*Working Paper on*

# Redefining Electricity Network to bring Economic Efficiency in Development and Operation of Power System in India

*Unlocking avenues to promote Distributed Energy Sources (Renewable Sources), to increase efficiency of Distribution System and for opening Bulk Electricity Market Access to Distributed Generation*

Manish Chaudhari[1]

Central Electricity Regulatory Commission
3rd Floor, Chandralok Building,
36, Janpath, New Delhi – 110001

[1] Staff of the Central Electricity Regulatory Commission.

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## INTRODUCTION

Electricity network facilitates conveyance of power from the point of generation to the point of consumption over long distance. Electricity network consists of transmission network and distribution network. The microgrid concept is yet to take shape in India. Distribution network (also known as "distribution system[2]") connects different demographic areas, including urban and rural areas to ensure supply of electricity to consumers. Transmission network (also known as "transmission system") connects different regions over long distance. In India, the electricity grid consists of about seventy[3] distribution networks, transmission network in each state and single inter-state transmission network. The Electricity Act, 2003 ("the Act") do not recognize the term 'electricity network' but it refers to it as inter-state transmission system[4], intra-state transmission system[5] and distribution system[6].

1.2. Regulation of electrical network includes effective management of the risk of monopoly pricing and promotion of investment in infrastructure. In India, the Central Electricity Regulatory Commission regulates[7] (also referred as "Central Commission") inter-state electricity transmission networks whereas the State Electricity Regulatory Commissions (also referred as "State Commission" as per their jurisdiction) regulates[8] intra-state electricity transmission network and distribution network. The tariff of distribution network is generally priced with retail supply tariff which includes cost of distribution network, supply of electricity and cost of servicing electricity at consumer end.

[2] For the purpose of this paper, a term "distribution network' and "transmission network" are used from technical angle instead of "distribution system" and "transmission system" respectively.
[3] Includes public and private distribution licensees
[4] *Ibid.* Section 2(36) of the Electricity Act, 2003
[5] *Ibid.* Section 2(37) of the Electricity Act, 2003
[6] *Ibid.* Section 2(19) of the Electricity Act, 2003
[7] *Ibid.* Section 79(c) of the Electricity Act, 2003
[8] *Ibid.* Section 86(c) of the Electricity Act, 2003

1.3. While the Act does not distinguish the network of transmission and distribution based on voltage level, for all practical purposes, the distribution network normally starts at 11 kV or 22 kV or 33 kV[9] and retail consumers are connected below this voltage level. If consumers are connected at higher voltage level, the transmission network may get extended upto consumer level, however, for the purpose of receiving electricity, it is deemed to have been connected to distribution network. With regard to network demarcation, a reference can be drawn towards the classification of network done in United Kingdom ('UK') where low voltage level starts from 132 kV[10]. In the United States of America ('USA'), the transmission system is divided into high voltage transmission and sub-transmission system. The sub-transmission system brings down the voltage upto 34 kV and further reduces upto 7.2 kV at distribution level[11]. This voltage level base demarcation under the Act may create difficulty in development of market and distribution energy resources. In USA, the Federal Energy Regulatory Commission has resolved this impediment and developed rules to connect distributed energy resources to distribution level and to facilitate distribute energy resources for accessing bulk electricity market[12].

1.4. The 'electricity network' in India came into existence when the State was reorganized post enactment of the Electricity Act, 2003. Prior to that it was integrated with generation and distribution activity. As a result, the transmission, distribution and generation have been recognized as a separate business activity. Demarcation between generation and transmission was recognized as interconnection point of generating station with transmission

[9] Distribution boundary starts from circuit breaker connected at 11 KV bus bar of Substation. In some cases, it may be higher than 11 KV.

[10] www.parliament.uk/globalassets/documents/post/pn163.pdf

[11] https://www.energy.gov/sites/prod/files/2015/12/f28/united-states-electricity-industry-primer.pdf

[12] This can be evidenced from order no, 2222 of Federal Energy Regulatory Commission wherein the Commission has intervened to specified minimum capacity for distribution energy resources and to provide role of Regional Transmission Operator

system with some exceptions[13] of dedicated line. Similarly, demarcation between transmission and distribution was considered as interconnection point from transmission and distribution network with some exceptions[14] of connecting consumer directly with transmission network. Normally, the distribution system was considered below 66 kV voltage level post 2003. This demarcation plays an important role for development of electricity market and economic efficiency point of view.

1.5 The distribution network with high voltage level is beneficial to consumer as the consumer seeking connection at high voltage level can also be managed by owner of distribution network independently without involvement of owner of transmission network. However, the consumer seeking connection at high voltage are limited to only few large-scale industries only. But at the same time, the distribution network with high voltage level is disadvantageous for development of market and achieving economic efficiency. **Firstly,** the distributed generation also known as distributed energy resources ('DER') are scattered having low capacity suitable for connection to distribution system. But while connecting with distribution system, it would be difficult to access bulk supply electricity market. This discourages the development of distribution energy resources. **Secondly,** the risk of balancing variation of renewable energy generation could be discounted if a small renewable generation capacity is promoted to get connected at lower voltage near to the consumer location (closed to load centre). In present electrical network system, the distributed generation, mainly renewable generation, are connected at high voltage level creating difficulty for balancing variation. The cost of balancing intermittent generation would also be high in case of connection of distributed generation at high voltage level. **Thirdly,** financial position of distribution

[13] The provisions of the Act permit generating companies to lay dedicated line for connection of generating station to transmission system. In this case, the interconnection point will extend to termination point of dedicated line from bus-bar of generating station.

[14] Where demand of consumer is high and connection at high voltage level is technical feasible option, such consumer will be allowed connection directly from transmission system and metering point will be interconnection point in that case.

companies is unable to attract the investment in the distribution network. Eventually, the strengthening of distribution system is impacted which may result in low ratio of High Voltage to Low Voltage line, deteriorating quality of supply. Further, it is difficult to ensure adequate maintenance of low voltage lines due to long distance lines. This would result in low voltage problem at consumer end and high technical losses.

1.6 The electricity network was restructured post enactment of the Act based on the scenario existing at that time. Primarily, the transmission system is evolved for evacuation of power from large pit head generating station. This requires development of large capacity high voltage transmission infrastructure. The distribution system carries low voltage lines used for distribution of power to consumer near to load centre. But emerging scenario of generation has been changed. Solar Photovoltaic, Wind Technology and forthcoming storage would offer small capacity generation project avoids expensive incremental transmission because it can be located at the load centre. The questions that arise here for considerations are, (i) Whether the network restructure evolved post enactment of the Act needs to be redefined to meet the emerging requirement for connecting distributed generation resources at low voltage level and to bring efficiency in operation and costs ?, (ii) Can redefining electrical network is possible within the ambit of existing legal framework or requires amendment under legislation ?; and (iii) What are the options available to redefine the electrical network ?. In this backdrop, this paper aims at discussing the need for redefining electrical network with the view to achieve economic efficiency of Indian Power system and to examine technically feasible options within the existing legal provisions.

## 2. NEED FOR NETWORK REFORM IN INDIA

### Efficient development of Electrical Network

2.1 In India, the transmission system is being developed based on coordinated development planning and National Electricity Plan issued under *Section 3* of the Act. The transmission sector has attracted significant investment during last decade and also brought competition for award of projects. A coordinated development of transmission system avoids duplication of transmission system by each transmission licensee and therefore, it offers economic efficiency in entire value chain of electricity. While transmission system is being developed in coordinated manner, the distribution system is being developed by each distribution licensee separately in their respective area. Sixth proviso of the *Section 14* of the Act provides for development of more than one distribution network in the same geographical area[15], which may lead to duplication of network.

2.2 Although, utilization of distribution system of one distribution licensee is permitted to be used by other distribution licensee by paying wheeling charges, but that may not be sound solution in terms of commercial principle of business. It is because one distribution licensee has invested in providing access to consumer by considering common business principle of profit maximization and to capture market. If such consumers opt to purchase electricity from distribution companies other than host distribution companies, that would impact commercially to host distribution company. The investment in infrastructure would require certainty of the buyers to purchase electricity from distribution company. Eventually, if instances of purchasing electricity from other than host distribution company increases, it may impact cash flow of distribution companies. It will further impact development and augmentation

[15] Sixth Proviso to Section 14 of the Act provides that " Provided also that the Appropriate Commission may grant a licence to two or more persons for distribution of electricity through their own distribution system within the same area, subject to the conditions that the applicant for grant of licence within the same area shall, without prejudice to the other conditions or requirements under this Act, comply with the additional requirements 1[relating to the capital adequacy, credit-worthiness, or code of conduct] as may be prescribed by the Central Government, and no such applicant, who complies with all the requirements for grant of licence, shall be refused grant of licence on the ground that there already exists a licensee in the same area for the same purpose." *(Emphasis supplied)*

of distribution network as the distribution companies may not encouraged to do so without certainty of the consumer purchasing electricity. In existing framework of development of distribution network by respective distribution licensee, coordinated development of distribution system for each area is not possible. This calls for need to ensure coordinated development of distribution system.

**Efficiency in Operation of Electrical Network**

2.3 An operation of the transmission system and distribution system are largely similar in nature. Similarity in transmission and distribution system provides possibility of integrating operation of distribution and transmission network on several counts. **First,** separate arrangement for operation and maintenance by distribution and transmission companies leading to duplication of common expenses. An integrated operation would result in savings in operational expenses in particular area. **Second** the technical losses are attributed to inefficient development and maintenance of distribution system which can be improvised by transmission companies as they have experience of coordinated development and operation of electrical network. An integrated operation would help to improvise operation and maintenance expenses of distribution network leading to reduction of technical losses. **Third,** financial performance of transmission companies is better placed and therefore, capex requirement for strengthening of low voltage network system would not be difficult. An integrated operation of distribution and transmission would help in smooth operation of electrical system. If some part of distribution system especially higher voltage lines upto 11 kV or upto distribution main is qualified as transmission system at state level, it would help in bringing efficiency in operation of electrical network. This requires change in network demarcation philosophy.

**Absorption of variability of intermittent Renewable Generation**

2.4 A huge penetration of renewable generation posed a new challenge of handling variability of generation. In order to absorb variability of generation, it is desirable that the renewable generation be connected on the same network where the load is connected. So that synergy between renewable generation and variation of load can be achieved effectively at load end and intermittency of generation will not propagate further in the power system. **Per contra**, recent trend of connecting renewable generation at transmission grid at high voltage level is noticed which makes balancing of power system more challenging. This could be avoided by evolving adequate institutional framework for providing connectivity to renewable generation in distribution system close to load centre.

2.5 The policy framework[16] is targeting huge capacity addition in renewable generation. The transition of electricity generation to renewable sources at large scale should be coupled with promotion of distributed generation resources. Without distributed generation resources, it would be difficult to achieve balancing of grid with large penetration of generation from intermittent resources. The existing framework of electrical network may create impediments for development of distributed generation resources at lower voltage level near to consumer end. This will further create a difficulty for absorption of variability of distributed generation resources mainly from renewable resources. Therefore, there is a need to review the demarcation of electricity network for enabling development of distributed generation sources so that absorption of variability of renewable generation sources could be addressed efficiently.

**Opening Bulk Electricity Market for Distributed Energy Resources**

2.6 The electricity sector is witnessing transition from traditional coal or gas fired large capacity generating station to renewable generation which are of the

[16] The Government of India has set a target of installing of installing 175 GW of renewable energy capacity by the year 2022, which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power

nature of distributed energy resources[17]. For distributed generation with low capital, development of specific associated transmission system would not be economically viable for distribution utility to develop and maintain the network. The successful integration of distributed generation would be possible when the distribution network permits the access to the bulk supply market. Unless, this issue is not addressed, the distributed energy resources would not be encouraged and trend of concentrating or aggregating small generation resources at one location would continue which may not be economical for bringing efficient investment in transmission system and for smooth operation of power system.

2.7 The present framework of permitting open access to consumer is not comparable for open access to distributed energy resources. The open access of distribution system for consumer is to be provided in existing margin. The open access to consumer may not be consistent with business strategy of any commercial entity and would not find sufficient encouragement. The open access to distribution energy resources is different. It may require to develop distribution system. At present, the distribution licensee accommodates such distribution energy resources for purchase full or part of electricity generation from such sources. But can distribution licensee be forced to develop distribution system for distributed energy resources that wants to sale power to open market or outside area of distribution licensee? If distribution licensee incurred expenditure for such distributed generation, can such expenditure be loaded on to the consumer of such distribution licensee ?. This issue requires detail examination of existing framework. Although open access to distributed energy sources will be helpful for the distribution companies to purchase electricity at reasonable rate (without additional burden of transmission

[17] In India, distributed energy resources have not been defined under the Act. Technically, distributed generation resources are that which are located on the distribution system or any subsystem thereof which also includes the resources connected behind a customer meter. However, in this paper, distributed energy sources refers to small capacity renewable energy resources prior to customer meter.

system) or to get wheeling charges for using distribution system for supplying electricity to bulk market or open market. In order to provide access to bulk electricity market for distributed energy resources, it is important to reorganize existing electricity network and to redefine in such a way so that it encourages distributed generation resources to get connected at lower voltage. This will also ensure utilization of distribution network infrastructure by distributed energy resources and strengthen recovery of cost of this infrastructure. This will pave the way for successful transition of energy resources to small and renewable generation resources.

**Differential Return to Retail Supply of electricity**

2.8 The distribution licensee operates distribution network and also provides retail supply to the consumer. The risk associated in operation of distribution network can be comparable[18] with transmission system. Further, retail supply of electricity to the consumer is not comparable to the distribution and transmission activity because of the nature of business[19] involved in retail supply. The retail consumer services are as such subjected to market changes and involves lot of uncertainties. The asset base and regulated equity in retail supply of electricity is less whereas uncertainties in cash flow and business risk are relatively higher[20]. However, the regulated return generally adopted for retail supply of electricity is same as generation of electricity and transmission of electricity. Thus, there is a need for considerations of differential return for

[18] Risk in distribution network is higher compared to transmission because of construction and development in residential area and difficulty to lay network upto consumer end. Receiving point in distribution is fixed by consumer which compels distribution company to establish network upto installation of consumer. However, in case of transmission system, receiving point (substation) is decided by the transmission companies which provides flexibility. Further, requirement of underground cable and overhead cable, level of operational faults etc. are higher comparted to transmission system. Present regulatory approach, while allowing regulated return, treats distribution system at par with transmission system.

[19] It is pertinent to note that retail supply of electricity is operated on business to customer (b2c) framework whereas the distribution network and transmission network are operated on business to business (b2b) framework.

[20] For example : Return on equity of Rs 2000-3000 Cr equity base is about Rs 400-600 Cr per annum whereas the distribution companies are undertaking business risk of about Rs 20000-30000 Cr per annum.

retail supply of electricity which also includes end consumer service (such as LT line operations etc). If the distribution system is qualified as transmission system (without changing ownership of distribution companies), the differential rate of return to retail supply and distribution network would be possible. This can be achieved by redefining distribution network under transmission or sub-transmission system.

**Impact due to financial stress in Distribution Segment**

2.9 The financial position of the distribution companies has weakened over the period. We are not going into the factors responsible for weakening financial position of distribution companies. But due to adverse financial position of one arm of entire value chain, payment cycle in entire value chain gets disrupted. It also affects further development in sector. Further, lower cash flow in entire value chain would make it difficult for concerned companies to repay debt of lenders. The Central Government has extended financial support[21] from time to time. However, such financial support is temporary and it does not offer a permanent and sustainable solution. The stress in distribution segment is impacting strengthening of distribution system, adoption of new technology such as smart grid technology and promotion for renewable etc. because of uncertainty in recovery. Institutional reform like network demarcation would be conducive for distribution company to develop electrical network and restructuring accounting of technical losses. The technical losses of common system could be shared on large spectrum of consumer base.

**Effective Utilization of Electrical network**

2.10 In view of promotional measures of policy framework for renewable generation, a recent trend of concentrating or aggregating small generation

[21] The Government has announced financial packages from time to time such as UDAY scheme. Also during May, 2020, the n liquidity scheme backed by public banks such as Power Financial Corporation (PFC) and Rural Electrification Corporation (REC).

resources at one location and connecting large renewable generation project at transmission grid at high voltage level have been noticed. The aggregation of renewable generation and conceiving large renewable generation project have been considered to achieve cost efficiency and reduction of generation cost so that power purchase cost of distribution licensee would reduce and benefit could be pass on to the consumer. It seems that this trend is evolved due to absence of suitable framework for distributed generation resources. However, it requires creation of additional infrastructure of transmission system to evacuate large quantity of power for conveyance upto consumer. Addition to this, there will be balancing cost also. Since cost of this additional infrastructure is ultimately paid by the distribution licensees and the consumer, it may not be beneficial from economical angle. *For example*: If the cost of renewable generation is reduced from Rs 3.00 per unit to Rs 2.00 per unit but if cost of additional transmission system (including inter-state, intra-state and balancing cost) is Rs 1.00 per unit, it may not be beneficial as the cash outgo of distribution licensee is same. It is pertinent to mention that large renewable generation project may be useful in specific cases where unused land or economic resources are available which needs to be explored in the interest of economy. Therefore, it requires holistic techno-economic analysis.

2.11 Traditionally, it is accepted that the investment in high capacity transmission system is beneficial for evacuation of power from large capacity pit head thermal generating station or hydro generating station located near to the natural resources. Such generating stations cannot be located near load centre and hence the conveyance of electricity upto load centre can be facilitated through high capacity transmission system. Unlike to above, the distributed generation such as Solar PV and Wind Energy generation provides opportunity to develop distributed generation near to load centre and therefore, expensive

transmission system can be avoided[22]. It seems that consideration of distributed generation is missing piece in Indian renewable development and that needs to be streamlined. If distributed generation is considered as part of the renewable development programme, it leads to avoid investment in transmission so that existing infrastructure can be used effectively. The adoption of distributed energy resources is inevitable as it offers cost-effective solutions for many homeowners and businesses using clean energy resources. If distributed energy resources are facilitated to connect at low voltage distribution system after removing barriers, it would not only avoid uneconomical expensive incremental investment in transmission assets but at the same time, ensures effective use of existing distribution system and the capex cycle will shift from transmission segment to distribution segment. The incremental cost of distribution system payable by the distribution companies would be reasonable in comparison to the incremental cost of transmission system. Overall, it would be advantageous for the distribution companies and for development of renewable generation.

2.12 The network reform is necessary for efficient development and operation of distribution network in line with transmission network. It is necessary for addressing challenge of variability of Renewable generation, promoting Distributed Energy Resources by opening bulk electricity market. It will also facilitate distribution companies for adopting approach of differential Return to Retail Supply of electricity, addressing bottlenecks in development due to financial stress in Distribution Segment. The network reform would facilitate in achieving economic efficiency by encouraging effective utilization of existing electrical network and avoiding expensive incremental transmission system. The reduction in overall transmission and distribution cost, purchasing

[22] "The cost burden of new large-scale transmission projects is exacerbated when low-capacity-factor generation, such as wind and solar, requires new dedicated lines. Solar PV at sufficiently large scale avoids expensive incremental transmission because it can be located at the load center." Kahn, E., "Avoidable Transmission Cost is a Substantial Benefit of Solar PV," The Electricity Journal vol.21 (June, 2008).

electricity from low cost distributed energy resources, the power purchase cost of distribution companies would be rationalized.

## 3. EVOLUTION OF NETWORK POST ELECTRICITY ACT, 2003

3.1 The electricity network in the State was reorganized post enactment of the Act, as several States have reorganized State Electricity Boards. In most of the States, an interconnection point between transmission and distribution network is considered as switchgear point or gantry point of the 11 kV or 22 kV or 33 kV feeder emanating from substation. The delivery point to the retail consumer is a point at which distribution companie(s) (also a supplier or seller) delivers electricity and consumer (also a buyer) receives electricity. This system was evolved for demarcation between transmission and distribution system, distribution and consumer. It may be observed that demarcation was made based on purpose of interconnection irrespective of voltage levels. The Act does not provide for demarcation between transmission and distribution on voltage basis. It is a matter of transmission license and distribution license[23] as issued by the State Commission or Central Commission, as the case may be. The Central Electricity Authority has recognized distinction while framing standards.

3.2 The Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010 (hereafter referred to as the 'CEA Regulations, 2010') issued under subsection *(2)* of Section 73[24] of the Act, distinguishes distribution and transmission boundaries on the basis of

[23] Post promulgation of the Act, roll out plan for separation of distribution network and transmission network was prepared by the State Electricity Board and accordingly, the demarcation was made for consideration of license. As per provision of the Act, there is no embargo that the distribution network of a distribution licensee cannot include a line of high voltage level. Similarly, there is no embargo that the transmission network of a transmission licensee cannot include a line of low voltage level such as 11 kV or 22 kV or 33 kV near to consumer installation.

[24] **"Section 73. (Functions and duties of Authority):**
The Authority shall perform such functions and duties as the Central Government may prescribe or direct, and in particular to -(a) …,(b) specify the technical standards for construction of electrical plants, electric lines and connectivity to the grid;"

voltage levels. **First** relevant provision is clause (1) of Regulation 74 of CEA Regulations, 2010 which provides the design parameters of distribution system which consists of 33 kV, 22 kV, 11 kV and 0.415 kV. **Second** relevant provision is clause (1) of Regulation 89 of CEA Regulations, 2010 that provides the design parameters of transmission lines which consists of 66 kV, 132 kV, 220 kV, 400 kV, 765 kV and 500 kV. As per CEA Regulations 2010, voltage level from 0.415 kV upto 66 kV are included under the distribution head and 66 kV to 765 kV AC and 500 kV DC voltage levels are included under transmission head. The Central Electricity Authority has classified the electric lines under transmission system and distribution system based on compatibility with the power system.

3.3 In accordance with CEA Regulations 2010, some of the State Regulatory Commissions have issued the regulations for demarcation. *For example:* Maharashtra Electricity Regulatory Commission (Transmission Open Access) Regulations, 2016 and the Maharashtra Electricity Regulatory Commission (Distribution Open Access) Regulations, 2016 provide for demarcation between the transmission and distribution boundaries on the basis of voltage. A multiple standards and regulation which demarcate the distribution and transmission system based on voltage level. Ultimately, it is the regulatory philosophy and scope of license i.e. transmission license and distribution license which decides the demarcation of network. Hon'ble Supreme Court in *Sai Wardha Power Generation Ltd versus Tata Power Distribution Ltd & ors*[25] took cognizance of license issued by the State Commission for demarcation between transmission licensee and distribution licensee to decide applicability of wheeling charges. Relevant portion of the para is extracted below: -

> "19. **...** As a matter of fact, the transmission licence issued to TPC-T includes 2x110 kV lines as part of the transmission system. Therefore, it is not open to TPC-T to contend that 2x110 kV line is a part of the distribution system of TPC-D till the transmission licence is

[25] On 3rd April, 2020, Hon'ble Supreme Court held that the CEA Regulations 2010, the Maharashtra Electricity Regulatory Commission (Transmission Open Access) Regulations, 2016 and the Maharashtra Electricity Regulatory Commission (Distribution Open Access) Regulations, 2016 provide for demarcation between the transmission and distribution boundaries on the basis of voltage. It was held that the Tribunal erred in ignoring the said Regulations while holding that 2x110 kV lines are part of the distribution system.

> modified. It is essential that the application filed by TPC-T for amendment of its transmission licence is decided first. If the application filed for amendment by TPC-T is allowed and reaches finality, the 2x110 kV lines will not form part of the transmission network. On the other hand, if the application of TPC-T for amendment of its licence is rejected, TPC-D cannot have a case for seeking inclusion of 2x110 kV lines in its distribution system for imposing wheeling charges on HPCL." *(Emphasis supplied)*

3.4 The network philosophy evolved is basically influenced by the differentiation created in Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010 considering technical compatibility of electrical lines with power system. The technical standard facilitates construction of the electrical plants and electric lines. The Act does not distinguish distribution and transmission system based on voltage level. It is a distribution company or transmission company which defines the scope of the license and accordingly, license granted by the State Commission or the Central Commission, as the case may be, recognizes distribution system and transmission system.

## 4. LEGAL FRAMEWORK FOR ELECTRICAL NETWORK

4.1 The Act recognizes the inter-state transmission system, state transmission system, distribution system and service line beyond distribution main separately. All these systems are collectively interpreted as electrical network in technical terms. However, the Act does not recognize the electrical network. Some of the countries[26] have recognized electrical network based on voltage level. Definition of transmission system under the Act is exhaustive and it does not limit boundary of electrical network. Legal framework for electrical network under the Act is as under: -

> *"Section 2(19) of the Act:*
>
> *(19) "distribution system" means the system of wires and associated facilities between the delivery points on the transmission lines or the generating station connection and the point of connection to the installation of the consumers;" (Emphasis supplied)*

i) Subsection (19) of the *Section* 2 of the Act defined distribution system. It contains mainly three elements. First is wires and associated facilities. Second is

[26] UK where low voltage level starts from 132 kV and below.

starting point of distribution system that is delivery points on the transmission lines or the generating station connection point. Third is terminal point of distribution system that is the point of connection to the installation of the consumer. It recognizes delivery points on the transmission lines which may be 132 kV or 11 kV or 0.415 kV high pressure cable line or any intermediary points on the transmission lines.

*"2. Definitions:-…*

*(36) "inter-State transmission system" includes -(i) any system for the conveyance of electricity by means of main transmission line from the territory of one State to another State;*

*(ii) the conveyance of electricity across the territory of an intervening State as well as conveyance within the State which is incidental to such inter-State transmission of electricity;*

*(iii) the transmission of electricity within the territory of a State on a system built, owned, operated, maintained or controlled by a Central Transmission Utility."*

*(37) "intra-State transmission system" means any system for transmission of electricity other than an inter-State*

ii) Subsection (36) of the *Section 2* defines "inter-State transmission system", Subsection (37) of the *Section 2* defines "intra-State transmission system" and Subsection (72) of the *Section 2* defines "transmission line". A definition of transmission system *inter-alia* inter-state transmission system and intra-state transmission system are generic and does not differentiate based on voltage level.

*2. Definitions:-*

*(69)"sub-station" means a station for transforming or converting electricity for the transmission or distribution thereof and includes transformers converters, switch-gears,capacitors, synchronous condensers, structures, cable and other appurtenant equipment and any buildings used for that purpose and the site thereof;*

*(25) "electricity system" means a system under the control of a generating company or licensee, as the case may be, having one or more -*
*(a) generating stations; or*
*(b) transmission lines; or*
*(c) electric lines and sub-stations;*
*and when used in the context of a State or the Union, the entire electricity system within the territories thereof;*

*(72) "transmission lines" means all high pressure cables and overhead lines (not being an essential part of the distribution system of a licensee) transmitting electricity from a generating station to another generating station or a substation, together with any step-up and step-down transformers, switch-gear and other works necessary to and used for the control of such cables or overhead lines, and such buildings or part thereof as may be required to accommodate such transformers, switch-gear and other works;*

iii) Two elements are important in definition of transmission lines. One is

"overhead lines or high-pressure cables" and other is "not being part of distribution system". The overhead lines and high-pressure cables include lines upto distribution main (upto 0.415 kV). Further, a definition of substation is also exhaustive which emphasizes transforming or converting electricity for the purpose of distribution. This definition is also generic and may not specify any voltage level for demarcation between transmission and distribution system.

iv) Clause (4) of the Electricity Rules, 2005 refers scope of distribution system consistent with the Act, as under:-

> **"4. Distribution System**.- The distribution system of a distribution licensee in terms of sub-section (19) of section 2 of the Act shall also include electric line, sub-station and electrical plant that are primarily maintained for the purpose of distributing electricity in the area of supply of such distribution licensee notwithstanding that such line, sub-station or electrical plant are high pressure cables or overhead lines or associated with such high pressure cables or overhead lines; or used incidentally for the purposes of transmitting electricity for others."

v) CEA Regulations, 2010 provides Technical Standards for Construction of Electrical Plants and Electric Lines that recognizes distribution system and transmission system based on voltage levels from technical compatibility point of view. The Chapter IV provides technical standard of Distribution substation and Chapter V provides technical standard electrical lines of 66 kV and above. Extract of relevant provisions are given in *Annexure-I*.

4.2 The scheme of network under the Act is exhaustive to define the electrical network under transmission system and distribution system in accordance with emerging requirement. It is technical standards specified by Central Electricity Authority which has created distinction of distribution substations and transmission lines based on nominal voltage level. The State Commission while issuing transmission and distribution license can define transmission network in accordance with emerging requirement. As per Act, if transmission lines are considered upto distribution main, the distribution system will start after the distribution main i.e. low-tension distribution network or 11 kV level as may

be decided by the distribution companies. The technical standards specified under Regulations was evolved long back taking into consideration prevailing situation and requirement at that time. After considering experience and emerging requirement, these technical standards need review. The Central Electricity Authority may review technical standards of electrical substation below 66 kV to make it compatible to integrate with power system and to meet emerging requirement to promote distributed energy resources.

## 5. OPTIONS FOR NETWORK REFORM

5.1 In view of discussion in foregoing paragraph, it is clear that the redefining network would facilitate to meet the emerging requirement for connecting distributed generation at low voltage level and to bring efficiency in development, operation and efficiency in cost. Further, redefining electrical network is possible within the ambit of existing legal framework without amendment under legislation. The related provisions of network under the Act are exhaustive and there is no embargo to redefine the electrical network within distribution system or transmission system. In view of this, following options have been emerged for network reform: -

5.1.1 **First** option is to reorganize electrical network of 220 kV and below under distribution network from present system of 66 kV and below and respective distribution licensee shall be responsible for efficient development and operation of the distribution system. The transmission network would be restricted to 400 kV and above only connecting inter-region and inter-state transmission lines. This option can be thought of, if number of consumers availing electricity at high voltage are more. In present circumstances, most of the consumer load is connected at low voltage and emerging scenario of distributed generation can also be connected at low voltage level;

5.1.2 **Second** option is to reorganize electrical network upto nearest point of consumer (distribution main) under transmission system and respective transmission licensee should be responsible for efficient development and operation. The distribution network would be below distribution main primarily consists low tension lines. In this option, the distribution lines need to be transferred and merged with transmission system. It involves the reorganization of distribution companies. This is also not feasible option as it involves several consequences and additional financial impact to distribution companies;

5.1.3 **Third** option is to redefine the electrical network under transmission and distribution network without reorganizing electrical network (transfer of assets). The electrical network upto nearest point of consumer (distribution main) could be redefined as transmission system or sub-transmission system and State Transmission Utility constituted by State Government would develop and operate the transmission network in coordinated manner. The distribution network would start after distribution main but the assets can be owned by the distribution companies upto higher voltage level.

5.2 In third option, instead of reorganization of existing network, it deals with only redefining electricity network upto 11 kV or distribution main as transmission system or sub transmission system. In this option, ownership of the existing distribution companies will not be altered. At the same time, proposed network is consistent with the provisions of the Act. This option could be implemented without amendment of the Act. It requires to recast obligations for development and operation of electricity network upto distribution mains or upto 0.415 kV, within the domain of State Transmission Utility or coordinating agency similar to standing committee for development of transmission system, a company formed by the State Government and

remaining network below 0.415 kV would be developed and operated by the distribution company as per their business strategy. Accordingly, state transmission network (also known as intra-state transmission system) may be defined upto distribution main. The regulations specified by the State Electricity Regulatory Commission in terms of tariff fixation, scheduling, metering and energy accounting, calculations of losses, allocation of transmission charges needs to be modified suitably to align with revised philosophy. Apart from above, the regulation and procedure related with connection of consumer needs to be expanded to include connection to distributed energy sources, prosumer and aggregator etc. A State Transmission Utility would be responsible for granting connectivity, access to transmission system irrespective of ownership as per Rules or Regulations specified by the State Government or the State Commission, as the case may be. The allocation of capacity in the transmission system would be made by State Transmission Utility as per the regulations specified by the State Commission.

5.3 The proposed approach can be implemented by modifying rules and regulations. The State Commission or the Central Commission, as the case may be, may consider to redefine electricity network by suitably amending regulations, the Central Government may consider to expand the scope of State Transmission Utility revising National Electricity Plan to meet emerging requirement of distributed energy sources and achieving economic efficiency. The Central Electricity Authority may consider to review technical standards below 66 kV level to make it compatible for power system operation in view of emerging market requirement and experiences.

**Additional Advantages**

5.4 *Section 43* of the Act deal with universal supply obligation of the distribution companies. This provision has laid down obligations of the distribution companies to provide a connection and supply to the consumer. It involves two

different activities. First is to connect the installations with electrical network and second is to supply electricity. While connecting installation of the consumer with electrical network, distribution companies would require to develop distribution network involving high voltage and low voltage lines. Sometime it is uneconomical for distribution companies especially where a small consumer located at remote places seeks demand for electricity demand. The distribution company would require to make disproportionate investment for establishing electrical network compare to revenue expected from such consumers. An additional expenditure for such electrical network is arising out of social obligations needs to be apportioned to all consumers. But in present regulatory framework, the distribution company is factoring such additional expenditure in the revenue requirement and apportioned within the consumers of only that distribution company. Proposed reorganization of electrical network would pave the way to share network expenditure arising out of universal supply obligations mandated under the Act.

5.5 The Federal Energy Regulatory Commission in United States of America has issued order No. 2222 on 17th September, 2020[27] to open up the country's wholesale energy markets for distributed energy resources like rooftop solar, behind-the-meter batteries and electric vehicles. This has enabled the owner of distributed energy resources to play in bulk energy markets while retaining the role of state regulators and utilities to maintain the soundness of their distribution grid operations and retail distributed energy resource programs. The trend of opening market for distributed energy resources observed at international level is attributed to emerging requirement and transition of energy. The proposed options to redefine network discussed in this paper would enable the distributed energy resources to connect at distribution level and at the same time, allow them to participate in open

[27] *https://www.ferc.gov/sites/default/files/2020-09/E-1_0.pdf*

market. Feeder Level Solarisation under Component-C of PM-KUSUM Scheme[28] can be facilitated to great extent in terms of installations of higher capacity plant and supplying electricity to anywhere in market.

5.6 There are several advantages of redefining electricity network at this stage. This will help to make more resilient grid for the future and to promote competition in electric markets by removing the entry barriers preventing distributed energy resources from competing on a level playing field. This proposition enables distributed energy resources to participate alongside traditional resources at regional level in organized wholesale markets. The renewable generating companies can also consider to establish merchant renewable plants in line with conventional plants and compete in open market. The short-term market or open market framework can be brought to next level wherein the cost of entire transmission system including all sub-transmission system as discussed in this paper may be merged entirely to bring one network charges and losses which can be applied to distributed energy resources and the consumer, subject to admissibility under legal framework. This concept cannot be extended in case of long-term access to avoid uncertainty as the investment was undertaken based on premises of agreements.

5.7 Apart from this, it offers several other benefits including lower costs for consumers through enhanced competition, more grid flexibility and resilience, and more innovation within the electric power industry. Further, it will help to introduce concept of aggregators for distributed energy resources and electricity demand to satisfy minimum size and performance requirement. This proposition would require power system to be redefined to include lower voltage upto 11 kV line. This can be included in transmission as sub-transmission system or transmission system and its operation can be entrusted to sub-load despatch centre already existing in State. Thus, state and regional

[28] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1678286

level system operator would be supported by system operator of sub-load despatch centre[30] and can be managed without creating additional infrastructure for system operator.

## 6. CONCLUSION

The institutional structure of electricity network demarcation plays important role in development of market and emerging requirement. The electricity network was restructured post enactment of the Act based on scenario existing at that time. The transition of generation resources towards renewable generation and distributed energy resources were not envisaged. In order to address the emerging requirement for connecting distributed generation resources at low voltage level and to bring efficiency in operation and costs, there is a need to redefine electricity network and to establish unified transmission network upto nearest point of consumer load upto 11 kV or 0.415 kV or distribution main, as per suitability of the State. The scheme of electricity network under the Act is exhaustive and there is no embargo to redefine the electrical network as part of distribution network or transmission network. The transmission system can be stretched nearest to the consumer point. This proposition unlocks various avenues for achieving economic efficiency, addressing technical losses of distribution system, simplification of sharing of cost arising out of universal supply obligations and opening bulk electricity market to distributed energy resources. The option recommended in this paper is to redefine distribution system upto 11 kV or 0.415 kV or distribution main as part of transmission system or sub-transmission system without altering the rights of the distribution companies. This option could be implemented with suitable amendment in regulation and policy framework only without amendment in the Electricity Act, 2003.

[30] In each state, Sub-load dispatch centers have been established in various area under Unified Load Despatch Centre scheme. This infrastructure is serviced by the consumer.

*-// Annexure-I //-*

**"CHAPTER IV**
**PART-C**
**DISTRIBUTION SUB-STATIONS (DSS)**

**74. General–** (1) The system shall conform to the design parameters indicated in Table 15 below:

Table 15

| Parameter | 33 kV | 22 kV | 11 KV | 0.415 kV |
|---|---|---|---|---|
| Nominal System Voltage (kV) | 33 | 22 | 11 | 0.415 |
| Highest System Voltage (kV) | 36 | 24 | 12 | 0.450 |
| System earthing | Solidly earth system | Solidly earth system | Solidly earth system | Solidly earth system |
| Frequency (Hz) | 50 | 50 | 50 | 50 |
| Lighting impulse withstand voltage (kV peak) | 170 | 125 | 75 | - |
| Power frequency withstand voltage (dry) (kVrms) | 70 | 50 | 28 | 3 |

….."

**"CHAPTER V**
**TECHNICAL STANDARDS FOR CONSRUCTION OF ELECTRIC LINES**
**PART A**
**ELECTRIC LINES (66 KV AND ABOVE)**

86. **General-** (1) Whenever a new transmission line is planned and constructed, the Owner shall ensure that the proposed new installation is compatible with the existing power system and is suitable for becoming, on commissioning, a natural and integral part of the power system. The overall performance and output as well as detailed operating characteristics and specifications of the installation shall conform to the rest of the power system i.e. the design and construction features shall be compatible with the system to which the new installation will be connected.

(2) ….

….

"89. Design and Construction of Transmission Lines

(1) Salient technical particulars and requirement of transmission lines

(a) Electrical Design Parameters of the Transmission Lines

(i) The electrical design parameters of the transmission lines for altitude upto 1000 m above mean sea level (MSL) shall be as indicated in Table 16 below:

Table 16

| Parameter | 66 kV AC | 132 kV AC | 220 kV AC | 400 kV AC | 765 kV AC | 500 kV DC |
|---|---|---|---|---|---|---|
| Nominal Voltage (kV) | 66 | 132 | 220 | 400 | 765 | 500 |
| Highest System Voltage (kV) | 72.5 | 145 | 245 | 420 | 800 | 525 |
| Full wave impulse withstand voltage (1.2/50 micro sec.) (kVpeak) | 325 | 650 | 1050 | 1550 | 2400 | 1800 |
| …. | | | | | | |
| … | | | | | | |

….”

It may be observed that Clause (1) of Regulation 74 of CEA Regulations, 2010 provides the design parameters of distribution system which consists of 33 kV, 22 kV, 11 kV and 0.415 kV whereas Clause (1) of Regulation 89 of CEA Regulations, 2010 provides the design parameters of transmission lines which consists of 66 kV, 132 kV, 220 kV, 400 kV, 765 kV and 500 kV;