather tanning industries, cement, sugar, paper, automobiles and safety matches. Global auto majors Hyundai Motors, Ford, Hindustan Motors and Mitsubishi have commenced production plants. Ashok Leyland and TAFE have set up expansion plants in Chennai. The state is an important exporter of tanned skin and leather goods, yarn, tea, coffee, spices, engineering goods, tobacco, handicrafts and black granite. Tamil Nadu contributes to 60 per cent of the tannery industry in India. In recent times knowledge based industries like I.T. and Biotechnology have become the thrust area in the industrial scene in Tamil Nadu. TIDEL, a software technology park, has been established in Tharamani, Chennai. The software exports from the State during the year 2012-13 is expected to be around Rs. 50,000 crores with an impressive growth rate of more than 10%. Top I.T. and Telecom companies such as Nokia, Motorola, Foxcon, Flextronic and Dell have commenced production. Handloom is another important cottage industry. Silk sarees of Kanchipuram are famous all over India. Cottage units produce cotton sarees, dhoties, towels and lungies.

As per 2011 census, the total population of Coimbatore district is 34,58,045, which constitute 4.79% of the state's population. The district has a population density of 460 persons per square km. The Sex ratio of the district stands at 1000 females for every 1000 males, which is better than the corresponding national figure. The Literacy rate of the district is 83.98%, higher than national literacy average. Around 15.5% population belongs to Schedule Castes and just 0.82% population belongs to Schedule Tribes. Though, the economy of Coimbatore district is mainly driven by industries, Agriculture is still one of the main sources of livelihood in the district with more than 3,00,000 people are engaged in it, either as cultivators or as labourers. Sorghum, Groundnut, Rivce, maize are the main crops of the district. Tomato, Tapoica, Onion, Brinjal and Bhendi are the major vegetables grown in the district. Banana is the main fruit grown in the district followed by Mango, Grapes, Sapota and Amla. Coconut is the prominent cash crop of the district, while Tea, Coffee and cotton also provide cash income in the hands of the farmers. Coimbatore is one of the most industrialized districts of Tamil Nadu. There are more than 25,000 small, medium and large sale industries. Coimbatore houses a large number of small and medium textile mills. It also has central Textile research institutes, such as South India Textile Research Association. Some of the major industries present in Coimbatore are PSG, Sakthi group of Industries, Larsen and Toubro, Lakshmi Machine Works (LMW), Premier Instruments & Control Limited (PRICOL), Premier Evolvics, ELGI Equipments, Shanti Gears, Roots Industries Ltd etc. Coimbatore is also called as the Pump City. The Major Pump industries present in the district such as Suguna pumps, Sharp Industries, CRI Pumps, Texmo Industries, Deccan Pumps & KSB Pumps are renowned worldwide. Coimbatore is also emerging as an IT and BPO city with the presence of companies like Tata Consultancy Services, Cognizant Technology, CSS Corp etc. The city also houses numerous jewelers engaged in jewellery exports and a few Wind Energy Companies.

The total population of Tirupur district is 24,79,052 which forms 3.44% of the state's population(As per 2011 census). About 38.64% of district's population lives in rural areas. The district has a population density of 478 persons per square km. The Sex ratio of the district stands at 989 females for every 1000 males, which is better than the corresponding national figure. The Literacy rate of the district is 78.68%, higher than national literacy average. Around 15.97% population belongs to Schedule Castes and just 0.22% population belongs to Schedule Tribes. Though, Tirupur is largely an industrial district, Agriculture still plays an important role in its economy. In Tirupur, majority of farmers belong to small and marginal category and they play a critical role in ensuring agricultural productivity of the district. The total area of cultivation is around 2,28,556 ha., mainly for food and commercial crops. The chief food crops of the district are paddy, millets and pulses, while cotton, oil seeds and coconut are main non food commercial crops. Coconut is one of the most important plantation crops, which occupies around 16.10% of the total cultivated area. Mango, Banana, Amla and Guava are the main fruits grown in the district. The economy of the district is largely driven by industries specially those belonging to textile sector. There are 7068 registered industrial units in the district, out of which 69 belong to Medium and Large scale. There are 7 Industrial Areas in the district. Textile has been the back bone of the economy of the district. It is due its textile sector, Tirupur became world famous and popularly known as T-shirt town of India. There are 6250 textile based industries in the district, out of which 1500 are knitting units. Huge numbers of direct and indirect employment is generated due to textile industries in the district.

According to 2011 census, total population of Karur district is 1,076,588 which constitutes 1.48 % of the state's population. Out of the total population, 59.18 % population lives in rural areas & 40.82 % lives in urban regions of district. The district has a population density of 367 persons per square km. With a sex-ratio of 1,015 females for every 1,000 males, the district stands much above the national average of

929. Scheduled Castes and Scheduled Tribes accounted for 20.8% and 0.05% of the population respectively. The average literacy of the district was 68.3%, compared to the national average of 72.99%. The district had a total of 287,095 households. There were a total of 543,298 workers, comprising 83,800 cultivators, 182,639 main agricultural labourers, 10,162 in house hold industries, 231,906 other workers, 34,791 marginal workers, 2,072 marginal cultivators, 18,198 marginal agricultural labourers, 1,178 marginal workers in household industries and 13,343 other marginal workers. Karur District is a part of cauvery delta region and utilization of land area in the district is up to 44.59%. 45% of land in Karur is used for agricultural activities to produce Paddy, Banana, Sugarcane, Beetle Leaf, Grams & Pulses, Tapioca, Kora grass, Groundnuts, Oilseeds, Tropical vegetables, Garland flowers, and Medicinal herbs. Karur contributes USD 1.1 billion in GDP of Tamil Nadu. Service industry has been playing a vital role in the economy of this District. It has contributed 67% to the district's GDP in 2011-12. Karur is famous for its home textiles. Maximum units have been established in Textile & Apparels Based category followed by Chemicals & Petro Chemicals units. Karur has a niche in five major product groups — bed linens, kitchen linens, toilet linens, table linens and wall hangings. Overall Karur generates around Rs.6000 crores in foreign exchange through direct and indirect exports. Allied industries like ginning and spinning mills, dyeing factories, weaving etc., employs around 450,000 people in and around Karur. Karur District is renowned for its Bus Body building industry throughout South India. The presence of 200 builders of Bus body in the region attracts the investments in Automobile sector.

As per 2011 census, Namakkal district has a population of 1,726,601 which is 2.39% of State's population. Out of the total population, 59.68 % population lives in rural areas & 40.32 % lives in urban regions of district. The district has a population density of 367 persons per square km.. The district has a sex-ratio of 986 females for every 1,000 males, much above the national average of 929. Scheduled Castes and Scheduled Tribes accounted for 20.% and 3.3% of the population respectively. The average literacy of the district was 68.12%, compared to the national average of 72.99%. The district had a total of 475,511 households. There were a total of 898,245 workers, comprising 152,497 cultivators, 228,614 main agricultural labourers, 35,156 in house hold industries, 422,885 other workers, 59,093 marginal workers, 5,976 marginal cultivators, 25,112 marginal agricultural labourers, 3,641 marginal workers in household industries and 24,364 other marginal workers. The main occupation in the district is agriculture. The cultivation generally depends on monsoon rains. Nearly 90 percent of the cultivated area is under food crops. The principal cereal crops of this district are paddy, Cholam, cumnu and ragi. Panivaragu, Kuthiraivali, Samai Varagu and Thinai are some of themillets cultivated. Among pulses, the major crops redgram, blackgram, greengram and horsegram. Among oil, seeds, groundnut, castor, and gingelly (sesame) occupy important places. Of the commercial crops, sugarcane, cotton and tapioca are some of the important crops. Namakkal finds a place of importance in the map of India because of its Lorry body building industry, a unique feature of the town. More than 150 Lorry body building workshops and with a number of subsidiary industries of auto body works are operating since 1960's. There are Lorries, Trailers and L.P.G. Tanker Lorries. Therefore it is called as "Transport City". Finished trucks and Rig Units are even exported to foreign countries from Namakkal. Nearly 25000 people are employed, both directly and indirectly, in truck body building activity and about 300 units in Namakkal and 100 Units in Tiruchengode are engaged in this activity. Besides, Poultry development has been rather phenomenal in the district of Namakkal. The district is also well known for its poultry and dairy industries, accounting for a bulk of supply of poultry products to neighbouring industries. In fact, Namakkal produces about 65% of the egg output of Tamil Nadu. Hence, called as 'Egg City'. There are 21457 registered industrial units in the district, out of which 80 belong to Medium and Large scale. There

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are 2 Industrial Areas in the district. It is one of the most vital and vibrant districts in terms of Industrial development in the state. The district provides enough scope for the development and growth of Industries engaged in the textile garments, Power loom, Automobile body building, Poultry Feed, Sago manufacturing and Rig Manufacturing unit.

According to 2011 census, total population of Erode district is of 2,251,744 which form 3.12% of State's population. Out of the total population, 48.57 % population lives in rural areas & 51.43 % lives in urban regions of district. The district has a population density of 391 persons per square km.. The district has a sex-ratio of 993 females for every 1,000 males, much above the national average of 929. Scheduled Castes and Scheduled Tribes accounted for 16.41% and 0.97% of the population respectively. The average literacy of the district was 66.29%, compared to the national average of 72.99% The district had a total of 658,071 households. There were a total of 1,195,773 workers, comprising 173,376 cultivators, 331,414 main agricultural labourers, 48,960 in house hold industries, 557,301 other workers, 84,722 marginal workers, 4,794 marginal cultivators, 38,798 marginal agricultural labourers, 5,362 marginal workers in household industries and 35,768 other marginal workers. Agriculture is the most important income source of the district. Paddy, plantain, silk, cotton, turmeric, coconut and sugarcane are some of the major products from agriculture and allied industries. Erode is also known as Turmeric city as it is an important market center for turmeric and produce around 43% total turmeric of the State. Erode district is also the leading producer of plantain, coconuts and white silk. The country's first automated silk reeling unit is located in the district at Gobichettipalayam. Bhavani & Chennimalai are well known for handloom powerloom textile products and ready-made garments. The district is also rich in its natural cattle wealth and has carved out an enviable position for itself in the field of dairy development industry in the State. The Tamil Nadu Milk Producers Federation has a milk collection center and processing plant at Erode from where pasturised milk is transported in cases to different parts of the State every day.. There are also three Poultry Extension centres in the district. There are at Chengampalli, Polavakalipalayam and Bhavani Sagar. In the Industrial map of Tamil Nadu, Erode district has a place of unique importance with 40.32% of population depending on non-agricultural sector. Industries and trade naturally occupy a place of prominence in the economy of the district. Industries that flourished in early days in the area were handloom weaving, carpet manufacturing, cart manufacturing, oil-pressing, brass vessel manufacturing etc. The cotton textile industry in Coimbatore and handloom industry in Erode district have encouraged the growth of various ancillary industries to meet the needs of the textile mills. There are a number of leather tanneries in Erode area. Large quantities of leather are brought here for tanning and later exported to foreign countries. The Government has also come forward to provide incentives to small enterprenuers. Industrial estates have been set up at Erode and other places where full facilities are offered to small industrialists. Small units have been set up here for the manufacture of steel furniture, nuller screen, etc.

Salem district has a population of 3,482,056 which forms 4.83% of State's population (2011census). Out of the total population of the district, 49.05 % population lives in rural areas & 50.95 % lives in urban regions. The district has a population density of 655 persons per square km.. The district has a sex-ratio of 954 females for every 1,000 males, much above the national average of 929. Scheduled Castes and Scheduled Tribes accounted for 16.67% and 3.43% of the population respectively. The average literacy of the district was 65.64%, compared to the national average of 72.99%. There were a total of 1,694,160 workers, comprising 247,011 cultivators, 396,158 main agricultural labourers, 132,700 in house hold industries, 785,161 other workers, 133,130 marginal workers, 9,993 marginal cultivators, 58,052 marginal agricultural labourers,

8,803 marginal workers in household industries and 56,282 other marginal workers. Agriculture is the main source of livelihood of the people in this district and about 70 % of the population is engaged in agriculture.. The food crops are sown in more than 72 % of the cultivated land. The major food crops are paddy, cholam, cumbu, ragi, redgram, greengram, blackgram and horsegram Turmeric, sugarcane, mango, bannana, tapiaco, groundnut & gingelly, and the famous mango fruits are the cash crops. Paddy, jowar, tapioca, sugarcane, groundnut and cotton are the major commercial crops & plantation crops like coffee, areca nut and betel vine. The district is rich in mineral deposits like Magnesite, Bauxite, Granite, Limestone, Quartz and Iron ore. Allied industries like Magnesite mining, Cement manufacture, bricks manufacture, Aluminum smelting etc thrive well. The Salem Steel Plant was an ambitious project started with a view to utilize the locally available iron-ore from Kanchamalai to produce steel. Now it is a public sector company engaged in rolling out cast steel blacks into sheets of required dimensions. It has many magnesite factories operated by private and public sectors such as Burn Standard & Co, Dalmia Magnesites and Tata Refractories, SAIL refractories. Rope making is another major cottage industry. Ropes are made by people out of the fibres of coconut, aloe, cotton and jute. Salem has a sizeable weaver population and weaving is an important house hold industry here. Both silk and cotton fabrics woven in Salem find popular market throughout the state. Making of silver ornaments and artifacts by hand work is an important cottage industry in Salem. The district has 48 Medium Scale Industries, 32,561 Small Scale Industries and 5826 Cottage Industries.

According to 2011 census, Dharmapuri district has a population of 1,506,843 which constitutes 2.09% of State's population. Out of the total population, 82.68 % population lives in rural areas & 17.32 % lives in urban regions of district. The district has a population density of 655 persons per square km.. The district has with a sex-ratio of 946 females for every 1,000 males, much above the national average of 929. . Scheduled Castes and Scheduled Tribes accounted for 16.29% and 4.18% of the population respectively. The average literacy of the district was 60.9%, compared to the national average of 72.99%.[3] The district had a total of 375,873 households. There were a total of 751,170 workers, comprising 191,080 cultivators, 217,062 main agricultural labourers, 11,308 in house hold industries, 233,546 other workers, 98,174 marginal workers, 10,248 marginal cultivators, 50,283 marginal agricultural labourers, 4,033 marginal workers in household industries and 33,610 other marginal workers. The district economy is mainly agrarian in nature. Nearly 70% of the workforce is dependent on agriculture and allied activities. The district is one among most backward and drought prone area in the state. It also forms a major horticultural belt in the state. As the area is drought – prone it has become essential to switch over to cultivation of drought tolerant perennial fruit crops in this district. Mango is the main horticulture crop of this District. It has the highest area under the fruit crops . The district accounts for nearly one-third area under mango and nearly one-half of the mango yield in the state. The district is an industrially backward one. However, after the formation of the SIPCOT industrial Complex in Hosur, a number of medium and large-scale units were started, most of them in and around Hosur. Presently 112 large-scale units are located in the district. Besides these, there were 10880 SSI units in the district. Besides, availability of huge granite reserves helped the growth of quarries and granite polishing industry in the district.

As per 2011 census, Thiruvannamalai district has a population of 2,464,875 which forms 3.42% of State's population. Out of the total population, 79.92% population lives in rural areas & 20.08 % lives in urban regions of district. The district has a population density of 655 persons per square km.. The sex-ratio of 994 females for every 1,000 males, much above the national average of 929. Scheduled Castes and Scheduled Tribes accounted for 22.94% and 3.69% of the population respectively. The average literacy of the district is 66%, compared to the national average of 72.99%. The district has a total of 588,836 households. There are a total of 1,238,177 workers, comprising 265,183 cultivators, 351,310 main agricultural labourers, 37,020 in house hold industries, 316,559 other workers, 268,105 marginal workers, 27,458 marginal cultivators, 173,753 marginal

agricultural labourers, 9,700 marginal workers in household industries and 57,194 other marginal workers. Tiruvannamalai district is known for its two major businesses, agriculture and silk saree weaving. Paddy, sugarcane and groundnut are the major crops grown in the district. Rice cultivation and processing is one of the biggest businesses in this district. The modern rice mill near Cheyyar is the biggest government owned mill and Arani has around 278 rice mills. Kalambur is also has around 20 Rice mills and known for variety of rice called Kalambur Ponni rice. Dairy farming is an important source of subsidiary income to small and marginal farmers. Poultry is also an important occupation. The district is suitable for promotion of floriculture. Chengam, Arni, Polur, Thandarampet, Cheyyar blocks are potential blocks to promote horticulture and floriculture activities. With such a high work force in agriculture and low work force engaged in industrial / service front, the district has failed to achieve a high level of industrialization. The industrial activities are in low profile activities such as flourmills, silk reeling and footloose industries. The concentration of such traditional units is centred around Tiruvannamali, Polur and Arni. . Out of 6078 units concentrated in this district, 41 % are falling under the category of cottage and rural industries. Most of the units are based on local resources. Fruit, vegetable and floriculture are the major thrust sectors that are considered as sleeping giants in the district. The availability of rare herbs and medicinal plants in Jawadhu Hills and in melchengam offers promotion of medicinal extraction units in a big way. The concentration of neem trees in Thiruvannamalai and adjoining district of Villupuram offers promotion of neem based industries in this district. By and large, the district is suitable for promotion of agro-based industries. The construction of SIPCOT Complex is under way and it is hoped that it will attract huge investment opportunities in future

The population of Vellore district as per census 2011 was 3,936,331, with a density of 648 persons per square km. It constitutes 5.46% of State's population. Around 56.76% population lives in rural areas & 20.08 % lives in urban area. The district has a sex ratio of 1,007 females for every 1,000 males, much above the national average of 929. The average literacy of the district was 70.47%, compared to the national average of 72.99% The district has 929,281 households. There are 1,689,330 workers, comprising 153,211 cultivators, 254,999 main agricultural labourers, 106,906 in household industries, 845,069 other workers, 329,145 marginal workers, 21,897 marginal cultivators, 136,956 marginal agricultural labourers, 29,509 marginal workers in household industries and 140,783 other marginal workers. The district is primarily agrarian with a majority of its population involved in agriculture. 56% of land in Vellore is used for agricultural activities to produce Paddy, Millets & other Cereals, Pulses, Sugarcane and Cotton. Vellore is one of the top producers of sugarcane and cocunut in the state. Oil seeds that are cultivated are groundnut, coconut, sunflower and gingelly. Vellore is among the top 10 contributors to GDP of the State, it contributes USD 3.8 billion in GDP of Tamil Nadu. Service industry has been playing a vital role in the economy of this district. It has contributed 56% to the district's GDP in 2011-12. Tertiary and Secondary sector are growing at the rate of 10.5% & 9%. The investments have been observed to be happening in Trade, Hotel & Restaurants, Banking & Insurance, Real estate, Construction and Manufacturing. The district is vibrant in terms of economic activity with leather and leather based industrial activity being the prominent ones. The district accounts for more than 37% of the country's leather export. Asia's biggest explosives manufacturing company, Tamil Nadu Explosives Limited (TEL), is in Vellore at Katpadi. This is India's only government explosives company with more than a thousand employees. BHEL - Boiler Auxiliaries Plant at Ranipet is a major heavy engineering unit of Tamil Nadu. There are three industrial estates: SIDCO at Katpadi, SIPCOT at Ranipet and SIDCO at Arakkonam. The government also plays an active role in promoting the same and hence further growth is expected in the leather industry. The district has seen significant growth in the past few years with around 3000 units established with an investment of $ 51 Million. Some of the prominent MSME clusters are leather, textile and handloom & safety match industries. The district also has 12 large scale and 300 medium scale industries.

Additional/detailed information regarding the environmental and social features along the alignment is provided in Section- IV.

SECTION – III : POLICY, LEGAL & REGULATORY FRAMEWORK

3.0 Power transmission project activities by their inherent nature and flexibility have negligible impacts on environmental and social attributes. Indian laws relating to environmental and social issues have strengthened in the last decade both due to local needs and international commitments. POWERGRID undertakes its activities within the purview of Indian and State specific laws keeping in mind appropriate international obligations and directives and guidelines with respect to environmental and social considerations of Funding Agencies.

3.1 ENVIRONMENTAL

3.1.1 CONSTITUTIONAL PROVISIONS

Subsequent to the first United Nations Conference on Human Environment at Stockholm in June, 1972, which emphasized the need to preserve and protect the natural environment, the Constitution of India was amended through the historical 42nd Amendment Act, 1976 by inserting Article 48-A and 51-A (g) for protection and promotion of the environment under the Directive Principles of State Policy and the Fundamental Duties respectively. The amendment, *inter alia* provide:

"The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country". (Article 48A)

"It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures". {Article 51A (g)}

Article 21 of the constitution provides, "no person shall be deprived of his life or personal liberty except according to procedure established by law".

Article 21 is the heart of the fundamental rights and has received expanded meaning from time to time after the decision of the Supreme Court in 1978. The Article 21 guarantee fundamental right to life – a life of dignity to be lived in a proper environment, free of danger of disease and infection. Recently, Supreme Court has broadly and liberally interpreted the Article 21, transgressing into the area of protection of environment, and held the protection of environment and citizen's right to live in eco-friendly atmosphere as the basic right guaranteed under Article 21.

Thus the Indian Constitution has now two fold provision:

(a) On the one hand, it gives directive to the State for the protection and improvement of environment.
(b) On the other hand the citizens owe a constitutional duty to protect and improve natural environment.

3.1.2 MANDATORY REQUIREMENTS (NATIONAL)

- **MoP order/sanction under The Electricity Act, 2003:**

Sanction of Ministry of Power (MoP), GoI is a mandatory requirement for taking up any new transmission project under the section 68(1) of The Electricity Act, 2003. The sanction authorizes POWERGRID to plan and coordinate activities to commission the new projects. Electricity act does not explicitly deal with environmental implications of activities related to power transmission. However, POWERGRID always integrates environmental protection within its project activities.

- **Forest Clearance under the Forest (Conservation) Act, 1980:**

When transmission projects pass through forest land, clearance has to be obtained from relevant authorities under the Forest (Conservation) Act, 1980. This Act was enacted to prevent rapid deforestation and environmental degradation. State governments cannot de-reserve any forest land or authorize its use for any non-forest purposes without approval from the Central government. POWERGRID projects, when involving forest areas, undergo detailed review and approval procedures to obtain a Forest Clearance certificate from Ministry of Environment Forest & Climate Change (MoEFCC), GoI before starting any construction activity in designated forest area.

- **Environmental Clearances under Environment (Protection) Act,1986:**

Since transmission line projects are environmentally clean and do not involve any disposal of solid waste, effluents and hazardous substances in land, air and water they are kept out of the purview of Environment (Protection) Act, 1986 (EPA). However, amendment in the Environment (Protection) Act, 1986 on 7th May' 1992 made it necessary to obtain clearance from MoEFCC for power transmission projects in three districts in the Aravalis (*viz.*, Alwar in Rajasthan and Gurgaon & Nuh-Mewat in Haryana). The Aravali range, in these areas, is heavily degraded; hence, any industrial activity there becomes critical. Environment Impact Notification, 1994 & 2006 lays down specific project categories that require clearance from MoEFCC Power transmission projects are not included in this list.

- **Ozone Depleting Substances (Regulation and Control) Rules, 2000 :**

MoEFCC vide its notification dated 17th July, 2000 under the section of 6, 8 and 25 of the Environment (Protection) Act, 1986 has notified rules for regulation /control of Ozone Depleting Substances under Montreal Protocol adopted on 16th September 1987. As per the notification certain control and regulation has been imposed on manufacturing, import, export and use of these compound. POWERGRID shall follow provisions of notification and phase out all equipments which uses these substances and planning to become a CFC free organization in near future.

- **Batteries (Management and Handling) Rules, 2001:**

MoEFCC vide its notification dated 16th May, 2001 under the section of 6, 8 and 25 of the Environment (Protection) Act, 1986 has put certain restriction on disposal of used batteries and its handling. As per the notification, it is the responsibility of bulk consumer (POWERGRID) to ensure that used batteries are not disposed of, in any manner, other than by depositing with the dealer/manufacturer/registered recycler/importer/ reconditioner or at the designated collection centres and to file half yearly return in prescribed form to the concerned State Pollution Control Board.

- **Hazardous Wastes (Management, Handling & Transboundary Movement) Rules, 2008 :**

Vide notification dated 24th September, 2008 under the EPA, 1986, MoEFCC notified rules for environmentally sound management of hazardous wastes to ensure that the hazardous wastes are managed in a manner which shall protect health and the environment against the adverse affects that may result from such waste. The used transformer oil has been declared as hazardous wastes vide this notification. As per the notification, all used oil is to be auctioned/sold to registered recyclers only and file annual return on prescribed form to the concerned State Pollution Control Board.

- **E-waste (Management and Handling) Rules, 2011:**

Vide notification dated 12th May 2011 under the EPA, 1986, MoEFCC notified rules for environmentally sound management of e-waste to ensure that e-waste are managed in a manner which shall protect health and the environment against the adverse effects that may result from hazardous substance contained in such wastes. Thus, it is the responsibility of the bulk consumer (POWERGRID) to ensure that e-waste generated is channelized to authorized collection center(s) or registered dismantler(s) or recycler(s) or is returned to the pick-up of take back services provided by the producer. POWERGRID, being a bulk consumer of electrical and electronics equipments shall maintain the record as per Form-2 for scrutiny by State Pollution Control Board.

- **The Biological Diversity Act, 2002 :**

Under the United Nations Convention on Biological Diversity signed at Rio de Janeiro on the 5th June, 1992 of which India is also a party, MoEF has enacted the Biological Diversity Act, 2002 to provide for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith. As per the provision of act certain areas which are rich in biodiversity and encompasses unique and representative ecosystems are identified and designated as Biosphere Reserves to facilitate their conservation. All restrictions applicable to protected areas like National Parks & Sanctuaries are also applicable to these reserves. POWERGRID will abide by the provision of act, wherever, applicable and try to totally avoid these biosphere reserves while finalizing the route alignment.

- **The Scheduled Tribes & Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006:**

This act recognizes and vests the forest rights and occupation in forest land to forest dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recognized.

The definitions of forest dwelling schedule tribes, forestland, forest rights, forest villages, etc. have been included in Section 2 of the Act. The Union Ministry of Tribal Affairs (MoTA) is the nodal agency for implementation of the Act while field implementation is the responsibility of the government agencies. Its implementation has also been linked with forest clearance process under Forest (Conservation) Act, 1980 w.e.f. August 2009 by MoEFCC. POWERGRID shall abide by the provisions of the act if any portion of the transmission line is passing through forest land, in occupation of the forest dwelling scheduled tribes and other traditional forest dwellers for laying of transmission lines. However, for linear projects including transmission lines obtaining of NoC from the gram sabhas has been exempted for the requirement of FRA compliance as per MoEF circular dated 5th February 2013.

3.1.3 FUNDING AGENCY:

The proposed project is co-financed by ADB as well as AIIB. AIIB has agreed to the application of ADB's Safeguard Policy Statement (SPS), 2009, which the AIIB found to be materially consistent with its Environmental and Social Policy and the Environmental and Social Standards, and which has appropriate monitoring procedures in place.

For POWERGRID, mandatory environment requirements with respect to ADB's Safeguard Policy Statement (SPS) are as follows:

- **ADB's Safeguard Policy Statement (SPS), 2009**

The SPS 2009 describes ADB's policy and operational procedures on three key safeguard areas: environment, involuntary resettlement, and indigenous peoples, as well as a set of specific safeguard requirements that borrowers are expected to meet when borrowing for development projects. Its objective is to ensure social and environmental sustainability of projects through avoidance, minimization, mitigation and/or compensation of adverse impacts on environment and affected peoples; and help Borrowers to strengthen their safeguard systems and to develop their capacity in managing the environmental and social risks.

SPS 2009 includes categorization of projects based on significance of potential environmental impacts. The category is determined by the project's most environmentally-sensitive component including direct, indirect, cumulative, and induced impacts within the project's area of influence. Project categorization system is given below:

Category A –an environmental impact assessment (EIA) is required for a project that is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented, and may affect an area larger than the sites or facilities subject to physical works.

Category B –an initial environmental examination (IEE) is required for a project that is likely to have adverse environmental impacts that are less adverse than those of Category A which are site-specific, few if any of them irreversible and in most cases mitigation measures can be designed more readily than Category A.

Category C– no environmental assessment is required but environmental implications will be reviewed for a project that is likely to have minimal or no adverse environmental impacts.

Category FI–if a project involves investment of ADB funds to or through a financial intermediary.

Based on the significance of the potential environmental impacts resulting from the transmission project and SPS 2009, the project is classified as environment category "B" requiring an IEE.

Power transmission projects financed by ADB are also required to follow the World Bank Group Environmental, Health, and Safety (EHS) General Guidelines and EHS Guidelines for Electric Power Transmission and Distribution published by the International Finance Corporation, 30 April 2007.

3.2 SOCIAL

3.2.1 CONSTITUTIONAL PROVISIONS

Constitutional provisions in regard to social safeguards are well enshrined in the preamble such as **JUSTICE,** social, economic and political; **LIBERTY** of thought, expression, belief, faith and worship; **EQUALITY** of status and of opportunity; **FRATERNITY** assuring the dignity of the individual and the unity and integrity of the Nation. Fundamental Rights and Directive Principles guarantee the right to life and liberty. Health, safety and livelihood have been interpreted as part of this larger right. Social safeguards provisions are dealt in detail in different Article such as Article-14, 15 17, 23, 24, 25, 46, 330, 332 etc. POWERGRID shall implement the said constitutional provision in true sprit to fulfill its environmental and social obligations and responsibilities.

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3.2.2 MANDATORY REQUIREMENTS (NATIONAL/STATE)

- **The Right to Fair Compensation and Transparency in Land Acquisition Rehabilitation and Resettlement Act, 2013 (RFCTLARRA) :**

Govt. of India replaced the old Land Acquisition Act, 1894 and notified the new RFCTLARRA, 2013 which came into force from 1st January 2014. This act ensures appropriate identification of the affected families/households, fair compensation and rehabilitation of titleholders and non-titleholders. However, the new act i.e. RFCTLARRA, 2013 authorizes State Govt. or its authorized Government agency to complete the whole process of acquisition of private land including Social Impact Assessment (SIA), Action Plan for R&R (i.e. Rehabilitation and Resettlement) & its implementation and POWERGRID's responsibility is limited to identification and selection of suitable land based on technical requirement and ensuring budget allocation.

- **Rights of Way and Compensation under Electricity Act, 2003[2]:**

The act has a provision for notifying transmission company under section 164 (B) to avail benefits of eminent domain provided under the Indian Telegraph Act, 1885. MoP, GoI vides gazette notification dated 23rd Dec'03 had already notified POWERGRID under this section of said act. Therefore, for the purpose of placing of any wires, poles, etc., POWERGRID has all the powers that the telegraph authority possesses. Thus, POWERGRID can erect and construct towers without actually acquiring the land. However, all damages due to POWERGRID activity are compensated at market rate. Power transmission schemes are always planned in such a way that the power of eminent domain is exercised responsibly.

3.2.3 FUNDING AGENCY

For POWERGRID, mandatory social requirements with respect to ADB's Safeguard Policy Statement (SPS) are as follows:

- **ADB's Safeguard Policy Statement, 2009**

ADB's Safeguard Policy Statement (SPS), June 2009 set out specific safeguard requirements for borrower as per its policy & operational procedures on three key safeguard areas: environment, involuntary resettlement, and indigenous peoples.

The key objective is to avoid or minimize involuntary resettlement (IR) by exploring project and design alternatives and to enhance, or at least restore, the livelihoods of all displaced persons in real terms relative to pre-project levels and to improve the standards of living of the displaced poor and other vulnerable groups. Regarding Indigenous People the objective of the policy is to design and implement projects in a way that fosters full respect for Indigenous Peoples' identity, dignity, human rights, livelihood systems, and cultural uniqueness as defined by the Indigenous Peoples themselves so that they (i) receive culturally appropriate social and economic benefits, (ii) do not suffer adverse impacts as a result of projects, and (iii) can participate actively in projects that affect them.

[2] Ministry of Power, Govt. of India vide its notification dated 15th Oct., 2015 has issued guidelines for payment of compensation for damages in regard to RoW for transmission lines. Once the above guidelines are adopted by the concerned State, compensation shall be paid as per the norms.

SECTION IV: APPROACH FOR ROUTE/SITE SELECTION

4.0 ROUTE SELECTION - (ASSESSMENT & MANAGEMENT PROCESS)

At the system planning stage itself one of the factors that govern the evolution of system is the possible infringement with the forest. Wherever such infringements are substantial, different alternative options are considered. The route/ site selection criteria followed is detailed below:

While identifying the transmission system, preliminary route selection is done by POWERGRID based on the Survey of India Topo sheets, Forest Atlas (Govt. of India's Publication) and Google Maps etc. During route alignment all possible efforts are made to avoid the forest involvement completely or to keep it to the barest minimum, whenever it becomes unavoidable due to the geography of terrain or heavy cost involved in avoiding it. *Presence of protected areas like National Parks, Wildlife Sanctuaries and other ecological sensitive areas are verified by superimposing the proposed alternative alignment on the Protected Area Network Geospatial Map of Wildlife Institute of India (WII), GoI.*

4.1 STUDY OF ALTERNATIVES

4.1.1 ENVIRONMENTAL CRITERIA FOR ROUTE SELECTION

For selection of optimum route, the following points are taken into consideration:

(i) The route of the proposed transmission lines does not involve any human displacement/rehabilitation.
(ii) Any monument of cultural or historical importance is not affected by the route of the transmission line.
(iii) The proposed route of transmission line does not create any threat to the survival of any community with special reference to Tribal Community.
(iv) The proposed route of transmission line does not affect any public utility services like playgrounds, schools, other establishments etc.
(v) The line route does not pass through any National Parks, Sanctuaries etc.
(vi) The line route does not infringe with area of natural resources.

In order to achieve this, POWERGRID undertakes route selection for individual transmission line in close consultation with representatives of concerned Forest Department and the Department of Revenue. Although under the law, POWERGRID has the right of eminent domain yet alternative alignments are considered, keeping in mind, the above-mentioned factors during site selection, *with minor alterations often added to avoid environmentally sensitive areas and settlements at execution stage.*

- As a rule, alignments are generally cited away from major towns, whenever possible, to account for future urban expansion.
- Similarly, forests are avoided to the extent possible, and when it is not possible, a route is selected in consultation with the local Divisional Forest Officer, that causes minimum damage to existing forest resources.
- Alignments are selected to avoid wetlands and unstable areas for both financial and environmental reasons.

In addition, care is also taken to avoid National parks, Sanctuaries, Eco-sensitive zones, Tiger reserves, Biosphere reserves, Elephant corridors and IBA sites etc. Keeping above in mind the routes of proposed lines under the project have been so aligned that it takes care of above factors. As such different alternatives for transmission lines were studied with the help of Govt. published data like Forest atlas, Survey of India and Google Maps etc.to arrive at most optimum route which can be taken up for detailed survey and assessment of environmental & social impacts for their proper management.

4.7 EVALUATION OF ALTERNATIVES ROUTE ALIGNMENT FOR 400 KV PUGALUR-PUGALUR LINE

Three different alignments **(Map-2)** were studied with the help of published data/maps and walkover survey to arrive at most optimum route for detailed survey. The comparative details of three alternatives in respect of the proposed line are as follows:

S.N	Description	Alternative-I	Alternative-II	Alternative-III
1.	**Route particulars**			
i.	Route Length (km)	58	55	60
ii.	Terrain			
	Hilly	Nil	Nil	Nil
	Plain	100%	100%	100%
2.	**Environmental impact**			
i.	Name of District(s) through which the line passes	Karur & Tirupur	Karur & Tirupur	Karur & Tirupur
ii.	Town in alignment	Kammarayakampatti Kodandur, Malaikovil, K.Paramatti	Kambaliyampatti, Vellakovil, Karukattu, Kunampatti, Munnur	Ollapalaiyam, Mulayampudi, Gudalur, Nedungur, Pavitram
iii.	House within RoW	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey
iv.	Forest involvement (km/ha.)	Nil	Nil	Nil
v.	Type of Forest (RF/PF)& whether part of Wildlife Area/ Elephant corridor/ Biodiversity Hotspots/ Biosphere Reserve/ Wetlands or any other environmentally sensitive area, if any	N.A	N.A	N.A
vi.	Density of Forest	N.A	N.A	N.A
vii.	Type of flora	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Papaya(*Carica papaya*), Banana (*Musa acuminate*)etc.	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Papaya(*Carica papaya*), Banana (*Musa acuminate*)etc.	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Papaya(*Carica papaya*), Banana (*Musa acuminate*) etc.

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S.N	Description	Alternative-I	Alternative-II	Alternative-III
viii.	Type of fauna	Domestic species like Goat (Capra hircus), Sheep (Ovis aries), Cow (Bos indicus), Buffalo (Bubalus bubalis) etc.	Domestic species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow *(Bos indicus)*, Buffalo *(Bubalus bubalis) etc.*	Domestic species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow *(Bos indicus)*, Buffalo *(Bubalus bubalis) etc.*
ix.	Endangered species, if any	Nil	Nil	Nil
x.	Historical/cultural Monuments, if any	Nil	Nil	Nil
3.	**Compensation Cost:**			
i.	Crop (Non Forest)	290.00 lakhs (@ 5 lakhs/km)	275.00 lakhs (@ 5 lakhs/km)	300.00 lakhs (@ 5 lakhs/km)
ii.	Land for Tower Base & RoW Corridor	2007.17 lakhs	1903.00 lakhs	2076.00 lakhs
iii.	Forest (CA+NPV)	Nil	Nil	Nil
4.	**Major Crossings:**			
i.	Highway(NH/SH)	Nil	1(NH)	Nil
ii.	Power Line (Nos.)	5	4	5
iii.	Railway Line (Nos.)	Nil	Nil	Nil
	River Crossing(Nos.	1	Nil	1
5.	**Overall remarks**	Line length is more and also involves moderate RoW issues due to habitation area & river crossing.	Line length is less and involves relatively less ROW issues & fewer habitats.	Line length is longest and also involves moderate RoW problems due to proximity of habitation area & river crossing.

From the comparative analysis of three alternative routes, it is evident that none of the three alternative routes studied involves forest or wildlife area. However, Alternative-II is shorter in length and involves less RoW issues as the line is not passing through major habitation areas as compared to Alternative-I & III. Since the route length is shorter, it will involve minimum tree felling & lesser degree of environmental impact is anticipated. Hence, Alternative - II is considered as the most optimum route and recommended for detailed survey.

4.8 EVALUATION OF ALTERNATIVES ROUTE ALIGNMENT FOR 400 KV PUGALUR-ARASUR LINE

Three different alignments **(Map-2)** were studied with the help of published data/maps and walkover survey to arrive at most optimum route for detailed survey. The comparative details of three alternatives in respect of the proposed line are as follows:

S.N	Description	Alternative-I	Alternative-II	Alternative-III
1.	**Route particulars**			
i.	Route Length (km)	58	60	62
ii.	Terrain			
	Hilly	Nil	Nil	Nil
	Plain	100%	100%	100%
2.	**Environmental impact**			
i.	Name of District(s) through which the line passes	Tirupur & Coimbatore	Tirupur & Coimbatore	Tirupur & Coimbatore

S.N	Description	Alternative-I	Alternative-II	Alternative-III
ii.	Town in alignment	Karumatampati, Palipalayam, Velampalayam, Palladam, Pongalur	Karumatampati, Mangalam, Tiruppur, Eilapalaiyam Avanashipalayam	Karumatampati, Soma-nur, Kalivelampatti, Vadugapalaiyam, Tayampalaiyam
iii.	House within RoW	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey
iv.	Forest involvement (km/ha.)	Nil	Nil	Nil
v.	Type of Forest (RF/PF)& whether part of Wildlife Area/ Elephant corridor/ Biodiversity Hotspots/ Biosphere Reserve/ Wetlands or any other environmentally sensitive area,if any	N.A	N.A	N.A
vi.	Density of Forest	N.A	N.A	N.A
vii.	Type of flora	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.
viii.	Type of fauna	Domestic fauna species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*	Domestic fauna species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*	Domestic fauna species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*
ix.	Endangered species, if any	Nil	Nil	Nil
x.	Historical/cultural Monuments, if any	Nil	Nil	Nil
3.	**Compensation Cost:**			
i.	Crop (Non Forest)	290.00 lakhs (@ 5 lakhs/km)	300.00 lakhs (@ 5 lakhs/km)	310.00 lakhs (@ 5 lakhs/km)
ii.	Land for Tower Base & RoW Corridor	2846.00 lakhs	2946.60 lakhs	3041.72 lakhs
iii.	Forest (CA+NPV)	Nil	Nil	Nil
4.	**Major Crossings:**			
i.	Highway(NH/SH)	Nil	1(NH)	Nil
ii.	Power Line (Nos.)	1	3	3
iii.	Railway Line (Nos.)	Nil	Nil	Nil
iv.	River Crossing (Nos	Nil	Nil	Nil
5.	**Overall remarks**	Line length is more and also involves moderate RoW issues due to habitation area & river crossing.	Line length is less and involves relatively less ROW issues & fewer habitats.	Line length is longest and also involves moderate RoW problems due to proximity of habitation area & river crossing.

From the above comparison of the three (3) different alternatives, it is evident that although there is no forest involvement in all the three routes, Alternative- I is found to be shortest route and also less RoW issues due to involve fewer habitation areas & crossings as compared to other two alternatives. Hence, lesser degree of environmental impacts like minimum tree felling as well as construction and O&M problems are anticipated. Hence, Alternative - I is considered as the most optimized route and recommended for detailed survey.

4.9 EVALUATION OF ALTERNATIVES ROUTE ALIGNMENT FOR 400 Kv PUGALUR-THIRUVALAM LINE

Three different alignments **(Map-2)** were studied with the help of published data/maps and walkover survey to arrive at most optimum route for detailed survey. The comparative details of three alternatives in respect of the proposed line are as follows:

S.N	Description	Alternative-I	Alternative-II	Alternative-III
1.	**Route particulars**			
i.	Route Length (km)	410	390	420
ii.	Terrain			
	Hilly	10%	10%	10%
	Plain	90%	90%	90%
2.	**Environmental impact**			
i.	Name of District(s) through which the line passes	Karur, Tirupur, Namakkal, Erode, Salem, Dharmapuri, Thiruvanamalai, Vellore	Karur, Tirupur, Namakkal, Erode, Salem, Dharmapuri, Thiruvanamalai, Vellore	Karur, Tirupur, Namakkal, Erode, Salem, Dharmapuri, Thiruvanamalai, Vellore
ii.	Town in alignment	Gudiyatatm, Makur Vanyambadi, Erode, Tiruppattur, Uttan-garai, Dharampuri,	Tiruvannamalai, Kaliakurichchi, Kambaliyumpatti,	Arcot, Tiruvannamalai, Arani, Kaliakurichchi, Kambaliyumpatti, Polur, Palipuram
iii.	House within RoW	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey
iv.	Forest involvement (km/ha.)	Approx. 4 km (18.4 Ha.)	Approx. 5 km (23 Ha)	Approx. 5 km (23Ha)
v.	Type of Forest (RF/PF)& whether part of Wildlife Area/ Elephant corridor/ Biodiversity Hotspots/ Biosphere Reserve/ Wetlands or any other environmentally sensitive area, if any	Reserve Forest	Reserve Forest	Reserve Forest
vi.	Density of Forest	Medium dense	Medium dense	Medium dense
vii.	Type of flora	*Mango (Mangifera indica), Arjuna (Terminalia arjuna), Jamun (Syzygium cumini), Coconut (Cocos nucifera)*, Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.	*Mango (Mangifera indica), Arjuna (Terminalia arjuna), Jamun (Syzygium cumini), Coconut (Cocos nucifera), Neem (Azadirachta indica), Areca Nut (Areca catechu), Paddy (Oryza sativa), Banana (Musa acuminate) etc.*	*Mango (Mangifera indica), Arjuna (Terminalia arjuna), Jamun (Syzygium cumini), Coconut (Cocos nucifera), Neem (Azadirachta indica), Areca Nut (Areca catechu), Paddy (Oryza sativa), Banana (Musa acuminate) etc.*

S.N	Description	Alternative-I	Alternative-II	Alternative-III
viii.	Type of fauna	Fox(*Vulpes benghalensis*, Wild boar (*Sus scrofa*) & domestic species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*	Fox (*Vulpes benghalensis*, Wild boar (*Sus scrofa*) & domestic species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*	Fox (*Vulpes benghalensis*, Wild boar (*Sus scrofa*) & domestic species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*
ix.	Endangered species, if any	Nil	Nil	Nil
x.	Historical/cultural Monuments, if any	Nil	Nil	Nil
3.	**Compensation Cost:**			
i.	Crop (Non Forest)	2030.00 lakhs (@ 5 lakhs/km)	1925.00 lakhs (@ 5 lakhs/km)	2075 lakhs (@ 5 lakhs/km)
ii.	Land for Tower Base & RoW Corridor	17283.00 lakhs	16390.00 lakhs	17667.00 lakhs
iii.	Forest (CA+NPV)	368.00 lakhs (@ 20 lakhs/ha.)	460.00 lakhs (@ 20 lakhs/ha.)	460.00 lakhs (@ 20 lakhs/ha.)
4.	**Major Crossings:**			
i.	Highway(NH/SH)	2(NH)	2(NH)	2(NH)
ii.	Power Line (Nos.)	40	37	40
iii.	Railway Line (Nos.)	2	5	5
iv.	River Crossing (Nos.)	2	2	2
5.	**Overall remarks**	Line length is more and also involve moderate RoW issues as the line route is passing close to habitation area	Shortest in line length and involve minimum RoW problems due to avoidance major habitation area	Line length is longest and also involve moderate RoW problems due to proximity of habitation area

From the above comparison of three (3) different alternatives, it is evident that although Alternative- II involve forest area like other alternatives but it found to be shortest route having minimum RoW issues. Further, lesser degree of environmental impacts like minimum tree felling as well as construction and O&M problems are anticipated as the line route of Alternative- II doesn't involve any major habitation areas like in other two alternatives. Hence, Alternative - II is considered as the most optimized route and recommended for detailed survey.

4.10 EVALUATION OF ALTERNATIVES ROUTE ALIGNMENT FOR 400 KV PUGALUR-EDAYARPALAYAM LINE

Three different alignments **(Map-2)** were studied with the help of published data/maps and walkover survey to arrive at most optimum route for detailed survey. The comparative details of three alternatives in respect of the proposed line are as follows:

S.N	Description	Alternative-I	Alternative-II	Alternative-III
1.	**Route particulars**			
i.	Route Length (km)	58	56	60
ii.	Terrain			
	Hilly	Nil	Nil	Nil
	Plain	100%	100%	100%
2.	**Environmental impact**			
i.	Name of District(s) line passes	Tirupur & Coimbatore	Tirupur & Coimbatore	Tirupur & Coimbatore

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S.N	Description	Alternative-I	Alternative-II	Alternative-III
ii.	Town in alignment	Chettipalayam, Laxminayakan-palaiyam, Vadamalaipalayam, Tayampalaiyam Kettanur,	Chettipalayam, Velappanayakkan-palaiyam, Mandripalayam, Vadamalaipalaiyam, Tayampalaiyam	Chettipalayam, Pannapatti, Muttukavundanpudi, Veruvedampaliyam, Kundadam
iii.	House within RoW	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey
iv.	Forest involvement (km/ha.)	Nil	Nil	Nil
v.	Type of Forest (RF/PF)& whether part of Wildlife Area/ Elephant corridor/ Biodiversity Hotspots/ Biosphere Reserve/ Wetlands or any other environmentally sensitive area, ifany	N.A	N.A	N.A
vi.	Density of Forest	N.A	N.A	N.A
vii.	Type of flora	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banan (*Musa acuminate*) etc	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.
viii.	Type of fauna	Domestic fauna species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*	Domestic fauna species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*	Domestic fauna species like Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*
ix.	Endangered species, if any	Nil	Nil	Nil
x.	Historical/cultural Monuments, if any	Nil	Nil	Nil
3.	**Compensation Cost:**			
iv.	Crop (Non Forest)	290.00 lakhs (@ 5 lakhs/km)	280.00 lakhs (@ 5 lakhs/km)	300.00 lakhs (@ 5 lakhs/km)
v.	Land for Tower Base & RoW Corridor	1785.82 lakhs	1724.34 lakhs	1847.40 lakhs
vi.	Forest (CA+NPV)	Nil	Nil	Nil
4.	**Major Crossings:**			
i.	Highway(NH/SH)	2(NH)	2(NH)	2(NH)
ii.	Power Line (Nos.)	8	8	8
iii.	Railway Line (Nos.)	Nil	Nil	Nil
iv.	River Crossing (Nos	Nil	Nil	Nil
5.	**Overall remarks**	Line length is relatively more and involves moderate RoW issues due to presence of habitation areas	Line length is less and involves relatively less ROW issues due to fewer habitats.	Line length is longest and also involves moderate RoW problems due to proximity of habitation area & plantation.

From the above comparison of three (3) different alternatives, it is evident that Alternative- II is found to be shortest route having minimum RoW issues. Further, lesser degree of environmental impacts like minimum tree felling as well as construction and O&M problems are anticipated as the line route of Alternative- II doesn't involve any plantation and habitation area like in other two alternatives. Hence, Alternative - II is considered as the most optimized route and recommended for detailed survey.

4.11 EVALUATION OF ALTERNATIVES ROUTE ALIGNMENT FOR 400 KV EDAYARPALAYAM – UDUMALPET LINE

Three different alignments **(Map-2)** were studied with the help of published data/maps and walkover survey to arrive at most optimum route for detailed survey. The comparative details of three alternatives in respect of the proposed line are as follows:

S.N	Description	Alternative-I	Alternative-II	Alternative-III
1.	**Route particulars**			
i.	Route Length (km)	58	56	60
ii.	Terrain			
	Hilly	Nil	Nil	Nil
	Plain	100%	100%	100%
2.	**Environmental impact**			
i.	Name of District(s) line passes	Tirupur & Coimbatore	Tirupur & Coimbatore	Tirupur & Coimbatore
ii.	Town in alignment	Chettipalayam, Pannapatti, Velur, Arasampalayam, Ramchandrapuram, Peddapampati, Udumalpet	Chettipalayam, Purandampalaiyam, Krshnapuram, Chikkanattu, Jallipatti, Tungavi, Udumalpet Gudimangalam,	Chettipalayam, Arasampalaiyam, Vadachittur, Kottampatti, Valakondapuram, Pukkalam, Udumalpet
iii.	House within RoW	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey	Shall be ascertained after detailed survey
iv.	Forest involvement (km/ha.)	Nil	Nil	Nil
v.	Type of Forest (RF/PF)& whether part of Wildlife Area/ Elephant corridor/ Biodiversity Hotspots/ Biosphere Reserve/ Wetlands or any other environmentally sensitive area, ifany	N.A	N.A	N.A
vi.	Density of Forest	N.A	N.A	N.A
vii.	Type of flora	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*)Banana (*Musa acuminate*) etc	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.	Coconut (*Cocos nucifera*), Neem (*Azadirachta indica*), Areca Nut (*Areca catechu*), Paddy (*Oryza sativa*), Banana (*Musa acuminate*) etc.
viii.	Type of fauna	Goat *(Capra hircus)*, Sheep *(Ovis aries)*, Cow (*Bos indicus*), Buffalo *(Bubalus bubalis)*	Goat (Capra hircus), Sheep (Ovis aries), Cow (Bos indicus), Buffalo (Bubalus bubalis)	Goat (Capra hircus), Sheep (Ovis aries), Cow (Bos indicus), Buffalo (Bubalus bubalis)
ix.	Endangered species, if any	Nil	Nil	Nil

S.N	Description	Alternative-I	Alternative-II	Alternative-III
x.	Historical/cultural Monuments, if any	Nil	Nil	Nil
3.	**Compensation Cost:**			
i.	Crop (Non Forest)	290.00 lakhs (@ 5 lakhs/km)	280.00 lakhs (@ 5 lakhs/km)	300.00 lakhs (@ 5 lakhs/km)
ii.	Land for Tower Base & RoW Corridor	1625.16 lakhs	1569.24 lakhs	1681.20 lakhs
iii.	Forest (CA+NPV)	Nil	Nil	Nil
4.	**Major Crossings:**			
i.	Highway(NH/SH)	2(NH)	2(NH)	2(NH)
ii.	Power Line (Nos.)	10	10	10
iii.	Railway Line (Nos.)	Nil	Nil	Nil
iv.	River Crossing (Nos	Nil	Nil	Nil
5.	**Overall remarks**	Line length is relatively more and also involves moderate RoW issues due to habitation areas	Line length is less, easy approachability to line route and involves relatively less ROW issues	Line length is longest and also involve moderate RoW problems due to proximity of habitation areas

From the comparative analysis of three alternative routes, it is evident that none of the three alternative routes studied involves forest area. However, Alternative-II is shorter in length, involves less RoW issues and also better approachability as compared to Alternative-I & III. Further, lesser degree of environmental impacts like minimum tree felling and construction and operational problems are anticipated. Hence, Alternative -II is considered as the most optimum route and recommended for detailed survey.

4.12 SUBSTATION

No new substation is envisaged under the instant scheme. However, only extension works involving construction of 16 nos. line bays in different substations is proposed. Since the above extensions works shall be undertaken in existing substations where lands are already in available and no fresh land required, R & R will not be an issue in the instant project.

SECTION – V: POTENTIAL ENVIRONMENTAL IMPACT, THEIR EVALUATION AND MANAGEMENT

5.0 IMPACT DUE TO PROJECT LOCATION AND DESIGN

Environmental impacts of transmission projects are not far reaching and are mostly localized to RoW (refer **Table- 5.1**). Actual 400 kV line including tower on ground along with RoW and extent of impact on land/vegetation is placed as **Fig.-1 & 1a** respectively. However, transmission projects have some effects on natural and socio-culture resources. These impacts can be minimized by careful route selection. In order to get latest information and further optimization of route, modern survey techniques/tools like GIS, GPS are also applied. Introduction of GIS and GPS in route selection result in access to updated/latest information, through satellite images and further optimization of route having minimal environmental impact. Moreover, availability of various details, constraints like topographical and geotechnical details, forest and environmental details etc. help in planning the effective mitigative measures including engineering variations depending upon the site situation/location. In the instant scheme also these techniques are used and detail survey using GIS/GPS is under progress. Although, all possible measures have been taken during the finalization of route alignment for the proposed transmission lines but due to peculiarity of terrain and demography of the area where subprojects are being implemented, some environmental impacts may be there. The explanations in brief with regard to specific environment review criteria based on preliminary survey are as follows:

Table- 5.1: RoW Width & Clearance between Conductors and Trees

Transmission Voltage	Max. RoW (In Meters)	Min. Clearance (in Meters) between conductor & Trees
400 kV	46	5.5

As per IS:5613 and MoEF guidelines dated 5th May' 2014 finalized in consultation with CEA

(i) Resettlement

Land is required for a) construction of substations and b) erection of transmission lines. In general requirement of land area for substation varies from 30 to 100 acres depending upon voltage levels, no. of bays, topography of land and other technical parameters.

As already explained in previous chapter, the instant scheme doesn't involve construction of any new substations. However, extension works proposed under present scheme involving construction of 16 nos. of line bays shall be undertaken in existing substations where lands are already in possession. Since no fresh land acquisition is involved, R & R will not be an issue in the instant project

In respect of (b), no permanent acquisition is envisaged. Land for tower and right of way is not acquired as agricultural activities can continue. A typical plan of transmission line tower footing indicating the above position along with extent of damage and area of influence are depicted in **Fig.-2 & 2a** respectively. As described earlier all measures are undertaken by POWERGRID at the line routing stage itself to avoid settlements such as cities, villages etc. It may be seen from the above description of proposed route alignments and also keeping in mind that no permanent acquisition of land is involved for tower foundation as per existing law, these subprojects don't require any resettlement of villagers. However, some temporary damages/ disturbances can take place, which will be compensated as per the law of the land and applicable/prevailing guidelines. In this regard, a separate document titled **"Compensation Plan for Temporary Damage"** (CPTD) detailing the entitlement matrix as well as provisions of

new guidelines issued in October, 2015 by the Ministry of Power for RoW compensation @ 85% land value for tower base & @15% of land value (maximum) for width of RoW corridor is proposed and all cases of temporary damages i.e. line portion shall be dealt as per provisions of CPTD.

(ii) **Land value depreciation**

Based on past experience land prices are generally expected to rise in the areas receiving power. Generally transmission lines pass through uninhabited area, agriculture fields and forests, where the land use is not going to change in foreseeable future. Therefore, the value of land will not be adversely affected to a significant degree.

(iii) **Historical/cultural monuments/value**

As per the policy of route selection, only that route alignment is finalized which avoids all the historical and cultural monuments. As per the preliminary assessment carried out during finalization of route alignment in consultation with State Revenue authorities and Archaeological Survey of India (ASI), no such monuments are coming in the proposed route alignments. Moreover, utmost care shall be taken during detailed survey to avoid such areas. However, during excavation, if any treasure, archaeological artifacts are found the same shall be intimated in writing to Collector/Archaeology department as per the provisions of Section-4 of "Indian Treasure Trove Act, 1878 as amended in 1949". The Collector shall initiate further action for its safe custody or its shifting to Treasury/ Secure place. The construction activity may be suspended temporarily during this process.

(iv) **Lines into precious ecological areas**

As already explained all precautions have been taken during route selection to avoid routing of line through forest and protected areas. In the instant case also protected areas like wildlife sanctuary, national parks, biosphere reserves etc have been completely avoided. However, in spite of taking due care during route selection involvement of some forest area (approx. 23 ha.) could not be avoided in one line i.e. 400 kV Pugalur- Thiruvalam line. As per regulation prior approval from GoI/MoEF shall be obtained under Forest (Conservation) Act, 1980 after detail survey and finalization of route through forest area in consultation with local forest authorities. Moreover, to minimize the loss of vegetation, suitable management measures as specified in EMP[3] (refer clause- 9) like minimizing RoW requirement, use of tall or extended tower etc, wherever feasible will be undertaken.

As per the initial study/assessment, most of the forests to be traversed by the subject line are categorised as Reserve Forest (RF) and found to be in various degree of degradation and even the wildlife species present are those who have adapted to open or disturbed habitat. Nonetheless, to mitigate losses to existing forests, clearing of the transmission line Right-of-Way will be done under supervision of forest department, and some low canopy seed trees and shrubs may be kept intact if they do not interfere with tower erection and line installation. The extracted wood will be sold by the forest department, who will also retain the sale proceeds. Three-meter wide strips of land below each conductor will be cleared during construction and one such strip shall be kept free of vegetation for maintenance purpose and regeneration up to certain height in remaining width of RoW will be allowed after construction activity. Periodical lopping/pruning of trees to maintain line clearance will be done under the direction of forest department (for details refer **Fig.-3** for tree felling pattern and refer **Fig.- 2a** for area of influence). Moreover, to prevent unauthorized tree felling in forest area measures like providing construction crews with fuel wood or alternative fuels by Contractor has been specified in EMP (refer clause- 24).

[3] ***Environment Management Plan (EMP) is placed at Table -6.1***

Transmission lines can serve as new access routes into previously inaccessible or poorly accessible forests, thereby accelerating forest and wildlife loss. In such cases, POWERGRID cannot take action itself, but local Forest Department personnel will normally assess the dangers and take appropriate action, such as establishing guard stations at the entrance to the forest etc. cost of which is borne by POWERGRID. Given the already easy access and degraded conditions at the proposed subprojects sites, this problem is not expected to be encountered. Nonetheless, POWERGRID staff will report to the Forest Department any noticeable encroachment induced by the Projects

(v) **Lines into other valuable lands**

Impacts on agricultural land will be restricted to the construction phase and when large-scale maintenance measures are required. The proposed transmission lines will pass mostly through agricultural fields. As per existing law, land for tower and right of way is not acquired and agricultural activities are allowed to continue after construction activity. POWERGRID pays compensation for all damages as per the law of the land and applicable/prevailing guidelines. Recently, MoP has issued guidelines for payment of compensation toward damages in regard to RoW for transmission lines (**Annexure-1**). However, the said compensation shall be paid to all affected farmers/land owners in addition to normal tree and crop damage compensation, once it is adopted by respective States.

In areas where transmission lines will traverse through agricultural land, compensation will be paid to owners for any crop damage incurred as a result of construction activities. POWERGRID field staff will consult affected villagers and local revenue dept. and apprise them about the project and tower location, which shall be erected in the agricultural land. Revenue dept. after evaluating the land loss due to construction activity and crop damages based on productivity of land arrives at the compensation cost which is paid to farmer. Agricultural activities will be allowed to continue following the construction period. If bunds or other on-farm works are disturbed during construction or maintenance, they will be restored to the owner's satisfaction following cessation of construction or maintenance activities. In the event that private trees are felled during construction or maintenance operations, compensation will be paid to the owner in an amount determined by the estimated loss of products from the tree over an eight year period (for fruit bearing trees). Agricultural lands under private ownership will be identified, and in accordance with normal POWERGRID procedures compensation will be paid to the affected villagers. The procedure for providing compensation is described in **Annexure-2.** Budgetary provision of Rs. 3050.00 lakhs is made in the cost estimate to meet these expenses.

(vi) **Interference with other utilities and traffic**

As per regulations enacted by Government of India, it is mandatory for POWERGRID to seek clearance prior to construction from department of Railways, Telecommunications and wherever necessary from aviation authorities that are likely to be affected by the construction of transmission lines. The transmission lines affect nearby telecommunication circuits by causing electrical interference. A standing committee - Power Telecom Co-ordination Committee (P.T.C.C.) has been constituted by Government of India to plan and implement the mitigating measures for the induced voltage which may occur to nearby telecom circuit and suggest necessary protection measures to be adopted. The committee suggests measures like rerouting of the telecom circuits, conversion of overhead telecom circuits into cables etc. to minimize the interference.

The cost of such measures is determined by the Committee on the basis of prevailing norms and guidelines. Though the exact cost to mitigate the impacts of induction in

neighboring telecom circuits would vary from case to case, the cost on an average works out to be Rs. 50,000/- per km. Provision to meet these expenses has been made in the cost estimate for the same for transmission line proposed under the instant scheme.

The main approach road for accessing the construction sites including three new substations are either through National Highways, i.e. NH-40, 44, 83,181 & 544 or through other State/Village Roads bifurcating from these National Highways. The volume of traffic on these roads is found to be of low to medium intensity. Therefore, possibility of any steep rise in volume of traffic due to mobilization for said projects is not envisaged.

Wherever transmission line crosses the railways, clearance is taken from that department. In general, the system is planned and executed in such a way that adequate clearance is maintained between transmission lines on the one hand, and railways, civil aviation and defense installations on the other. Wherever the transmission lines pass near to airports, the towers beyond specified height are painted in alternate orange and white stripes for easy visibility and warning lights are placed atop these towers.

(vii) **Interference with drainage pattern**

As the transmission lines are constructed aerially and the blockage of ground surface is limited to area of tower footings, which is very small, there is little possibility of affecting drainage pattern. Moreover, the proposed transmission lines don't involve any tower to be placed in river beds for river crossing. However, management measures as specified in EMP (refer clause-5 & 12) like appropriate siting of towers shall be undertaken during detailed alignment survey and design to avoid any incidence of flooding hazards of loss of agricultural production due to interference with drainage patterns or irrigation channels. In the infrequent instances where the natural flow/drainage is affected, flow will be trained and guided to safe zones.

5.1 ENVIRONMENTAL PROBLEMS DUE TO DESIGN

(i) **Escape of polluting materials**

The equipments installed on lines and substations are static in nature and do not generate any fumes or waste materials. However, detailed specification with respect to equipment design has been included in tender document to avoid any incidence of land and water contamination. Apart from this, solid waste like packing materials, cables, aluminium conductor, sand, aggregate material, cements and steel generated during construction is carefully handled and removed from site.

(ii) **Explosion/fire hazards**

During the survey and site selection for transmission lines, it has been ensured that these are kept away from oil/gas pipelines and other sites with potential for creating explosions or fires. Fires due to flashover from lines can be a more serious problem in forest. However, adequate safety measures shall be taken to avoid such incidence and has been included in EMP (refer clause - 15, 23 & 52). Besides this forest authorities also incorporate measures like making fire lines to prevent spreading of fire in the affected forest area. Apart from this, states of art safety instruments are installed in the substations on both the ends so that line gets tripped within milliseconds in case of any fault.

(iii) **Erosion hazards due to inadequate provision for resurfacing of exposed area**

The volume of soil excavated in the construction of transmission lines vary significantly depending upon several factors including wind zone, type of towers, type of foundation, topography of the land etc. It is estimated quantity of soil excavation for construction of

400KV Pugalur- Thiruvalam, 400KV Pugalur- Pugalur, 400KV Pugalur- Arasur, 400KV Pugalur- Edayarpalayam & 400KV Edayarpalayam- Udumulpet line would be around 4,83,768m3, 72,274 m3, 74,810 m3, 57,827 m3 and 40,672 m3 respectively. However, most of these excavated materials (about 80-90%) will be used for re-filling after construction work is over and remaining materials will be disposed properly as detailed out in EMP(refer clause - 25, 26 & 28). Moreover, the topsoil disturbed during the development of sites will be stored properly and used to restore the top surface of the platform. Left over infertile and rocky material will be dumped at carefully selected dumping areas and used as fill for foundations and leveling. Further, excavation in the hilly areas is avoided in rainy days. In hill slopes and erosion prone soils, internationally accepted engineering practices including bio-engineering techniques, wherever, feasible shall be undertaken to prevent soil erosion. Hence, possibility of erosion of exposed area due to construction activity is negligible.

(iv) **Environmental aesthetics**

Since spacing between the towers in case of 400kV transmission lines is approx. 400 meters, there will be no adverse affect on the visual aesthetics of the localities particularly when it is ensured to route the lines as far away from the localities as possible. POWERGRID takes up plantation of trees to buffer the visual effect around its substations and to provide better living conditions. Wherever POWERGRID feels appropriate, discussions will be held with local Forest Department officials to determine feasibility of planting trees along roads running parallel to transmission lines to buffer visual effect in these areas. In addition, towers may be painted grey or green to merge with the background.

(v) **Noise/vibration nuisances**

The equipment installed at substation are mostly static and are so designed that the noise level always remains within permissible limits i.e. 85 dB as per Indian standards. The noise levels reported during normal operating conditions are about 60 to 70 dB at 2 m. distance from the equipment. To contain the noise level within the permissible limits whenever noise level increases beyond permissible limits, measures like providing sound and vibration dampers and rectification of equipment are undertaken. In addition, plantations of sound absorbing species like Casuarinas, Tamarind and Neem are raised at the substations that reduce the sound level appreciably. It is reported that 93 m3 of woodland can reduce the noise level by 8 dB. Actual noise levels measured at perimeters of existing substations are 35 to 45 dB.

(vi) **Blockage of Wildlife passage**

The proposed transmission lines are passing mostly through agricultural land wasteland etc. and only a small portion (5km) Pugalur-Thiruvalam line is passing through reserved forest. Since there are no protected areas, migration path of wildlife like elephant corridors exist near the subproject project locations, possibility of any disturbance to wildlife is not anticipated. Another phenomenon reported in some places viz. Bird hit/electrocution by electric lines during landing and takeoff near the water bodies, fly path of birds is also not envisaged in the instant case due to routing of line away from such areas.

5.2 ENVIRONMENTAL PROBLEMS DURING CONSTRUCTION PHASE

(i) **Uncontrolled silt runoff**

As already explained, during construction a total of approximately 7,29,351 m3 excavated material will be generated from towers and bays foundation. However, adequate measures shall be taken to store excavated materials properly for leveling and refilling after construction is over. In case of hill slopes and erosion prone soils,

internationally accepted engineering practices including bio-engineering techniques, wherever, feasible shall be undertaken to prevent soil erosion. Moreover, excavation in the hilly areas is avoided in rainy days. Hence, uncontrolled silt run off is not anticipated.

(ii) **Nuisance to nearby properties**

As already described in preceding paras, during site selection due care is taken to keep the lines away from settlements. Further, all the construction activities will be undertaken through the use of small mechanical devices e.g. tractors and manual labour, therefore nuisance to the nearby properties if any, is not expected. Further, line bays extension work in substations shall be confined to existing substations which are already inaccessible for general public due to its separation/demarcation by the boundary wall. Moreover, such areas are declared as prohibited for general public as per the provisions of Electricity Act. Hence, any adverse impact arising during the construction will be temporary and limited to the boundaries of existing substations only and will neither impact nearby habitat/property nor health & safety of neighboring community

(iii) **Interference with utilities and traffic and blockage of access way**

Transportation of construction materials will be mostly through road network. Access to the site will be along existing National/State highway or village paths. Minor improvements to paths may be made where necessary, but no major construction of roads will be needed either during construction or as a part of maintenance procedures. In case, access road is not available at some places, existing field/path may be utilized and compensation for any damage to crop or field is paid to the owner.

As and when a transmission line crosses any road/ railways line, adequate care/caution is taken so as not to cause any hindrance to the movement of traffic. Stringing at the construction stage is carried out during lean traffic period in consultation with the concerned authorities and angle towers are planted to facilitate execution of work in different stages.

POWERGRID will follow all applicable standards concerned with safety for transmission and erection of Substation. These include IS: 5613 – recommendation on safety procedures and practices in electrical work as per CEA (Measures relating to Safety and Electric Supply) Regulation, 2010 notified in the Gazette on 20th Sept. 2010 (**Annexure-3**). Apart from this, safety precaution like barricading of work area with reflective tape/illumination and placement of visible signage shall be undertaken to avoid any unforeseen incident. Furthermore, speed restrictions are imposed on project vehicles in project/habitation areas. Moreover, the construction activities associated with transmission line projects are not so extensive and only limited excavation is involved in tower foundations. As such, the volume of traffic and movement of construction vehicles laden with construction materials is quite limited and don't pose any safety hazards for local population as well as increase in road accidents. The extension activities in substation area are always undertaken in enclosed/confined area.

(iv) **Inadequate resurfacing for erosion control**

Since the proposed transmission lines are to be constructed in mostly plain areas, soil erosion will not be a major issue. If due to terrain at some points towers may be placed on slopes and erosion prone soils, internationally accepted engineering practices including bio-engineering techniques wherever feasible shall be undertaken to prevent soil erosion. This will include cutting and filling slopes wherever necessary. The back cut slopes and downhill slopes will be treated with revetments. As explained above adequate steps shall be taken to resurface the area after construction. Wherever sites are affected by active erosion or landslides, both biological and engineering treatment

will be carried out, e.g. provision of breast walls and retaining walls, and sowing soil binding grasses around the site. Further, construction is generally undertaken in dry/non-monsoon period.

(v) **Inadequate disposition of borrow area**

As mentioned earlier the transmission line tower and line bays foundation involve excavation small scale basis and the excavated soil is utilized for back filling. Hence, acquisition/opening of borrow area is not needed.

(vi) **Protection of Worker's health/safety**

All health and safety issues and its management aspects are integral part of project/contract specific safety plan (**Annexure-4**) which is also part of contract condition. Various aspects such as work and safety regulations, workmen's compensation, insurance are adequately covered under the General Conditions of Contract (GCC), a part of bidding documents. Project is executed as per the approved plan and is regularly monitored by dedicated Safety personnel. Moreover, for strict compliance of safety standard/plan a special provision as a deterrent has been added in the contract which provides for a heavy penalty of Rs.10 lakhs for each accidental death and Rs1.0 lakh/each for any injury and is deducted from the contractor's payment and paid to the deceased/affected family (**Annexure – 5**).

POWERGRID maintains safety as a top priority and has framed guidelines/checklist for workers' safety as its personnel are exposed to live EHV apparatus and transmission lines. These guidelines/checklists include work permits and safety precautions for work on the transmission lines and substation both during construction and operation (**Annexure-6**) and is regularly monitored by site in-charge. In addition training is imparted to the workers in fire fighting and safety measures. Standard safety tools like helmet, safety belt, gloves etc. are provided to them in accordance to the provisions of Safety Rules. First aid facilities will be made available with the labour gangs, and doctors called in from nearby towns when necessary. The number of outside (skilled) labourers will be quite small, of the order of 25-30 people per group and remaining workforce of unskilled labourers will be comprised of mostly local people. As per policy/norms preference shall be given to the eligible local labor having required skills a specific clause has been incorporated in contract conditions (refer clause- 22.2.1 of GCC) for compliance of same by Contractor. Workers are also covered by the statutory Workmen (Compensation) Act, Regular health checkups are conducted for construction workers. The construction sites and construction workers' houses will be disinfected regularly, if required. In order to minimize/checking of spread of socially transmitted diseases e.g. HIV/AIDS etc. POWERGRID will conduct awareness building programs on such issues for the construction workers.

5.3 ENVIRONMENTAL PROBLEMS RESULTING FROM OPERATION

(i) **O&M Staff/Skills less than acceptable resulting in variety of adverse effects**

The O&M program in POWERGRID is normally implemented by substation personnel for both, the lines as well as substations. However in respect of the long distance transmission lines, there are monitoring offices that are located at various points en-route. Monitoring measures employed include patrolling and ground based thermo-vision scanning.

The supervisors and managers entrusted with O&M responsibilities are intensively trained for necessary skills and expertise for handling these aspects. A monthly preventive maintenance program will be carried out to disclose problems related to cooling oil, gaskets, circuit breakers, vibration measurements, contact resistance, con-

densers, air handling units, electrical panels and compressors. Any sign of soil erosion is also reported and rectified. Monitoring results are published monthly, including a report of corrective action taken and a schedule for future action.

POWERGRID is following the approved international standards and design, which are absolutely safe. Based on the studies carried out by different countries on the safety of EHV lines in reference to EMF affect POWERGRID have also carried out such studies with the help of PTI, **USA** and **CPRI, Bangalore** on their design. The studies inferred that the POWERGRID design are safe and follow the required international standard (for details refer **Annexure- 7**).

Additionally, in order to, ascertain the actual value of EMF, studies by independent as well as in house agencies were carried out. The values are presented in **Table- 5.2** below:

Table 5.2: Actual values of EMF in POWERGRID lines

S N	Name of Line	Maximum Value		ICNIRP Limits		Name of the Agency	Remarks
		Electric Field (KV/m)	Magnetic Field (μT)	Electric Field (KV/m)	Magnetic Field (μT)		
1	400 KV S/C	2.5	--	5	100	CPRI, Bangalore & Osmania University, Hyderabad	All readings at 1.8 meter height.
2	400 KV D/C	3.5	--	5	100		
3	400 KV D/C Ballabhgarh-Maharanibagh	3.7	2.32	5	100	Corporate Technology Deptt. (CTD) PGCIL	
4	400 KV D/C Bhiwadi- Agra	4.8	2.84	5	100	CTD, PGCIL	
5	400 KV D/C Hyderabad-Ramagundam	3.2	5.04	5	100		

From the above, it is evident that values of Electric and Magnetic Field are well within the limits prescribed by ICNIRP for continuous exposure. Since, residential areas are mostly avoided during routing of line, the chances of continuous exposure are remote

Management of SF6 gas is given utmost importance considering its Global Warming Potential. Strict and well defined procedure has been put in place for storage, handling and refilling of SF6 gas cylinders. Every refill is documented and any unusual variation in gas volume is reported to concerned higher officials for review and rectification. Each and every leakage is promptly detected, addressed and documented.

Considering the importance of SF6 management, it is also incorporated in EMP (refer clause - 45)

Poly Chlorinated Biphenyls (PCBs) due to its high heat capacity, low flammability and low electrical conductivity was extensively used as insulating material in capacitors and transformers. But after the finding that these PCBs are non-biodegradable and has carcinogenic tendency, its use in electrical equipments as insulating medium has been banned all over the world long back. However, it has been reported in some studies that chances of contamination of oil with PCB is possible. Keeping that in mind, POWERGRID has taken all possible steps in association with NGC, UK and setup Regional testing laboratories for testing of existing oil for PCB traces and results of this suggests that PCB contamination is not an issue with POWERGRID. The World Bank has also made following comments after a detailed study on Management of PCBs in India:

"Power Grid was the most advanced in testing for PCBs of the organizations visited for this project. They have established a procedure for identification of the presence of PCBs in transformer oil and more detailed analysis for positive identification sample. To date no significant concentrations of PCBs have been detected. Power Grid do not appear to have any significant issues regarding PCB management and have initiated a testing program. The experience & laboratories of Power Grid could be used to provide a national PCB auditing service".

5.4 CRITICAL ENVIRONMENTAL REVIEW CRITERIA

(i) Loss of irreplaceable resources

The transmission projects do not involve any large scale excavation. In the proposed transmission lines, land is affected to the extent 278 sq. m below the tower base for which compensation is paid to land owner. In the instant scheme, one line i.e. 400kV Pugalur-Thiruvalam transmission line is passing through approximately 5km (23 ha.) of forest area. However, as per regulations, afforestation on double the diverted area in respect of forest will be undertaken to compensate any loss of natural resources.

(ii) Accelerated use of resources for short-term gains

The subject project will not be making use of any natural resources occurring in the area during construction as well as maintenance phases. The construction materials such as tower members, cement etc. shall come from factories while the excavated soil shall be used for leveling and backfilling to restore the surface. During construction of line, very small quantity of water is required which is met from nearby existing source or through tankers. Hence, it may be seen that the activities associated with implementation of subject project shall not cause any accelerated use of resources for short term gain.

(iii) Endangering of species

As described earlier, no endangered species of flora and fauna exist in the subprojects area is getting affected thus there is no possibility of endangering/ causing extinction of any species.

(iv) Promoting undesirable rural-to urban migration

The subject project will not cause any submergence or loss of land holdings that normally trigger migration. It also does not involve acquisition of any private land holdings. Hence, there is no possibility of any migration.

5.5 PUBLIC CONSULTATION:

Public consultation/information is an integral part of the POWERGRID project cycle. POWERGRID follows a well defined procedure for conducting public consultation involving different techniques as laid down in its ESPP, which is also approved by The World Bank under the Use of Country System (UCS). There are 10 different techniques which are used either independently or in combination appropriately at different milestones of the project depending on field conditions.(for details refer **Annexure -8**). The location for public meeting is usually selected at every 50-100 km involving major villages/habitated area en-route of line. However, in other villages/parts, informal group meetings or other techniques are applied for consultation. The consultation and feedback process is a continuous one and implemented regularly at different milestone of project cycle.

The process of consultation and information dissemination begins even before the start of work as POWERGRID informs the general public by publishing in 2 (Two) local newspapers in vernacular language on implementation of project indicating the route of final alignment with name of the town /villages its passing. During survey also

POWERGRID site officials meet people and inform them about the routing of transmission lines. During construction, every individual, on whose land line is constructed and people affected by RoW, are consulted. Apart from this, Public consultation using different technique like Public Meeting, Small Group Meeting, Informal Meeting shall also be carried out during different activities of project cycle. During such consultation the public are informed about the project in general and in particular about the following:

- Complete project plan (i.e. its route and terminating point and substations, if any, in between);
- Design standards in relation to approved international standards;
- Health impacts in relation to EMF;
- Measures taken to avoid public utilities such as school, hospitals, etc.;
- Other impacts associated with transmission lines and POWERGRID approach to minimizing and solving them;
- Trees and crop compensation process.

Additionally, questions, doubts and apprehensions of members of public are heard and answered to the extent possible. Queries raised by participants are mostly concentrated on improvement in power availability to their village, safety and RoW compensation. Some of the queries raised are presented below:

- ✓ Whether this line will improve the power supplies in our village and remove frequent interruption/outage;
- ✓ Whether these lines are safe for the nearby dwellers without any problems of electrocution while working in the fields;
- ✓ What is compensation policy for the standing crops damaged and compensation for the land occupied by the tower footings;
- ✓ What about employment for local people and procedure for same;
- ✓ What is the width of RoW for cutting tree. How much compensation for the trees will be given and when.

In the instant scheme also, many group meetings were organized (informally and formally) in all villages where the interventions are likely to happen. Such consultation culminated in public meeting organized at different locations as provided in **Table- 5.3**. These meetings were attended by Gram Panchayat leaders/members, Village heads, interested villagers/general public and representatives from POWERGRID. Village women folk also actively participated in consultation. To ensure maximum participation, prior intimation in local language was given and such notices were also displayed at prominent places/panchayat office etc. During the public consultation details of line and its importance were explained to the villagers by the officials of POWERGRID. The consultation was arranged in interactive manner in local language and queries like crop/land compensation, engagement employment opportunities, health & safety, improvement of power scenario & infrastructure in region etc. were addressed. The initiative was appreciated by the villagers and they assured their cooperation for construction of the said lines. The process of such consultation shall continue during different stage of project implementation and even during O& M stage. Details of above public consultation meetings including public notice, list of participants, photographs and public queries & answers are enclosed as **Annexure -9**.

Table -5.3: Public Consultation en-route of Transmission Lines

Sl. No.	Date & time of Consultation	Venue	Person Attended
1.	31st May 2016 11.00 AM	At- Community Hall Village-Ammapalyam	Total 25 persons including Panchayat members, interested

		District- Thiruvanamalai State- Tamil Nadu	villagers/ general public attended
2.	1st June 2016, 11.00 AM	At- Village Primary School Village- Poosimalaikuppam District- Arani, State- Tamil Nadu	Total 77 persons including Panchayat head & member, interested villagers/ general public attended
3.	2nd June 2016 11.00 AM	At- Gram Panchayat Village-Satur District- Arcot State- Tamil Nadu	Total 29 persons including Panchayat head & members, interested villagers/ general public attended
4	12th Dec.'2015 10.00 AM	At- Village Primary School Village- Muthalipalayam District- Tiruppur State- Tamil Nadu	Total 50 persons including Panchayat President & members, Panchayat Council Members and interested villagers/ general public attended
5	16th Dec.' 15, 3.00 PM	At- Grampanchayat Community Hall, Village- Arasampalayam District- Coimbatore, State- Tamil Nadu	Total 25 persons including Village heads, interested villagers/ general public attended

5.6 CONCLUSIONS:

It is clear from the above assessment/studies that the project area is not so rich in natural forest resources. Though careful route selection have completely avoided protected areas in all lines but in spite of taking all precautions involvement of some reserve forest couldn't be achieved in case of one line i.e. 400kV Pugalur-Thiruvalam line due to geographical constraint and location of substations/load centers. However, route is so aligned that it involves minimum forest area and there will be minimum vegetation loss and other environment impacts. Moreover, with implementation of various management measures as listed in EMP, it is envisaged that intensity of possible impacts shall be nullified to the extent possible. The infrastructural constraints are very real and pose a limiting factor on the development of the area. The above facts while on the one hand underline the need for implementation of the subject scheme for overall development of the area and on other hand suggests that a detailed EIA may not be necessary due to negligible and manageable impact of transmission line.

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SECTION – VI: PROJECT IMPLEMENTATION ARRANGEMENT & MONITORING

6.0 ENVIRONMENTAL MONITORING PROGRAM IN POWERGRID:

Monitoring is a continuous process for POWERGRID projects at all the stages be it the site selection, construction or maintenance.

The success of POWERGRID lies in its strong monitoring systems. Apart from the site managers reviewing the progress on daily basis regular project review meetings are held at least on monthly basis which is chaired by Executive Director of the region wherein apart from construction issues the environmental aspects of the projects are discussed and remedial measures taken wherever required. The exceptions of these meetings are submitted to the Directors and Chairman & Managing Director of the Corporation. The progress of various on-going projects is also informed to the Board of Directors. Flow chart showing institutional arrangement for implementation ESPP is placed as **Exhibit-2**. A three tier support structure has also been developed at corporate, regional and site level with following functions for effective implementation of environment and social safeguard measures.

6.1.1 Corporate Level

An Environmental Management Cell at corporate level was created within POWERGRID in 1992 and subsequently upgraded to an Environment Management Department (EMD) in 1993 and in 1997 it has been further upgraded to Environment & Social Management Deptt. (ESMD) by incorporating social aspect of project. Briefly, the ESMD's responsibilities are as follows:

- Advising and coordinating RHQs and Site to carry out environmental and social surveys for new projects;
- Assisting RHQs and site to finalize routes of entire power transmission line considering environmental and social factors that could arise en-route;
- Help RHQs and Site to follow-up with the state forest offices and other state departments in expediting forest clearances and the land acquisition process of various ongoing and new projects;
- Act as a focal point for interaction with the MoEFCC for expediting forest clearances and follow-ups with the Ministry of Power;
- Imparts training to POWERGRID's RHQs & Site Officials on environment and social issues and their management plan.

6.1.2 Regional Level

At its Regional Office POWERGRID has a Environmental and Social Management Cell (ESMC) to manage Environmental and Social issues and to coordinate between ESMD at the Corporate level and the Divisional Headquarters. The key functions envisaged for ESMC are:

- Advising and coordinating field offices to carry out environmental and social surveys for new projects envisaged in the Corporate Investment Plan;
- Assisting the ESMD and site to finalize routes of entire power transmission lines considering the environmental and social factors that could arise en-route;
- To follow-up forest clearances and land acquisition processes with state forest offices and other state departments for various ongoing and new projects;

- Acting as a focal point for interaction with the ESMD and site on various environmental and social aspects.

6.1.3 Site Office

At the Divisional Headquarters level, POWERGRID has made the head of the division responsible for implementing the Environmental and Social aspect of project and are termed as Environmental and Social Management Team (ESMT). Key functions of the ESMT are:

- Conduct surveys on environmental and social aspects to finalize the route for the power transmission projects;
- Conduct surveys & Interact with Revenue Authorities for land acquisition;
- Interact with the Forest Departments to make the forest proposal and follow it up for MoEFCC clearance;
- Implementation of Environment Management Plan (EMP);
- Monitoring of EMP & producing periodic reports on the same.

From above, It may be noted that POWERGRID is well equipped to implement and monitor its environment and social management plans.

As regards monitoring of impacts on ecological resources particularly in Forest and Protected areas like Wildlife Sanctuaries or National Parks, it is generally done by the concerned Divisional Forest Officer, Chief Wildlife Warden and their staff as a part of their normal duties. A detailed Environment Management Plan (EMP) including monitoring plan for all possible environmental and social impact and its proper management has been drawn (**Table- 6.1**) and will be implemented during various stage of project execution. Since many provisions of EMP are to be implemented by contractor, hence for proper monitoring EMP has been included in the contract document. A budget estimate towards tree/crop compensation and EMP implementation is prepared and is placed at **Annexure-10.** A summary of the same is presented below:

S. N.	Budgetary Head	Amount (Rs. Lakhs)
1	Forest compensation	460.00
2	Tree & Crop Compensation	3050.00
3	Land Compensation for Tower Base and RoW Corridor	24520.00
4	EMP Implementation, Monitoring & Audit	86.50
	Total	**28116.50**

Any other measures like provision of bird guards, spike guards, barbed wire fencing or any other arrangement for addressing the issues like bird hit/animal/elephant scratching etc. shall be finalized only after detailed/ check survey and finalization of route alignment. Since the detailed/ check survey is part of main package requirement of such measures, its extent and estimated cost shall be incorporated in the revised cost estimate proposal which is normally prepared for all projects as there is a considerable time gap between planning and actual implementation. However, as per the preliminary assessment such additional measures may not be required in the instant scheme as no such impact are envisaged due to routing of lines far away from such sensitive areas.

6.2 GRIEVANCE REDRESSAL MECHANISM (GRM)

Grievance Redress Mechanism (GRM) is an integral and important mechanism for addressing/resolving the concern and grievances in a transparent and swift manner. Many minor concerns of peoples are addressed during public consultation process initiated at the beginning of the project. For handling grievance, Grievance Redress

Committee (GRC) will be established at two places, one at the project/scheme level and another at Corporate/HQ level. The GRCs shall include members from POWERGRID, Local Administration, Panchayat Members, Affected Persons representative and reputed persons from the society on nomination basis under the chairmanship of project head. The composition of GRC shall be disclosed in Panchayat/Village council offices and concerned district headquarter for wider coverage.

The complainant will also be allowed to submit its complaint to local project official who will pass it to GRC immediately but not more than 5 days of receiving such complaint. The first meeting of GRC will be organized within 15 days of its constitution/disclosure to formulate procedure and frequency of meeting. However, GRC meeting shall be convened within 15 days of receiving a grievance for its solution. GRC endeavor will be to pronounce its decision/ may also refer it to corporate GRC for solution within 30-45 days of receiving grievances. In case complainant/appellant is not satisfied with the decision of GRC they can approach POWERGRID Corporate Level Committee/District Collector or Court of law for solution.

The corporate level GRC shall function under the chairmanship of Director (Project) who will nominate other members of GRC including one representative from corporate ESMC who is conversant with the environment & social issues. The meeting of Corporate GRC shall be convened within 7-10 days of receiving the reference from project GRC or complainant directly and pronounce its decision within next 15 days.

6.3 ENVIRONMENTAL REVIEW :

Periodic review by corporate ESMD and higher management including review by POWERGRID CMD of all environmental and social issues is undertaken to ensure that EMP and other measures are implemented at site. A semi-annual environmental monitoring report reflecting the status of EMP implementation and corrective actions if any, will be prepared and disclosed on POWERGRID's website. The monitoring report will also be submitted to ADB for disclosing on its website. The format of environmental monitoring report is enclosed as **Annexure-11**. The IEE, the EMP, and revisions and updates, if any will also be disclosed. Besides, an annual review by Independent Auditor under ISO: 14001 shall also be undertaken for compliance of agreed policy and management plan.

Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
7	Line through protected area/ precious ecological area	Loss of precious ecological values/ damage to precious species	Avoid siting of lines through such areas by careful site and alignment selection (National Parks, Wildlife Sanctuary, Biosphere Reserves/ Biodiversity Hotspots)	Tower location and line alignment selection (distance to nearest designated ecological protected/ sensitive areas)	Consultation with local forest authorities - once	POWERGRID	Part of tower siting survey and detailed alignment survey and design
			Minimize the need by using RoW wherever possible	Tower location and line alignment selection	Consultation with local authorities and design engineers - once	POWERGRID	Part of tower siting survey and detailed alignment survey and design
8	Line through identified Elephant corridor / Migratory bird	Damage to the Wildlife/ Birds and also to line	Study of earmarked elephant corridors to avoid such corridors, Adequate ground clearance, Fault clearing by Circuit Breaker, Barbed wire wrapping on towers, reduced spans etc., if applicable	Tower location and line alignment selection. Minimum/maximum ground clearance	Consultation with local forest authorities – once. Monitoring – quarterly basis	POWERGRID	Part of tower sitting and detailed alignment survey & design and Operation
			Avoidance of established/ identified migration path (Birds & Bats). Provision of flight diverter/ reflectors, bird guard, elevated perches, insulating jumper loops, obstructive perch deterrents, raptor hoods etc[5]., if applicable	Tower location and line alignment selection	Consultation with local forest authorities - once	POWERGRID	Part of tower siting survey and detailed alignment survey and design
9	Line through forestland	Deforestation and loss of biodiversity edge effect	Avoid locating lines in forest land by careful site and alignment selection	Tower location and line alignment selection (distance to nearest protected or reserved forest)	Consultation with local authorities – once	POWERGRID	Part of tower siting survey and detailed alignment survey and design

[5] As per International/National best practices and in consultation with concerned forest/wildlife Authority.

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
			Minimise the need by using existing towers, tall towers and RoW, wherever possible		Consultation with local authorities and design engineers – once		
			Measures to avoid invasion of alien species	Intrusion of invasive species	Consultation with local forest authorities - once		
			Obtain statutory clearances from the Government	Statutory approvals from Government	Compliance with regulations – once for each subproject		
10	Lines through farmland	Loss of agricultural production/ change in cropping pattern	Use existing tower or footings wherever possible.	Tower location and line alignment selection.	Consultation with local authorities and design engineers – once	POWERGRID	Part of detailed alignment survey and design
			Avoid sitting new towers on farmland wherever feasible	Tower location and line alignment selection	Consultation with local authorities and design engineers – once		Part of detailed sitting and alignment survey /design
11	Noise related**	Nuisance to neighbouring properties	Substations sited and designed to ensure noise will not be a nuisance	Noise levels	Noise levels to be specified in tender documents – once	POWERGRID	Part of detailed equipment design
12	Interference with drainage patterns/ irrigation channels	Flooding hazards/ loss of agricultural production	Appropriate sitting of towers to avoid channel interference	Tower location and line alignment selection (distance to nearest flood zone)	Consultation with local authorities and design engineers – once	POWERGRID	Part of detailed alignment survey and design
13	Escape of polluting materials**	Environmental pollution	Transformers designed with oil spill containment systems, and purpose-built oil, lubricant and fuel storage system, complete with spill clean up equipment.	Equipment specifications with respect to potential pollutants	Tender document to mention specifications – once	POWERGRID	Part of detailed equipment design /drawings

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Table- 6.1: ENVIRONMENT MANAGEMENT PLAN

Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
Pre-construction							
1	Location of line towers and line alignment and design	Exposure to safety related risks	Setback of dwellings to line route designed in accordance with permitted level of power frequency and the regulation of supervision at sites.	Tower location and alignment selection with respect to nearest dwellings	Setback distances to nearest houses – once	POWERGRID	Part of tower sitting survey and detailed alignment survey and design
2	Equipment specifications and design parameters	Release of chemicals and gases in receptors (air, water, land)	PCBs not used in substation transformers or other project facilities or equipment.	Transformer design	Exclusion of PCBs in transformers stated in tender specification – once	POWERGRID	Part of tender specifications for the equipment
			Processes, equipment and systems not to use chlorofluorocarbons (CFCs), including halon, and their use, if any, in existing processes and systems should be phased out and to be disposed of in a manner consistent with the requirements of the Government	Process, equipment and system design	Exclusion of CFCs stated in tender specification – once Phase out schedule to be prepared in case still in use – once	POWERGRID	Part of tender specifications for the equipment Part of equipment and process design
3	Transmission line design	Exposure to electromagnetic interference	Line design to comply with the limits of electromagnetic interference from power lines	Electromagnetic field strength for proposed line design	Line design compliance with relevant standards – once	POWERGRID	Part of design parameters
4	Substation location and design**	Exposure to noise	Design of plant enclosures to comply with noise regulations.	Expected noise emissions based on substation design	Compliance with regulations - once	POWERGRID	Part of detailed siting survey and design
		Social inequities	Careful selection of site to avoid encroachment of socially, culturally and archaeological sensitive areas (i.e. sacred groves,	Selection of substation location (distance to sensitive area).	Consultation with local authorities -once	POWERGRID	Part of detailed siting survey and design

Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
			graveyard, religious worship place, monuments etc.)				
5	Location of line towers & line alignment and design	Impact on water bodies	Avoidance of such water bodies to the extent possible. Avoidance of placement of tower inside water bodies to the extent of possible	Tower location and line alignment selection (distance to water bodies)	Consultation with local authorities– once	POWERGRID	Part of tower siting survey and detailed alignment survey and design
		Social inequities	Careful route selection to avoid existing settlements and sensitive locations	Tower location and line alignment selection (distance to nearest dwellings or social institutions)	Consultation with local authorities and land owners – once	POWERGRID	Part of tower siting survey and detailed alignment survey and design
			Minimise impact on agricultural land	Tower location and line alignment selection (distance to agricultural land)	Consultation with local authorities and land owners – once		
			Careful selection of site and route alignment to avoid encroachment of socially, culturally and archaeological sensitive areas (i. g. sacred groves, graveyard, religious worship place, monuments etc.)	Tower location and line alignment selection (distance to sensitive area)	Consultation with local authorities -once		
6	Securing lands for substations**	Loss of land/ income change in social status etc.	In the case of Involuntary Acquisitions, Compensation and R&R measures are extended as per provision of RFCTLARRA, 2013[4]	Compensation and monetary R&R amounts/ facilities extended before possession of land.	As per provisions laid out in the act	POWERGRID	Prior to award/start of substation construction.

[4] In the instant case, no involuntary acquisition of land is involved. Hence this clause shall not be applicable.

Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
			Substations to include drainage and sewage disposal systems to avoid offsite land and water pollution.	Substation sewage design	Tender document to mention detailed specifications – once	POWERGRID	Part of detailed substation layout and design /drawings
14	Equipments submerged under flood	Contamination of receptors	Substations constructed above the high flood level(HFL) by raising the foundation pad	Substation design to account for HFL (elevation with respect to HFL elevation)	Base height as per flood design- once	POWERGRID	Part of detailed substation layout and design/drawings
15	Explosions /Fire	Hazards to life	Design of substations to include modern fire fighting equipment	Substation design compliance with fire prevention and control codes	Tender document to mention detailed specifications – once	POWERGRID	Part of detailed substation layout and design /drawings
			Provision of fire fighting equipment to be located close to transformers				
Construction							
16	Equipment layout and installation	Noise and vibrations	Construction techniques and machinery selection seeking to minimize ground disturbance.	Construction techniques and machinery	Construction techniques and machinery creating minimal ground disturbance- once at the start of each construction phase	POWERGRID (Contractor through contract provisions)	Construction period
17	Physical construction	Disturbed farming activity	Construction activities on cropping land timed to avoid disturbance of field crops (within one month of harvest wherever possible).	Timing of start of construction	Crop disturbance – Post harvest as soon as possible but before next crop – once per site	POWERGRID (Contractor through contract provisions)	Construction period
18	Mechanized construction	Noise, vibration and operator safety, efficient operation	Construction equipment to be well maintained.	Construction equipment – estimated noise emissions	Complaints received by local authorities – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period

Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
		Noise, vibration, equipment wear and tear	Turning off plant not in use.	Construction equipment – estimated noise emissions and operating schedules	Complaints received by local authorities – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
19	Construction of roads for accessibility	Increase in airborne dust particles	Existing roads and tracks used for construction and maintenance access to the line wherever possible.	Access roads, routes (length and width of new access roads to be constructed)	Use of established roads wherever possible – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
		Increased land requirement for temporary accessibility	New access ways restricted to a single carriageway width within the RoW.	Access width (meters)	Access restricted to single carriage –way width within RoW – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
20	Construction activities	Safety of local villagers	Coordination with local communities for construction schedules, Barricading the construction area and spreading awareness among locals	Periodic and regular reporting /supervision of safety arrangement	No. of incidents- once every week	POWERGRID (Contractor through contract provisions)	Construction period
		Local traffic obstruction	Coordination with local authority/ requisite permission for smooth flow of traffic	Traffic flow (Interruption of traffic)	Frequency (time span)- on daily basis	POWERGRID (Contractor through contract provisions)	Construction period
21	Temporary blockage of utilities	Overflows, reduced discharge	Measure in place to avoid dumping of fill materials in sensitive drainage area	Temporary fill placement (m^3)	Absence of fill in sensitive drainage areas – every 4 weeks	POWERGRID (Contractor through contract provisions)	Construction period
22	Site clearance	Vegetation	Marking of vegetation to be removed prior to clearance, and strict control on clearing activities to ensure minimal clearance.	Vegetation marking and clearance control (area in m^2)	Clearance strictly limited to target vegetation – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
			No use of herbicides and pesticides				

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
23	Trimming /cutting of trees within RoW	Fire hazards	Trees allowed growing up to a height within the RoW by maintaining adequate clearance between the top of tree and the conductor as per the regulations.	Species-specific tree retention as approved by statutory authorities (average and max. tree height at maturity, in meters)	Presence of target species in RoW following vegetation clearance – once per site	POWERGRID (Contractor through contract provisions)	Construction period
		Loss of vegetation and deforestation	Trees that can survive pruning to comply should be pruned instead of cleared.	Species-specific tree retention as approved by statutory authorities	Presence of target species in RoW following vegetation clearance - once per site	POWERGRID (Contractor through contract provisions)	Construction period
			Felled trees and other cleared or pruned vegetation to be disposed of as authorized by the statutory bodies.	Disposal of cleared vegetation as approved by the statutory authorities (area cleared in m^2)	Use or intended use of vegetation as approved by the statutory authorities – once per site	POWERGRID (Contractor through contract provisions)	Construction period
24	Wood/ vegetation harvesting	Loss of vegetation and deforestation	Construction workers prohibited from harvesting wood in the project area during their employment, (apart from locally employed staff continuing current legal activities)	Illegal wood /vegetation harvesting (area in m^2, number of incidents reported)	Complaints by local people or other evidence of illegal harvesting – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
25	Surplus earthwork/soil	Runoff to cause water pollution, solid waste disposal	Soil excavated from tower footings/ substation foundation disposed of by placement along roadsides, or at nearby house blocks if requested by landowners	Soil disposal locations and volume (m^3)	Acceptable soil disposal sites – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
26	Substation construction**	Loss of soil	Loss of soil is not a major issue as excavated soil will be mostly reused for leveling and re-filling. However, in case of requirement of excess soil the same will be met from	Borrow area sitting (area of site in m^2 and estimated volume in m^3)	Acceptable soil borrow areas that provide a benefit - every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period

Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
			existing quarry or through deep excavation of existing pond or other nearby barren land with agreement of local communities				
		Water pollution	Construction activities involving significant ground disturbance (i.e. substation land forming) not undertaken during the monsoon season	Seasonal start and finish of major earthworks(P^H, BOD /COD, Suspended solids, others)	Timing of major disturbance activities – prior to start of construction activities	POWERGRID (Contractor through contract provisions))	Construction period
27	Site clearance	Vegetation	Tree clearances for easement establishment to only involve cutting trees off at ground level or pruning as appropriate, with tree stumps and roots left in place and ground cover left undisturbed	Ground disturbance during vegetation clearance (area, m^2)	Amount of ground disturbance – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
				Statutory approvals	Statutory approvals for tree clearances – once for each site		
28	Tower erection Substation foundation-disposal of surplus earthwork/fill	Waste disposal	Excess fill from substation/tower foundation excavation disposed of next to roads or around houses, in agreement with the local community or landowner.	Location and amount (m^3)of fill disposal	Appropriate fill disposal locations – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
29	Storage of chemicals and materials	Contamination of receptors (land, water, air)	Fuel and other hazardous materials securely stored above high flood level.	Location of hazardous material storage; spill reports (type of material spilled, amount (kg or m^3) and action taken to cont-ol and clean up spill)	Fuel storage in appropriate locations and receptacles – every 2 weeks	POWERGRID (Contractor through contract provisions)	Construction period
30	Construction schedules	Noise nuisance to neighbouring	Construction activities only undertaken during the day and local communities	Timing of construction (noise emissions, [dB(A)]	Daytime construction only – every 2 weeks	POWERGRID (Contractor through contract	Construction period

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
		properties	informed of the construction schedule.			provisions)	
31	Provision of facilities for construction workers	Contamination of receptors (land, water, air)	Construction workforce facilities to include proper sanitation, water supply and waste disposal facilities.	Amenities for Workforce acilities	Presence of proper sanitation, water supply and waste disposal facilities – once each new facility	POWERGRID (Contractor through contract provisions)	Construction period
32	Influx of migratory workers	Conflict with local population to share local resources	Using local workers for appropriate asks	Avoidance/reduction of conflict through enhancement/ augmentation of resource requirements	Observation & supervision–on weekly basis	POWERGRID (Contractor through contract provisions)	Construction period
33	Lines through farmland	Loss of agricultural productivity	Use existing access roads wherever possible	Usage of existing utilities	Complaints received by local people /authorities - every 4 weeks	POWERGRID (Contractor through contract provisions)	Construction period
			Ensure existing irrigation facilities are maintained in working condition	Status of existing facilities			
			Protect /preserve topsoil and reinstate after construction completed	Status of facilities (earthwork in m^3)			
			Repair /reinstate damaged bunds etc after construction	Status of facilities (earthwork in m^3)			
		Loss of income.	Land owners/ farmers compensated for any temporary loss of productive land as per existing regulation.	Process of Crop/tree compensation in consultation with forest dept.(for timber yielding tree) and Horticulture deptt.(for fruit bearing tree)	Consultation with affected land owner prior to implementation and during execution.	POWERGRID	During construction
34	Uncontrolled erosion/silt runoff	Soil loss, downstream siltation	Need for access tracks minimised, use of existing roads.	Design basis and construction procedures (suspended solids in receiving waters; area re-vegetated in m^2;	Incorporating good design and construction management practices – once for each site	POWERGRID (Contractor through contract provisions)	Construction period
			Limit site clearing to work areas				

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
			Regeneration of vegetation to stabilise works areas on completion (where applicable)	amount of bunds constructed [length in meter, area in m^2, or volume in m^3])			
			Avoidance of excavation in wet season				
			Water courses protected from siltation through use of bunds and sediment ponds				
35	Nuisance to nearby properties	Losses to neighbouring land uses/ values	Contract clauses specifying careful construction practices.	Contract clauses	Incorporating good construction management practices – once for each site	POWERGRID (Contractor through contract provisions)	Construction period
			As much as possible existing access ways will be used	Design basis and layout	Incorporating good design engineering practices– once for each site		
			Productive land will be reinstated following completion of construction	Reinstatement of land status (area affected, m^2)	Consultation with affected parties – twice – immediately after completion of construction and after the first harvest		
		Social inequities	Compensation will be paid for loss of production, if any.	Implementation of Tree/Crop compensation (amount paid)	Consultation with affected parties – once in a quarter	POWERGRID	Prior to construction
36	Flooding hazards due to construction impediments of natural drainage	Flooding and loss of soils, contamination of receptors (land, water)	Avoid natural drainage pattern/ facilities being disturbed/blocked/ diverted by on-going construction activities	Contract clauses (e.g. suspended solids and BOD/COD in receiving water)	Incorporating good construction management practices-once for each site	POWERGRID (Contractor through contract provisions)	Construction period
37	Equipment submerged under flood	Contamination of receptors (land, water)	Equipment stored at secure place above the high flood level(HFL)	Store room level to be above HFL (elevation difference in meters)	Store room level as per flood design-once	POWERGRID	Construction period

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
38	Inadequate siting of borrow areas (quarry areas)	Loss of land values	Existing borrow sites will be used to source aggregates, therefore, no need to develop new sources of aggregates	Contract clauses	Incorporating good construction management practices – once for each site	POWERGRID (Contractor through contract provisions))	Construction period
39	Health and safety	Injury and sickness of workers and members of the public	Safety equipment's (PPEs) for construction workers	Contract clauses (number of incidents and total lost-work days caused by injuries and sickness)	Contract clauses compliance – once every quarter	POWERGRID (Contractor through contract provisions)	Construction period
			Contract provisions specifying minimum requirements for construction camps				
			Contractor to prepare and implement a health and safety plan.				
			Contractor to arrange for health and safety training sessions				
40	Inadequate construction stage monitoring	Likely to maximise damages	Training of environmental monitoring personnel	Training schedules	No. of programs attended by each person – once a year	POWERGRID	Routinely throughout construction period
			Implementation of effective environmental monitoring and reporting system using checklist of all contractual environmental requirements	Respective contract checklists and remedial actions taken thereof.	Submission of duly completed checklists of all contracts for each site - once		
			Appropriate contact clauses to ensure satisfactory implementation of contractual environmental mitigation measures.	Compliance report related to environmental aspects for the contract	Submission of duly completed compliance report for each contract – once		
Operation and Maintenance							
41	Location of line towers and line alignment & design	Exposure to safety related risks	Setback of dwellings to overhead line route designed in accordance with permitted level of power frequency and the	Compliance with setback distances ("as-built" diagrams)	Setback distances to nearest houses – once in quarter	POWERGRID	During operations

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
			regulation of supervision at sites.				
42	Line through identified bird flyways, migratory path	Injury/ mortality to birds, bats etc due to collision and electrocution	Avoidance of established/ identified migration path (Birds & Bats). Provision of flight diverter/reflectors, elevated perches, insulating jumper loops, obstructive perch deterrents, raptor hoods etc., if applicable	Regular monitoring for any incident of injury/mortality	No. of incidents- once every month	POWERGRID	Part of detailed siting and alignment survey /design and Operation
43	Equipment submerged under flood	Contamination of receptors (land, water)	Equipment installed above the high flood level (HFL) by raising the foundation pad.	Substation design to account for HFL ("as-built" diagrams)	Base height as per flood design – once	POWERGRID	During operations
44	Oil spillage	Contamination of land/nearby water bodies	Each transformer has a secure and impervious underlying pit with a storage capacity of at least 20% of the total oil volume of the transformer and the individual pits are connected to a main collection sump of capacity of 220% of largest transformer oil volume, which acts as a Secondary Containment, in case of a leakage.	Substation bunding (Oil sump) ("as-built" diagrams)	Bunding (Oil sump) capacity and permeability - once	POWERGRID	During operations
45	SF_6 management	Emission of most potent GHG causing climate change	Reduction of SF6 emission through awareness, replacement of old seals, proper handling & storage by controlled inventory and use, enhance recovery and applying new technologies to reduce leakage	Leakage and gas density/level	Continuous monitoring	POWERGRID	During Operations

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
46	Inadequate provision of staff/workers health and safety during operations	Injury and sickness of staff /workers	Careful design using appropriate technologies to minimise hazards	Usage of appropriate technologies (lost work days due to illness and injuries)	Preparedness level for using these technologies in crisis – once each year	POWERGRID	Design and operation
			Safety awareness raising for staff.	Training/awareness programs and mock drills	Number of programs and percent of staff /workers covered – once each year		
			Preparation of fire emergency action plan and training given to staff on implementing emergency action plan				
			Provide adequate sanitation and water supply facilities	Provision of facilities	Complaints received from staff /workers every 2 weeks		
47	Electric Shock Hazards	Injury/ mortality to staff and public	Careful design using appropriate technologies to minimise hazards	Usage of appropriate technologies (no. of injury incidents, lost work days)	Preparedness level for using these technology in crisis- once a month	POWERGRID	Design and Operation
			Security fences around substations	Maintenance of fences	Report on maintenance – every 2 weeks		
			Barriers to prevent climbing on/ dismantling of towers	Maintenance of barriers			
			Appropriate warning signs on facilities	Maintenance of warning signs			
			Electricity safety awareness raising in project areas	Training /awareness programs and mock drills for all concerned parties	Number of programs and percent of total persons covered – once each year		
48	Operations and maintenance staff skills less than acceptable	Unnecessary environmental losses of various types	Adequate training in O&M to all relevant staff of substations & line maintenance crews.	Training/awareness programs and mock drills for all relevant staff	Number of programs and percent of staff covered – once each year	POWERGRID	Operation
			Preparation and training in the use of O&M manuals and standard operating practices				
49	Inadequate	Diminished	Staff to receive training in	Training/awareness	Number of programs	POWERGRID	Operation

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Clause No.	Project activity/ stage	Potential Impact	Proposed mitigation measures	Parameter to be monitored	Measurement & frequency	Institutional responsibility	Implementation schedule
	periodic environmental monitoring.	ecological and social values.	environmental monitoring of project operations and maintenance activities.	programs and mock drills for all relevant staff	and percent of staff covered – once each year		
50	Equipment specifications and design parameters	Release of chemicals and gases in receptors (air, water, land)	Processes, equipment and systems using chlorofluorocarbons (CFCs) , including halon, should be phased out and to be disposed of in a manner consistent with the requirements of the Govt.	Process, equipment and system design	Phase out schedule to be prepared in case still in use – once in a quarter	POWERGRID	Operations
51	Transmission line maintenance	Exposure to electromagnetic interference	Transmission line design to comply with the limits of electromagnetic interference from overhead power lines	Required ground clearance (meters)	Ground clearance - once	POWERGRID	Operations
52	Uncontrolled growth of vegetation	Fire hazard due to growth of tree/shrub /bamboo along RoW	Periodic pruning of vegetation to maintain requisite electrical clearance. No use of herbicides/ pesticides	Requisite clearance (meters)	Assessment in consultation with forest authorities - once a year(pre-monsoon/post-monsoon	POWERGRID	Operations
53	Noise related	Nuisance to neighbouring properties	Substations sited and designed to ensure noise will not be a nuisance.	Noise levels {dB(A)}	Noise levels at boundary nearest to properties and consultation with affected parties if any - once	POWERGRID	Operations

***** These measures will not be applicable in the instant case since no new substation is covered under the present scope of works.***

EXHIBIT – 1

SCHEMATIC MAP SHOWING PROPOSED SUBPROJECTS

HVDC BIPOLE LINK BETWEEN WESTERN REGION (RAIGARH, CHHATTISGARH) & SOUTHERN REGION (PUGALUR, TAMIL NADU)- NORTH TRICHUR (KERALA)
SCHEMES - I, II & III

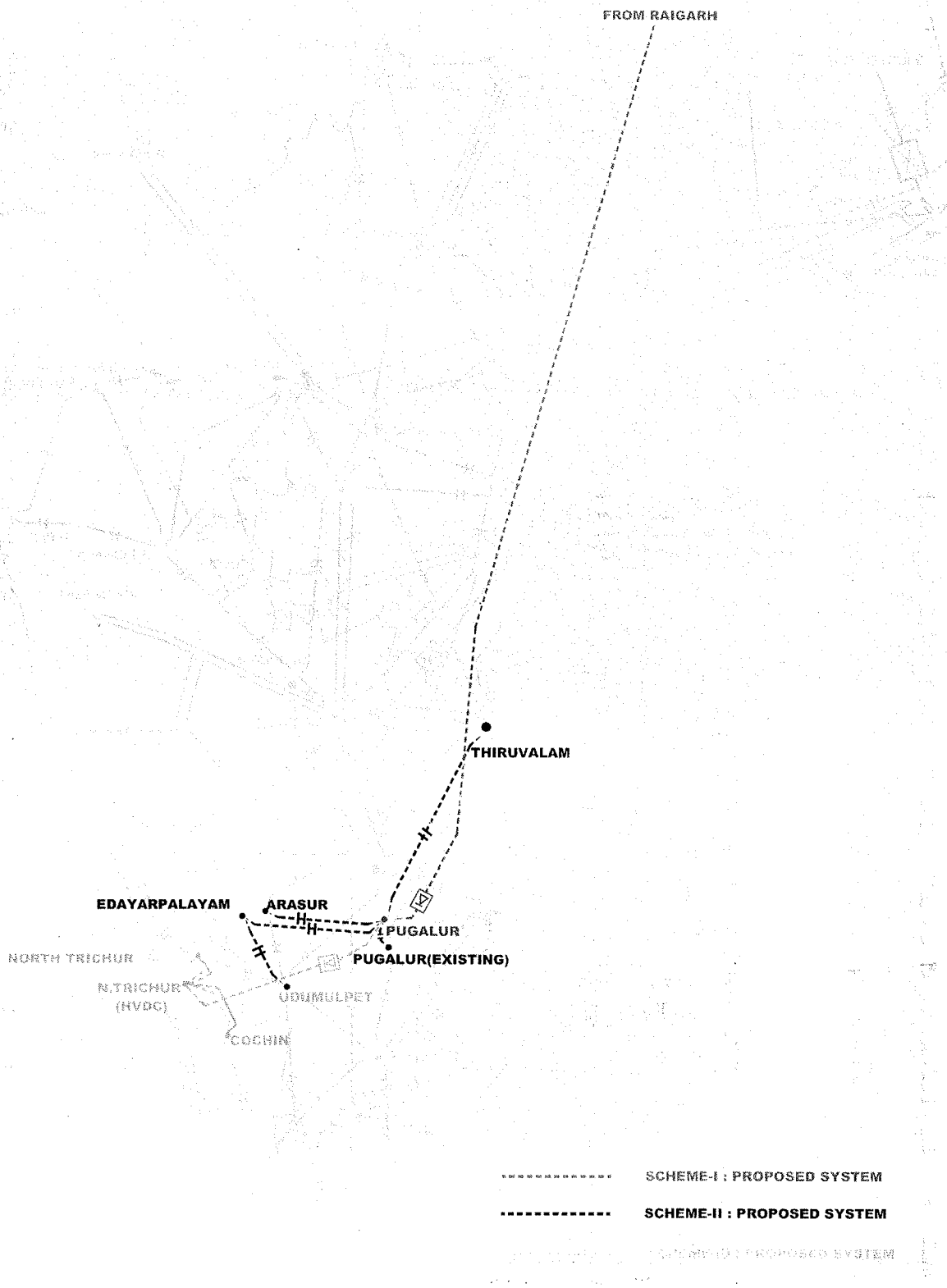

EXHIBIT – 2

ORGANISATIONAL SUPPORT STRUCTURE FOR EMP & ESPP IMPLEMENTATION

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ORGANISATIONAL SUPPORT STRUCTURE FOR ESPP IMPLEMENTATION & MONITORING

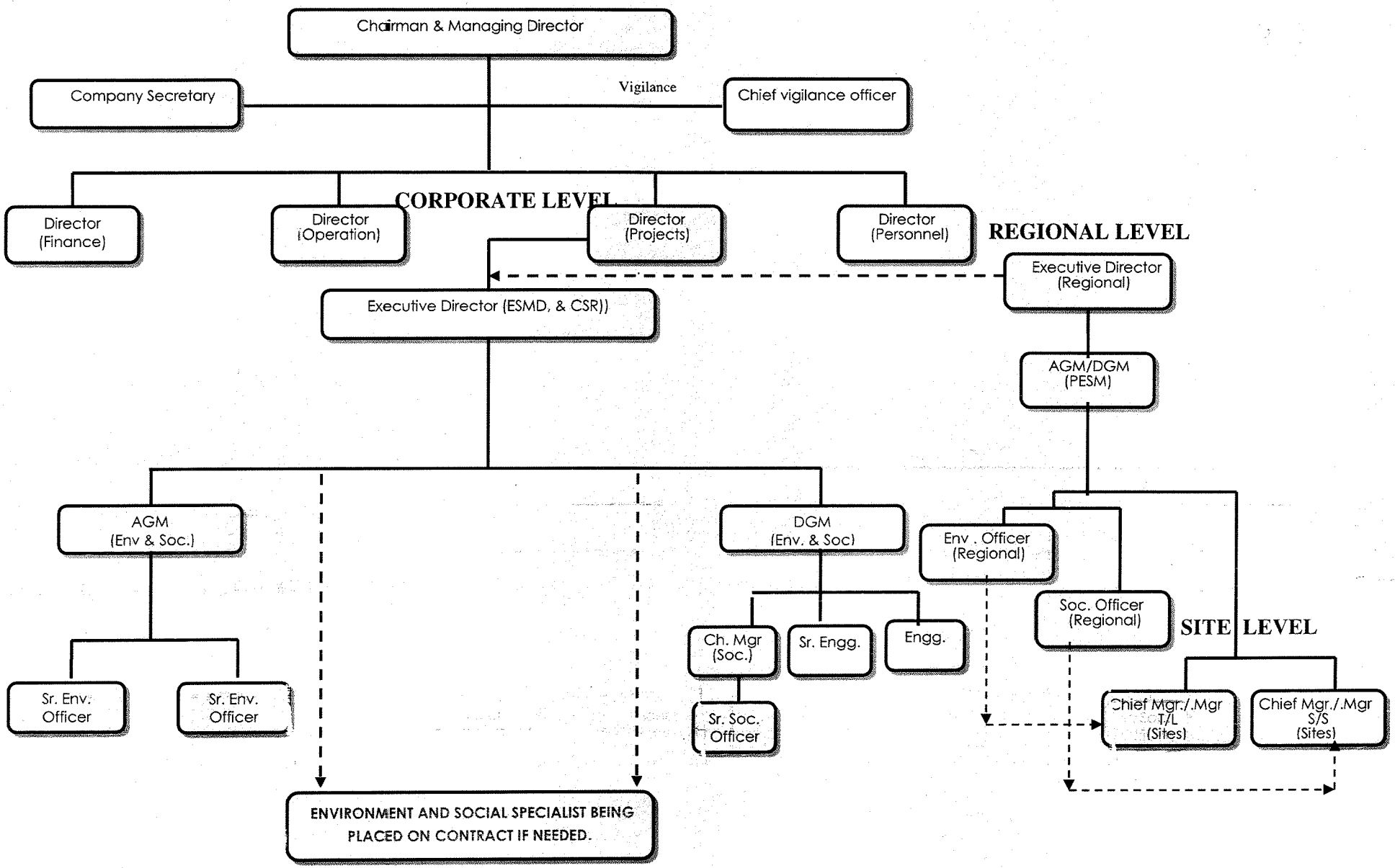

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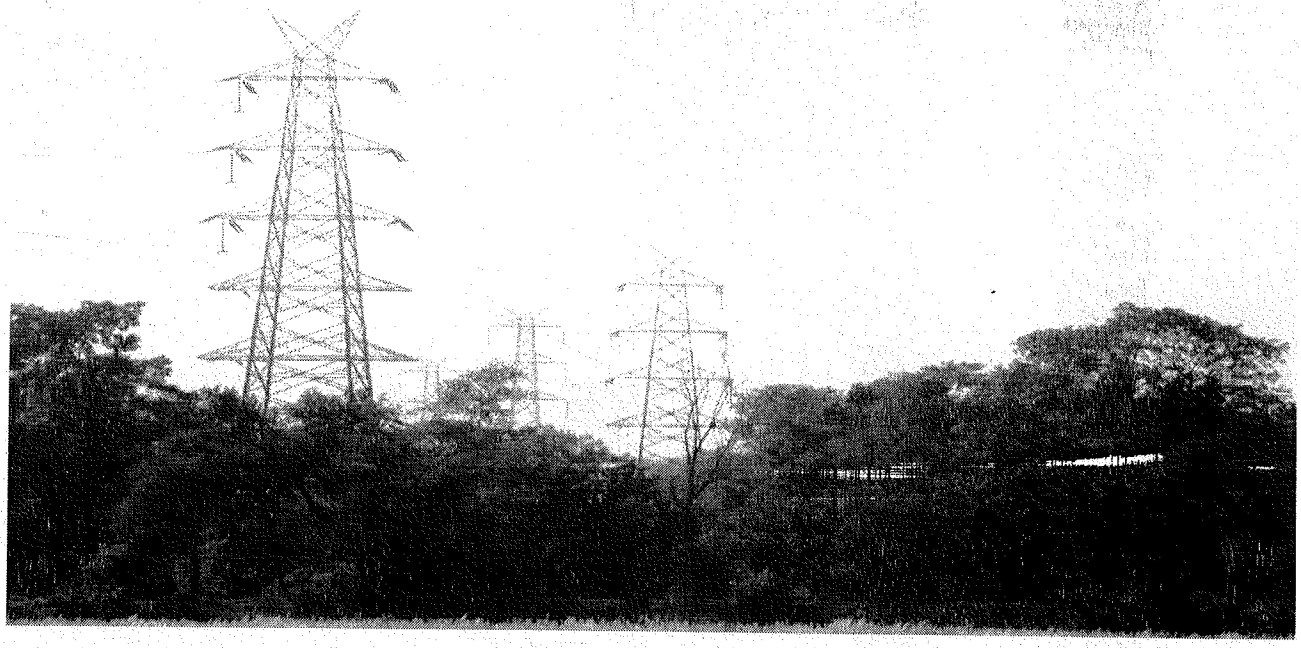
FIGURE – 1

400 KV LINE DEPICTING ACTUAL POSITION ALONG WITH ROW AND EXTENT OF DAMAGE

Fig. -1

Actual 400 KV Transmission Line



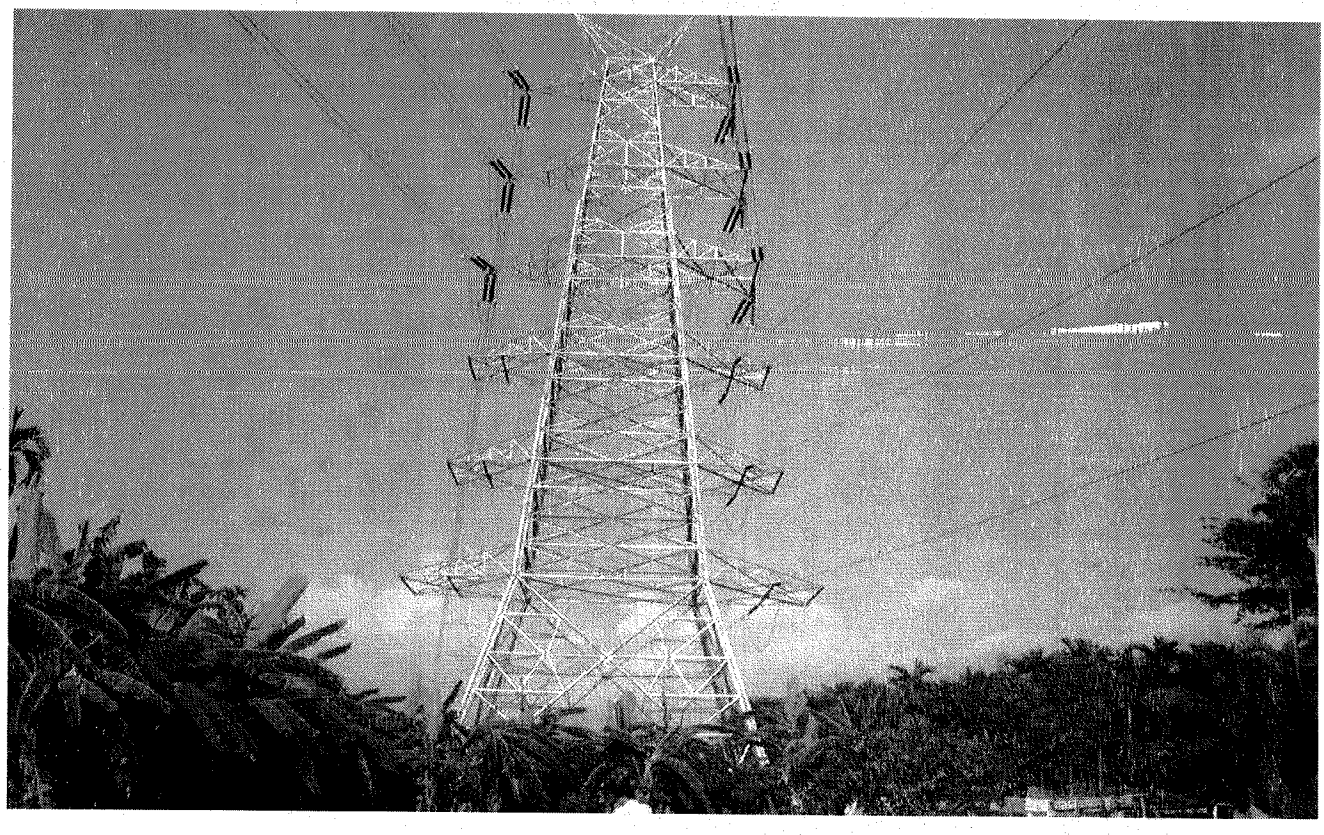


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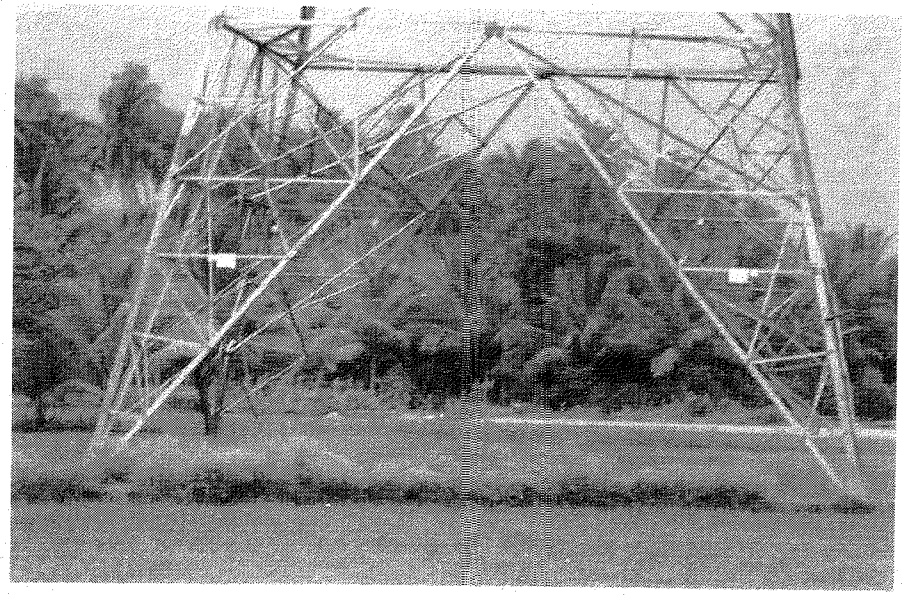
FIGURE – 1a

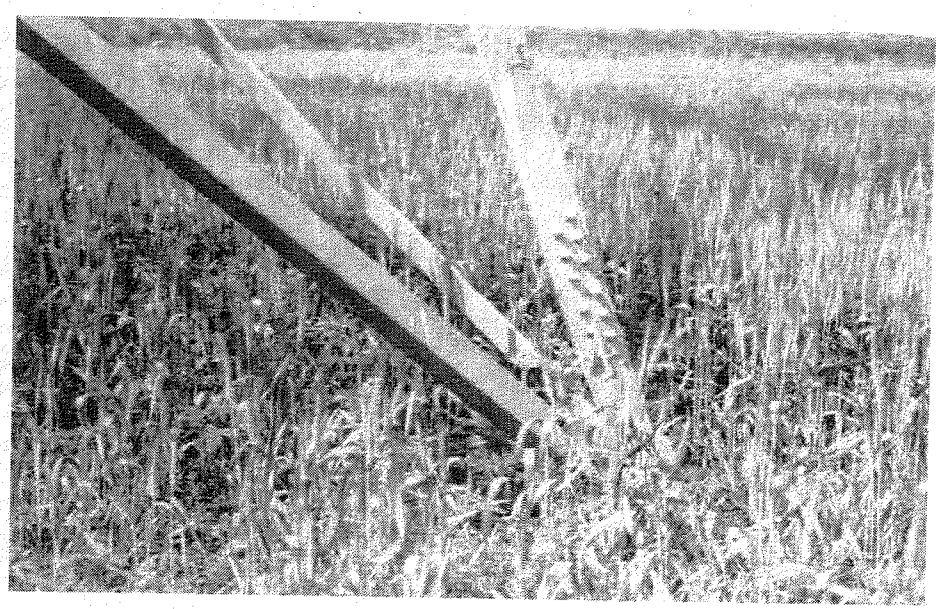
400 KV TOWER BASE SHOWING IMPACT ON AGRICULTURAL LAND AND CROP

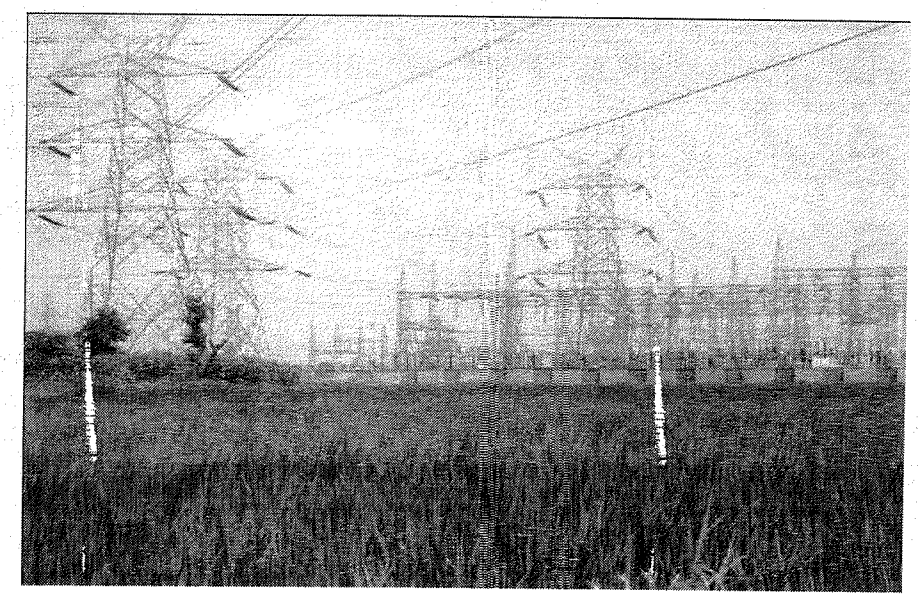
Fig.-1a

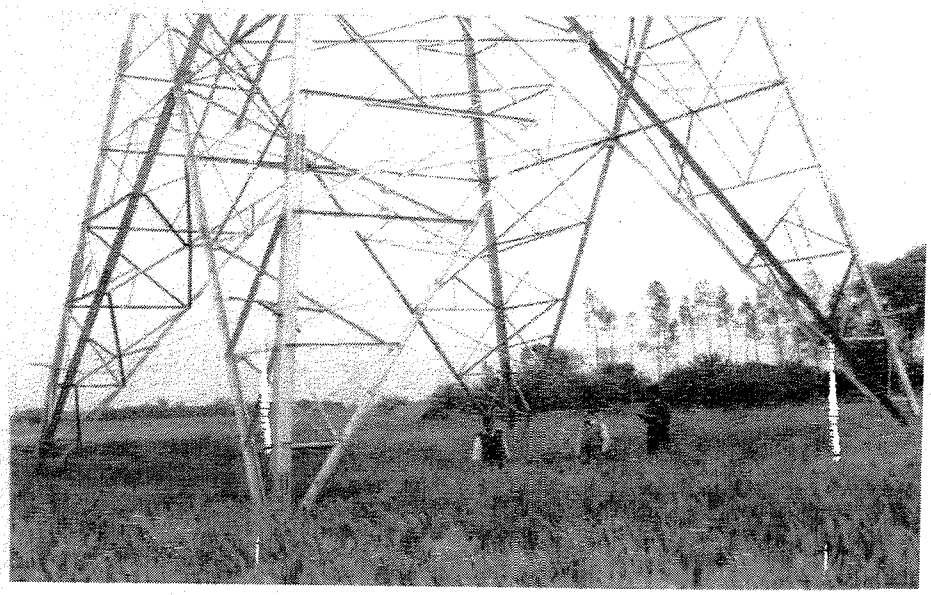
(25)

Tower Base showing extent of impact on agricultural land and Crop.









(22b)

FIGURE – 2

TYPICAL PLAN OF TRANSMISSION LINE TOWER FOOTINGS SHOWING ACTUAL GROUND POSITION AND EXTENT OF IMPACT

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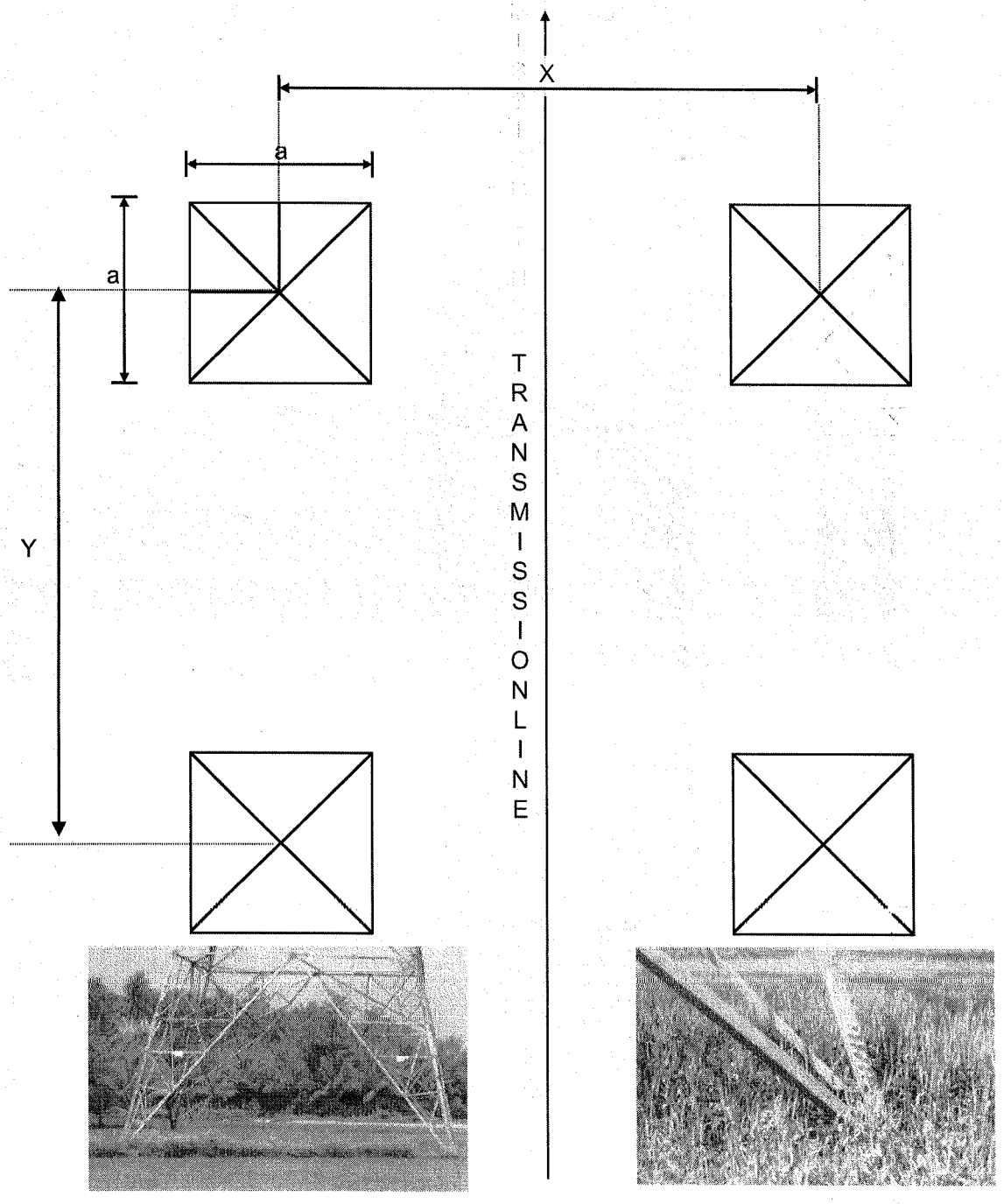
Fig.-2

TYPICAL PLAN OF TRANSMISSION LINE TOWER FOOTINGS SHOWING ACTUAL GOUND POSITION AND EXTENT OF IMPACT



ACTUAL POSITION ON GROUND

INDICATIVE MEASURES

X & Y = 10-15 METERS

a = 300- 450 mm

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FIGURE – 2a

SCHEMATIC DIAGRAM INDICATING AREA OF INFLUENCE/IMPACT OF 400KV TRANSMISSION LINE

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FIG.-2a

TREE FELLING AREA FOR 400KV QUAD TRANS. LINE

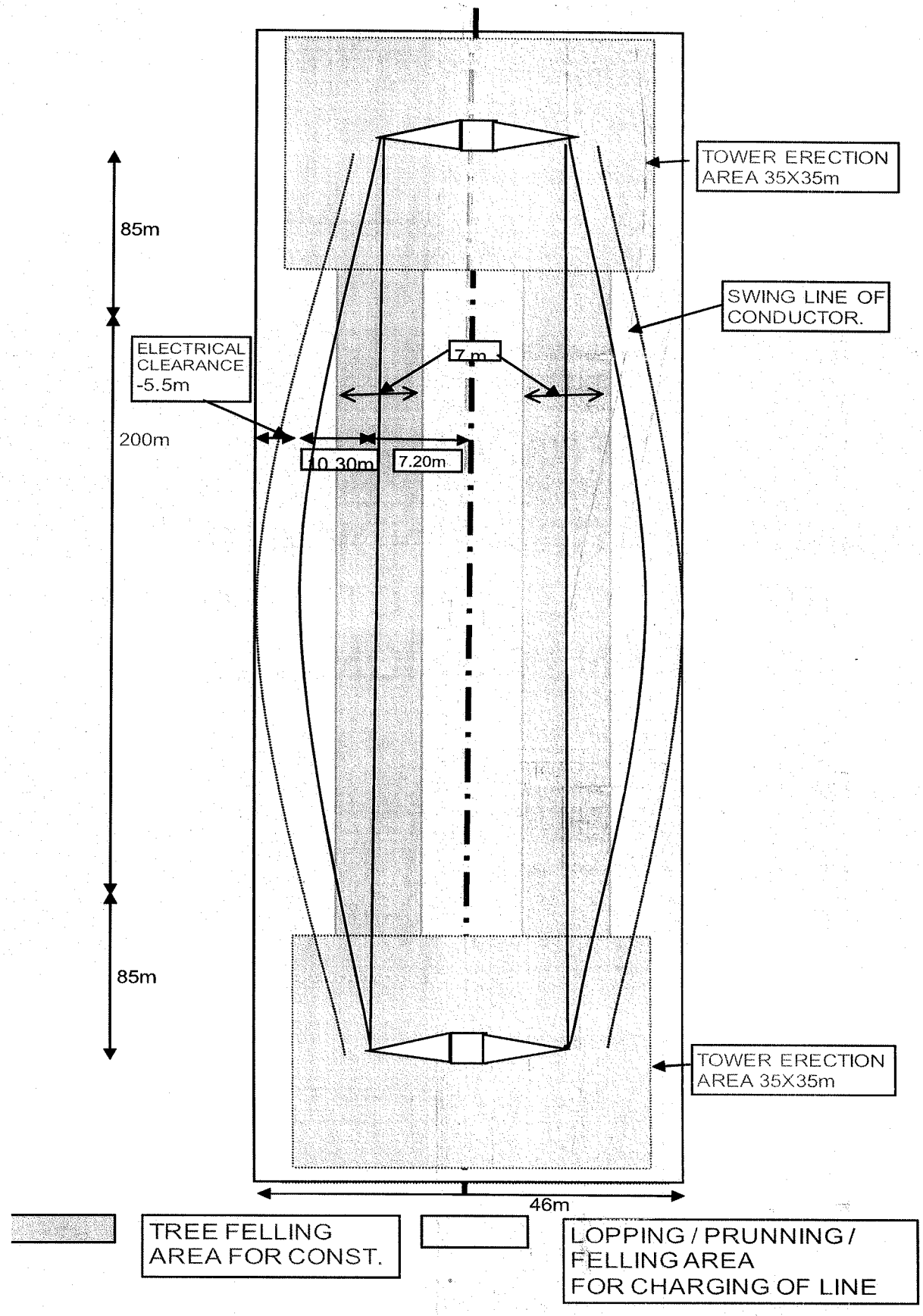


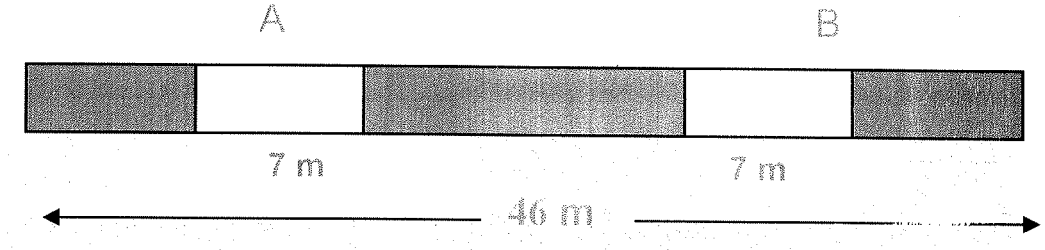
FIGURE – 3

SCHEMATIC DIAGRAM INDICATING TREE FELLING PATTERN IN FOREST AREA FOR 400KV TRANSMISSION LINE

Fig.-3

RIGHT OF WAY IN FOREST: 400 KV D/C QUAD LINE

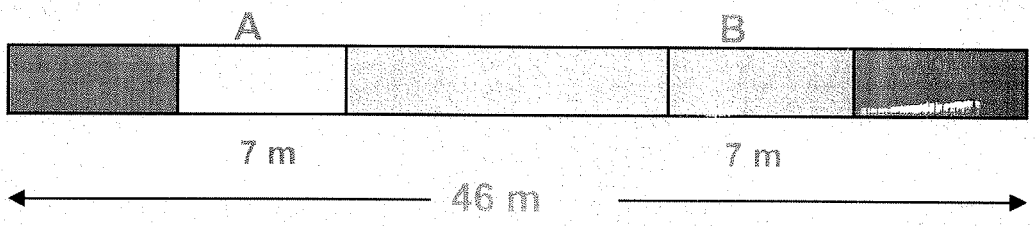
DURING CONSTRUCTION



Area where trees are lopped

Area where trees are completely felled

AFTER CONSTRUCTION



Area where trees are lopped

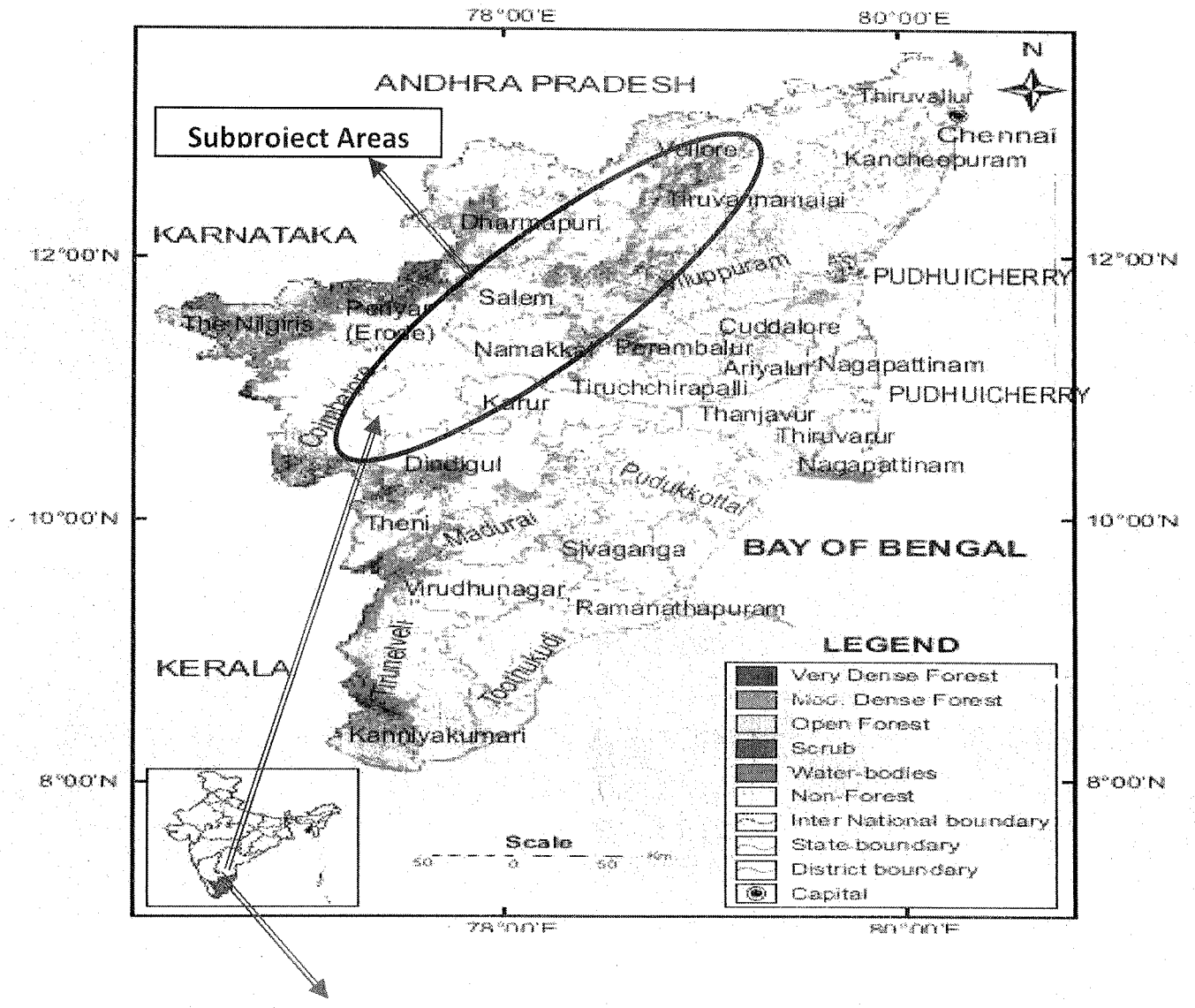
Area where trees are completely felled for O&M Purpose

Area allowed for regeneration up to a height of 1m to 1.5 m

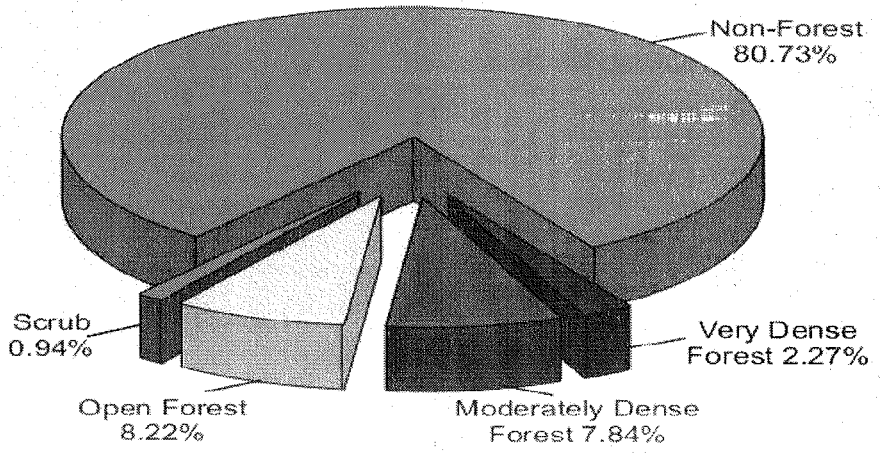
MAP – 1

FOREST COVER MAP OF TAMIL NADU

Map-1 : Forest Cover Map of Tamil Nadu



Forest Cover of Tamil Nadu



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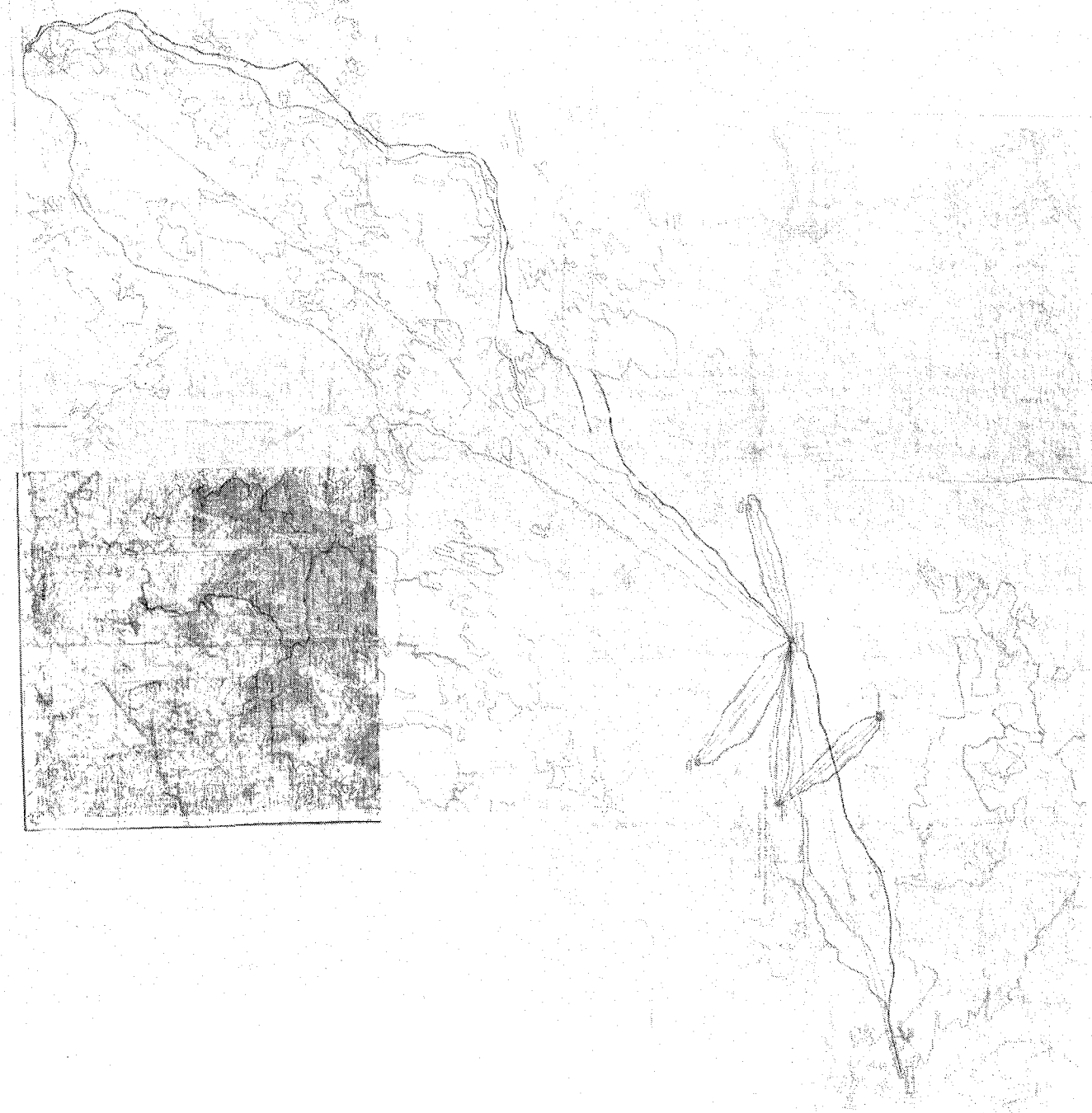
MAP – 2

ALTERNATIVES ROUTE ALIGNMENT OF PUGALUR- PUGALUR, PUGALUR-ARASUR, PUGALUR-THIRUVALAM, PUGALUR – EDAYARPALAYAM, EDAYARPALAYAM-UDUMULPET 400KV (QUAD) D/C LINE



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F. No. 7-25/ 2012-FC
Government of India
Ministry of Environment, Forests and Climate Change
(Forest Conservation Division)

Indira Paryavaran Bhawan
Aliganj, Jorbagh Road
New Delhi - 110 003
Dated: 19th November, 2014

To

The Principal Secretary (Forests),
All State /Union Territory Governments

Sub: **Guidelines for diversion of forest land for non-forest purposes under the Forest (Conservation) Act, 1980- Guidelines for laying transmission lines through forest areas** - *reg.*

Sir,

I am directed to refer to this Ministry's letter of even number dated 5th May 2014 on the above-mentioned subject, where-under this Ministry sent a copy of revised guidelines for laying transmission lines through forest areas, and to say that in partial modification of the said guidelines, clause 4 (ix) of the said guidelines which reads as *"In case of transmission lines passing through National Parks, Wildlife Sanctuaries and Wildlife Corridors, insulated conductors shall only be used to prevent electrocution of animals"* **shall be read as** "In case of transmission lines passing through elephant reserves/corridors, additional clearances of at least 6 m shall be provided over and above minimum clearance (as stipulated under Central Electricity Authority (Measures relating to safety & Electricity Supply) Regulations, 2010) above the ground from the lowest conductor of the transmission lines ".

Yours faithfully,

(H.C. Chaudhary)
Director

Copy To:-

1. Prime Minister's Office (*Kind attn.*: Shri Santosh D. Vaidya, Director).
2. Secretary, Ministry of Power, Government of India, Shram Shakti Bhawan, New Delhi.
3. Chairman, Central Electricity Authority, Ministry of Power, Sewa Bhawan, R.K. Puram, New Delhi 110 066.
4. Principal Chief Conservator of Forests, all State/UT Governments.
5. Nodal Officer, the Forest (Conservation) Act, 1980, all State/UT Governments.
6. All Regional Offices, Ministry of Environment, Forests and Climate Change (MoEFCC).
7. Joint Secretary in-charge, Impact Assessment Division, MoEFCC.

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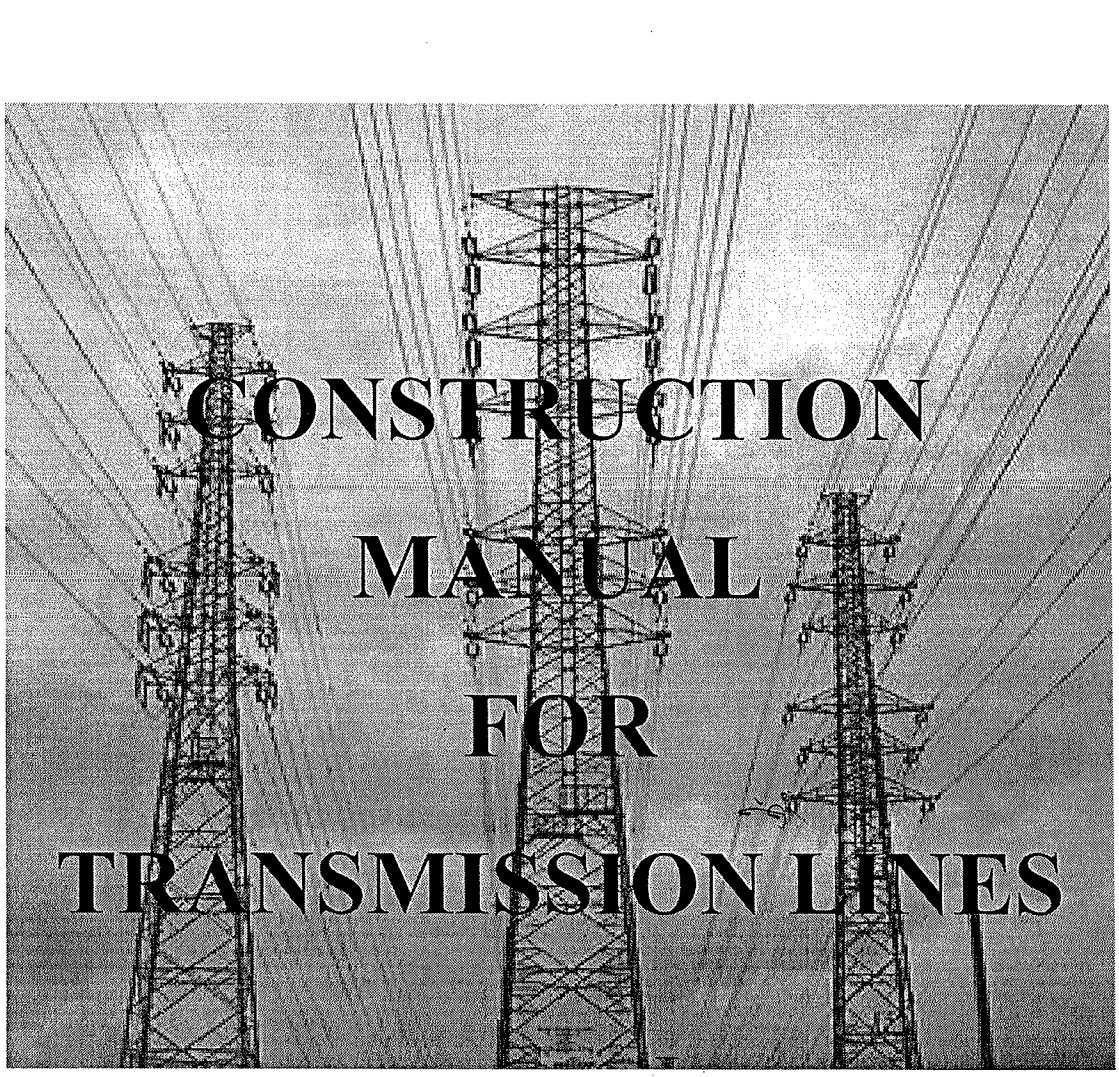
8. All Assistant Inspector General of Forests/ Director in the Forest Conservation Division, MoEFCC.
9. Director, Regional Offices Headquarters (ROHQ) Division, MoEFCC.
10. Sr. Director (Technical), NIC, MoEFCC with a request to place a copy of the letter on website of this Ministry.
11. Sr. PPS to the Secretary, Ministry of Environment, Forests and Climate Change.
12. Sr. PPS to the Director General of Forests & Special Secretary, MoEFCC.
13. Sr. PPS to the Addl. Director General of Forests (Forest Conservation), MoEFCC.
14. PS to the Inspector General of Forests (Forest Conservation), MoEFCC.
15. Guard File.

(H.C. Chaudhary)
Director

(239)

RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LTD.
(Regd. Office: Vidyut Bhavan, Janpath, Jyoti Nagar, Jaipur–302005)



CONSTRUCTION MANUAL FOR TRANSMISSION LINES

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2.3 The left hand side of the tower footing curve is placed at the starting point of each section. Initially, the template is shifted to the right, ensuring at all times that the tower footing curve is touching the starting point, to a position where the ground clearance curve is just above the ground profile, i.e., the ground clearance curve should not touch or cross the ground line plotted on the profile. The second tower location is then marked at the point where the tower footing curve on the right hand side cuts the ground profile.

2.4 The second tower location is then used as the reference and the third tower location is marked in a similar manner as above. This is continued till the end of the section is reached.

2.5 It may be possible that a very short or very long span remains at the end of the section. In such cases, depending on the economics of the options, the span can be distributed evenly or other spans in the section can be increased (not normally exceeding the basic span) by using tower extensions wherever possible.

2.6 The ground clearance curve shall not only clear the route centre line profile but also the profile to the left or right of the centre line upto a distance equal to maximum cross arm spread on either side.

2.7 Besides normal ground clearance, the clearance between power conductor and objects like other power or telecommunication lines, houses, trolley wires, roads, railway tracks, canal embankments etc., is also to be checked. In these cases, the clearance of the conductor from these objects is to be maintained.

NR for trees

2.8 The requisite or extra clearance can be obtained either by reducing the span or providing extension to tower body depending on which alternative is most economical. Normally, 3 metre & 6 metre extensions are available for towers upto 220 kV. 220 kV Special Towers with 4.5 metre, 9 metre & 18 metre extensions designed for long spans are also available. 3 metre, 6 metre, 9 metre, 18 metre & 25 metre extensions are available for 400 kV towers.

2.9 The tower locations with extensions or towers with additional heights are marked on the ground profile at that point of the tower footing curve which is at a height equal to the tower extension or the difference in height with reference to the height of the bottom cross arm of the special tower (with extension, if provided) above the ground profile. This point above the ground profile is used as the reference / initial point for the tower footing curve when spotting the next tower location.

2.10 When a tower location with extension or a tower with additional height is to be marked on the ground profile, then a point is marked at that location on the ground profile which is at a height equal to the tower extension or the difference in height with reference to the height of the bottom cross arm of the special tower (with extension, if provided). This point above the ground profile is used as the reference point for the tower footing curve.

2.11 A figure showing the application of a sag template on the profile is given at Appendix – C.

2.12 In spans where towers are located at different ground levels, the lowest point of the conductor sag may be outside the span. This is termed as an "Uplift" condition. This indicates that the total weight of conductor is taken up by the tower at the higher ground level and the tower at the lower ground level is being pulled up by a force equal to the weight of conductor between the lower support and the lowest point of the conductor sag. If the upward pull of the uphill span becomes greater than the downward load of the next adjacent span, actual uplift will be caused and the conductor would tend to swing clear upwards of the tower. The suspension towers cannot be used under uplift conditions. This type of condition can be resolved by providing extensions to the suspension tower at the lower level or by using a B – type tower designed for uplift conditions.

2.13 The intermediate spans in a section should preferably be as near as possible to the basic design span. In case any individual span becomes too short on account of undulations in ground profiles, one or more line supports of the section, wherever possible, may be extended by inserting standard body extensions to increase the span length.

2.14 While crossing over existing power lines, one of the towers of the crossing span of the new line is preferably located near the existing power line for taking advantage of the higher height of the conductors near the tower. This reduces the necessity of increasing the height of the towers of the new line for obtaining the requisite clearance. Double suspension / tension insulator strings, depending on the type of the towers, are to be used in the new line on such crossings.

2.15 While crossing below existing power lines of higher voltage, both the adequate ground clearance for the new line and the specified clearance of the new line from the existing power line shall be ensured. This can be achieved by using towers / structures of lesser height or by using sub station structures (if there is no right of way problem) in the new line. Alternatively, the height of the existing power line can be increased by providing tower extensions. Double suspension / tension insulator strings, depending on the type of the towers, are to be provided on the existing power line at such crossings.

2.16 The length of double suspension insulator strings is more than that of single suspension strings because of the yoke plates provided in them. Therefore, when double suspension insulator strings are used, additional ground clearance shall be provided when spotting towers so that the specified ground clearance is available after stringing.

2.17 The following clearances shall be provided between the lowest conductor of the line crossing over another line and the top most conductor / earth wire of the line crossing underneath as per Rule 87 of the Indian Electricity Rules, 1956.

Minimum clearances in metres between lines crossing each other.

Sl. No.	Nominal System Voltage	132 kV	220 kV	400 kV	800 kV
1.	Low & Medium	3.05	4.58	5.49	7.94
2.	11 – 66 kV	3.05	4.58	5.49	7.94
3.	132 kV	3.05	4.58	5.49	7.94
4.	220 kV	4.58	4.58	5.49	7.94
5.	400 kV	5.49	5.49	5.49	7.94
6.	800 kV	7.94	7.94	7.94	7.94

2.18 The minimum clearances required as per Rule 80 of the Indian Electricity Rules, 1956 shall be maintained, according to the voltage of the lower line, from the conductors of the line passing near a pole / tower or any supporting structure of the second line.

2.19 For crossing of a non – navigable river, the clearance of the bottom conductor of lines upto 220 kV shall be at least 3 metres above the highest flood level (HFL). The clearance of the bottom conductor of 400 kV lines in such a case shall be reckoned with respect to the highest flood level (HFL).

2.20 For crossing of navigable rivers, the clearance as approved by the concerned navigation authorities shall be maintained.

2.21 The crossing span of National Highways and major roads shall not normally exceed 250 metres. One of the towers of the crossing span can be located near the road in order to obtain

CHAPTER – 9

CLEARING OF RIGHT OF WAY

1.0 GENERAL:

1.1 It is advisable to carry out the work of clearing the right of way as early as possible during the construction of the line.

1.2 The work of clearing of right of way should preferably be carried out in the seasons when there are no standing crops in the agriculture fields. This has two advantages. Firstly, there is least resistance from the farmers. Secondly, there is no need to pay any cost towards compensation for damage to crops.

1.3 However, tree cutting necessary for paying out and sagging of conductor may be got done during the stringing operation.

2.0 CLEARANCE OF RIGHT OF WAY:

2.1 The width of right of way for the various line voltages is repeated below.

Line Voltage	Width of Right of Way
132 kV	27 metres
220 kV	35 metres
400 kV	52 metres

2.2 A drawing showing the requirements of line clearance within the right of way is given at Appendix – A.

2.3 Cutting of trees, shrubs, bushes, etc. in the right of way is to be got done as shown in the drawing above. All trees, shrubs, bushes, etc. which infringe on the clearances are to be cut.

2.4 Small bush growth, shrubs and trees whose height is not expected to rise beyond 3 meters may be allowed to remain.

2.5 Grass growth on the boundary walls (Dola) of agriculture fields which can grow to a height such as to infringe on the clearance are to be cut.

2.6 Trees outside right of way but of such height as may infringe on line clearance are to be trimmed accordingly.

2.7 Trees or bushes growing inside or very close to the legs of towers shall be cut / removed.

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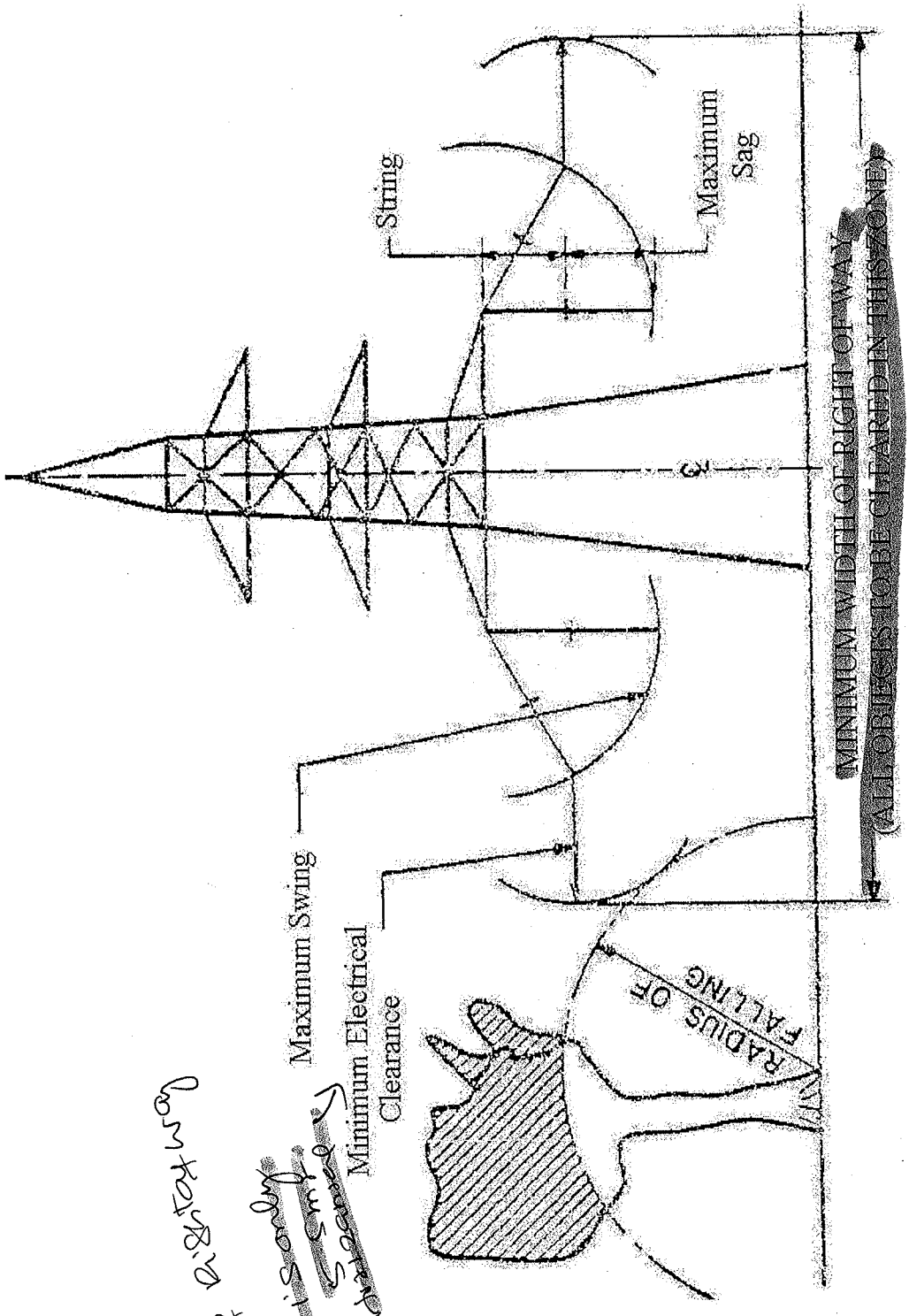
APPENDIX – A



Note: - Portion of tree falling within zone to be topped or trimmed

LINE CLEARANCE (RIGHT OF WAY) REQUIREMENT