Chapter 2

TRANSMISSION PLANNING

2.0 INTRODUCTION

The transmission systems in the country consist of Inter-State and Intra State Transmission System. Over decades a robust inter-state and inter-regional transmission system has evolved in the country. Inter State (and Inter-regional) transmission system is mainly owned by POWERGRID. In future, Inter-State Transmission System (ISTS) schemes would also be built through competitive bidding by private sector entities. Already, a number of such schemes by the private sector or joint venture between private sector and POWERGRID are under construction. Planning and developing inter-state transmission system for IPP projects is a challenging task because there is greater uncertainty about their actual materialization, commissioning schedule and their beneficiaries are most often not known at the time of transmission planning. The process of transmission planning and development has become very dynamic in the market driven scenario. To reduce Right Of Way(ROW) requirements for transmission lines and overcome constraints in availability of land for substations, 765 kV transmission voltage is being increasingly adopted and GIS substations are being provided wherever availability of land is a problem. Massive expansion of inter-state transmission system is under way to cater to the transmission requirement of new generation projects.

2.1 GROWTH OF TRANSMISSION SYSTEM

At the time of Independence, power systems in the country were essentially isolated systems developed in and around urban and industrial areas and the highest transmission voltage was 132 kV. The state-sector network grew at voltage level up to 132 kV during the 50s and 60s and then to 220 kV during 60s and 70s. Subsequently, in many states (U.P., Maharashtra, M.P., Gujarat, Orissa, A.P., and Karnataka) substantial 400kV network was also added as large quantum of power was to be transmitted over long distances.

To supplement the efforts of the states in increasing generation capacities, Central Sector generation utilities viz. National Hydroelectric Power Corporation (NHPC) and National Thermal Power Corporation (NTPC) were created in 1975. These corporations established large generating stations for the benefit of States in a region. These corporations also undertook development of associated transmission lines, for evacuation of power and delivery of power to the beneficiary States transcending state boundaries. By the end of 1980s, strong regional networks came into existence and in 1989, transmission wings of Central generating companies were separated to set up Power Grid Corporation of India (POWERGRID). Power grid was set up to give thrust to implementation of transmission system associated with Central generating stations and inter-Regional transmission programme based on perspective planning done by Central Electricity Authority (CEA).

Considering the operational regime of the various Regional Grids, it was decided around 1990s to establish initially asynchronous connection between the Regional Grids to enable them to exchange large regulated quantum of power. Accordingly, a 500 MW asynchronous HVDC back-to-back link between the NR - WR at Vindhyachal was established. Subsequently, similar links between WR – SR (1000 MW capacity at Bhadrawati), between ER – SR (1000 MW capacity at Gazuwaka) and between ER – NR (500 MW capacity at Sasaram), were established. In 1992 the Eastern Region and the North-Eastern Region were synchronously interconnected through a Birpara-Salakati 220kV double circuit transmission line and subsequently by a 400 kV D/C Bongaigaon -Malda line. Western Region was interconnected to ER-NER system synchronously through 400kV Rourkela-Raipur D/C line in 2003 and thus the Central India system consisting of ER-NER-WR came in to operation. In 2006 with commissioning of Muzaffarpur-Gorakhpur 400kV D/C line, the Northern region also got interconnected to this system making an upper India system ('NEW' grid) having the NR-WR-ER-NER system.

Recognizing the need for development of National grid, thrust was given to enhance the capacity of inter-regional links in a phased manner. Total inter-regional transmission capacity at the end of 9th Plan was 5,750 MW. During 10th Plan i.e. 2002-07, a total of 8300 MW of inter-regional capacities were added. Total inter-regional transmission capacity at the end of 10th Plan was 14,050 MW. In order to facilitate evacuation of power from various hydro power projects in the country, CEA has evolved river basin wise transmission plans in consultation with the State Transmission Utilities. An Integrated transmission system for evacuation of power from hydro generating projects proposed in river basins of Uttarakhand, Himachal Pradesh, Arunachal Pradesh and Sikkim has been evolved.

2.2 REVIEW OF ACHIEVEMENTS DURING 11TH PLAN

2.2.1 Programme and achievements during 11th plan

A programme for construction of 88,515 ckm transmission lines for evacuation of power from generating stations as well as for strengthening of transmission network was envisaged at the beginning of the 11th Plan corresponding to generation capacity addition programme of 78,700 MW. Subsequently, during the mid-term appraisal by the Planning Commission, generating capacity target for the 11th plan was scaled down to 62,374 MW. Accordingly, 68,673 ckm of transmission line addition in the 11th plan was anticipated during Mid-Term appraisal of the Planning Commission. This comprises 2,773 ckm of 765 kV lines, 40,000 ckm of 400 kV lines, 24,300 ckm for 230/220 kV lines and 1600 ckm for HVDC lines. Against this programme, actual addition of transmission lines during first four years of 11th Plan is 49,852 ckm comprising of 1,636 ckm of 765 kV lines, 1580 ckm of HVDC lines, 26,856 ckm of 400 kV lines and 19,780 ckm of 230/220 kV lines .

A programme of 1,57,691 MVA of transformation capacity corresponding to generation capacity addition programme of 78,700 MW was envisaged at the beginning of the 11th Plan. During the mid-term appraisal by the Planning Commission, no revision in transformation capacity addition programme was indicated. Against the original programme of 1,57,691 MVA at the beginning of 11th plan, the actual achievement of transformation capacity addition during the first four years of 11th Plan is 99,075 MVA comprising of 4,500 MVA of 765 kV, 3,000 MW for HVDC, 40,920 MVA for 400 kV and 50,655 MVA for 230/220 kV.

For the terminal year of 11th Plan period i.e. 2011-12, a programme of transmission line addition of 21,792 Ckm and transformation capacity addition of 27,380 MVA has been made. In the event of full achievement of these targets for 2011-12, the total achievements during 11th Plan would be 71,644 ckm for transmission line addition, 1,23,455 MVA AC transformation capacity additions and 5,500 MW of HVDC terminal capacity addition. The following table indicates the programme, achievements during the first four years of the 11th Plan and anticipated additions in 11th Plan for transmission lines and substations.

Table 2.1

Transmission Lines- 11th Plan Programme & Achievement

(All figures in circuit kms)

Voltage level	XI plan programme	Achievement up to Mar 2011 during XI Plan	Anticipated addition during 2011-12	Anticipated addition in 11th Plan
765 kV	2773	1636	824	**2460**
± 500 kV HVDC	1600	1580	2000	**3580**
400 kV	40000	26856	12401	**39257**
220 kV	24300	19780	6567	**26347**
Total	**68673**	**49852**	**21792**	**71644**

Table: 2.2

Sub Stations & HVDC Terminal capacity- 11th Plan Programme & Achievement

(Figures in MVA/MW)

Voltage level	XI plan Programme	Achievement up to March 2011 during XI plan	Anticipated addition during 2011-12	Anticipated addition in 11th Plan
765 kV	24500	4500	4000	**8500**
400 kV	51960	40920	8725	**49645**
220 kV	72731	50655	14655	**65310**
Total – AC Substation capacity in MVA	**149191**	**96075**	**27380**	**123455**
± 500 kV HVDC	8500	3000	2500	**5500**
Total- HVDC terminal capacity in MW	**8500**	**3000**	**2500**	**5500**

The following table gives the cumulative growth in transmission lines and substation capacity at the end of various Plan periods.

Table 2.3

CUMULATIVE GROWTH IN TRANSMISSION LINES					
	Unit	At the end of 8th Plan i.e. March 1997	At the end of 9th Plan i.e. March 2002	At the end of 10th Plan i.e. March 2007	Anticipated at the end of 11th Plan i.e. March 2012
Transmission Lines					
765 kV	Ckm	0	1160	2184	**4644**
HVDC	Ckm	1634	4738	5872	**9452 ***
400 kV	Ckm	36142	49378	75722	**114979**
230/220 kV	Ckm	79600	96993	114629	**140976**
Total	Ckm	117376	152269	198407	**270051**
CUMULATIVE GROWTH IN SUBSTATION CAPACITY					
Substations					
765 kV	MVA	0	0	0	**8500**
HVDC	MW	0	5200	8200	**13500****
400 kV	MVA	40865	60380	92942	**142587**
230/220 kV	MVA	84177	116363	156497	**221807**
Total	MVA/ MW	125042	181943	257639	**386394**

Note: Growth figures upto the end of 10th plan as given above for transmission lines are for achievement of stringing. It is assumed that length of transmission line commissioned upto the end of 10th Plan is same as the length of transmission line strung upto the end of the 10th Plan. The anticipated transmission line addition during 11th Plan is added to the length of the line strung upto end of the 10th Plan to arrive at the growth figures at the end of 11th Plan.

*** including 2500 MW, 1000 km by Adani Power**
**** The 200 MW HVDC Monopole between Bursur- L.Sileru is not in operation.**

2.2.2 Inter-regional capacity addition during 11th Plan

The total inter-regional transmission capacity at the beginning of 11th Plan was 14,050 MW. During Mid Term Review of 11th Plan, additional inter-regional transmission systems of 18,600 MW capacities were anticipated, taking the expected inter-regional capacity to 32,650 MW by end of 11th Plan. Out of the programme for 11th Plan, 2400 MW capacity was added during 2007-08, 3300 MW during 2008-09, 1000 MW during 2009-10 and no addition during 2010-11. Thus a capacity addition of 6700 MW has already been added in 11th Plan up to 31-03-2011. With these additions the total transmission capacity of inter-regional transmission system, as on 31-03-2011 is 20,750 MW. The Barh – Balia 400kV Quad D/C line of 1600 MW transmission capacity has been completed but this line is yet to be commissioned as the associated Barh generation project is getting delayed. In addition, two more inter-regional links i.e. Gaya–Balia 765kV S/C (2100 MW) and Rourkela- Raigarh 400kV

D/C line with series compensation (1400 MW) lines are under construction and likely to be completed within 11th Plan period. With these links, total inter-regional capacity, on all India basis is anticipated to be 25,850 MW by end of 11th Five Year Plan. Thus there would be shortfall of 6800 MW in inter-regional transmission capacity addition during 11th Plan. This is on account of Ranchi – WR (Bilaspur) Pooling Point 765kV S/C (2100 MW), Sasaram-Fathepur 765 kV S/C (2100 MW) and 400 kV D/C Bongaigaon-Siliguri 400 kV D/ C Quad (1600 MW) which have slipped to 12th Plan. The 1000 MW Narendra – Kolhapur HVDC back-to-back has been dropped. The delay in Sasaram-Fatehpur 765 kV S/c line is on account of delay in commissioning of DVC generation projects with which this line is associated. The transmission service provider for Bongaigaon-Siliguri line has been selected through tariff based competitive bidding in 2010 and as per the terms of the award this line is now expected in early 12th Plan.

2.2.3 Fund Requirement and actual utilization during 11th Plan

Total Fund requirement for transmission system development and related schemes as estimated at the beginning of XI plan was Rs 1,40,000 Crore(Central Sector- Rs 75,000 Crore, and State Sector- Rs 65,000 Crore). Against this estimated funds requirement, the total utilization during XI Plan is anticipated to be of the order of Rs. 1,22,800 Crore.

2.2.4 Analysis and Reasons for shortfall in targets

The achievement of transmission line addition in the first four years of the 11th plan has been by and large satisfactory. The shortfall in addition of transformation capacity is mainly on account of substations associated with the generation projects which have now slipped to 12th Plan. It is expected that in the terminal year of 11th plan, the transmission line target would be fully met.

2.3 OPEN ACCESS IN TRANSMISSION AND TRADING OF ELECTRICITY

2.3.1 Transmission Planning keeping in view Open Access

Based on application by a generator for Long Term Open Access, the transmission system is planned for evacuation of power from generating stations. The system planning studies are carried out considering projected demand in accordance with load forecasts. The loads of various States are assumed irrespective of any PPAs. However adequate intra-state transmission system is also required to absorb power injected from ISTS. During the planning process, some design margins get created in the network generally due to long term optimisation. These margins, along with operational and reliability margins which are variable in nature and depend upon system conditions and load flow pattern at that time provide sufficient additional capacity in the system for trading and States to buy power more than their long-term PPAs. However, these margins can be utilized only up to a limit and may result into congestion if States start buying Power much in excess of their forecasted requirements.

2.3.2 Provisions in Electricity Act and CERC Regulation

Enactment of the Electricity Act, 2003 has opened up hitherto constrained electricity market which was characterized by long term PPAs and inability of Distribution Companies and consumers to have a choice of suppliers. Besides, de-licensing generation and removing controls on captive generation, the provision regarding availability of non-discriminatory open access in transmission from the very beginning and open access in distribution in a phased manner are important features of the Act. This creates an enabling environment for competition among generators/traders to choose their customers and vice-versa.

Access to inter-State transmission system is governed by the regulations of the Central Electricity Regulatory Commission. The Central Transmission Utility (CTU) is the nodal agency for providing medium term (3 months to 3 years) and long term (12 to 25 years) access that is typically required by a generating station or a trader on its behalf. The nodal agency for grant of short term open access (up to three months) is the Regional Load Dispatch Centre. The nodal agency for providing transmission access to the power exchanges is the National Load Dispatch Centre.

2.3.3 Long term Open access in inter-state transmission

2.3.3.1 The nodal agency for providing long term open access in inter-state transmission is the CTU. Up till March 2011, CTU has received about 187 Long Term Access(LTA) applications for transfer of power from their generation projects of capacity of about 1,77,000 MW to various target regions. The applications were processed by CTU and progress of each generation project in terms of land acquisition, fuel tie-up, environment and forest clearance, water linkage, EPC award, financial closure etc. was reviewed by CTU and CEA. Based on the progress, LTA has been granted to 135 applicants with capacity of about 1,17,000 MW. Out of this, transmission system is already in place for a capacity of about 43,500 MW and system strengthening identified for a capacity of about 73,500MW. The progress of balance 52 applications with capacity of about 60,000MW was not up to the mark and was proposed to close/review the application based on subsequent progress.

2.3.3.2 The grant of Long Term Access generally involves evolution or strengthening of the ISTS to accommodate desired transaction of power and is akin to transmission planning. The primary inputs required for transmission planning include (i) generation plant capacity, (ii) its location, (iii) time frame of materialization, (iv) beneficiaries to whom the power shall be delivered etc. However, in the present circumstances, none of these inputs are available with certainty. Under such a situation where the basic inputs required for evolving a transmission Plan are not available readily, it is prudent that transmission planners follow some innovative strategies to ensure fulfillment of broad objectives including ensuring that (i) transmission development takes place to cater to the transmission requirement, (ii) bottling up of the power is avoided, (iii) mismatch of generation and transmission system is avoided, (iv) congestion if observed in some part of grid should be removed at the earliest etc. In view of above it is a challenge to evolve optimal transmission system and once the plan is in place it is equally challenging to plan its implementation so as to avoid mismatch between development of generation project and transmission system.

2.3.3.3 Most of the generation projects for which additional system strengthening has been identified are mainly located in Orissa, Chhattisgarh, Sikkim, Jharkhand, Madhya Pradesh, coastal Andhra Pradesh and Tamil Nadu. While processing these applications, readiness of generation projects in terms of above parameters was examined in association with the beneficiaries of concerned regions and CEA. For the generation projects having no firm beneficiaries, transmission system requirement has been worked out on the basis of target beneficiaries/regions. Based on the information furnished by the applicants, group of generation projects who have made progress on ground were prioritized and considered for grant of Long Term Access. For this, system strengthening has been identified which includes 11 nos. High Capacity Power Transmission Corridors catering to about 58,000 MW generation capacity and also comprises of latest technologies like 765kV AC / ±800kV HVDC. The High Capacity Power Transmission Corridors include:

- Transmission System Associated with Phase-I Generation Projects in Orissa
- Transmission System Associated with IPP projects in Jharkhand
- Transmission System Associated with IPP projects in Sikkim
- Transmission System Associated with IPP projects in Bilaspur complex, Chattisgarh & IPPs in Madhya Pradesh
- Transmission System Associated with IPP projects in Chattisgarh
- Transmission System Associated with IPP projects in Krishnapatnam Area, Andhra Pradesh
- Transmission System Associated with IPP projects in Tuticorin Area, Tamil Nadu
- Transmission System Associated with IPP projects in Srikakulam Area, Andhra Pradesh
- Transmission System Associated with IPP projects in Southern Region for transfer of power to other regions
- Transmission System Associated with IPP projects in Vemagiri area in SR for power transfer to other regions
- Transmission System Associated with IPP projects in Nagapattinam / Cuddalore area in SR for power transfer to other regions

The transmission corridors shall be commissioned progressively matching with commissioning of IPP generation projects.

2.3.3.4 Challenges in processing LTA

Distribution utilities, to meet their long term requirement of power, are not inviting Case-1/ Case-2 bids. In absence of firm beneficiaries, transmission is being developed based on target beneficiaries indicated by the generation project developers. Absence of firm beneficiaries may result into sub-optimal utilisation in one part of grid or congestion in another part. Further, the time schedule of commissioning of some of the generation projects is not certain. This puts a lot of risk on investment in transmission infrastructure and also, the time line for implementation of transmission system by CTU/ other transmission licensees becomes difficult to meet.

2.3.4 Medium term Open Access (MTOA)

Only two (2) applications were received for MTOA from UT Dadar and Nagar Haveli and UT Daman & Diu in Western Region for transfer of 54MW from 500MW NSPCL generating station in Bhilai (Chhattisgarh). MTOA has been granted.

2.3.5 Short Term Open Access

Short term Customer or the power exchange on behalf of buyers and sellers intending to avail short term access makes an application to the nodal agency. The short term customers are eligible for short term open access over the surplus capacity available after use by long term customers and medium term customers due to inherent design margins available. The application for bilateral transaction contains details such as name and location of the supplier and buyer, contracted power (MW) to be scheduled, point of injection, point of drawal, starting time block and date etc. Whenever the proposed bilateral transaction has a State utility or an intra state entity as buyer or seller, concurrence of the State Load Despatch centre shall be obtained in advance and submitted along with the application. A Summary of the short term transactions bilateral and collective processed is as under:

Table 2.4
Summary of Open Access short term transactions

Year	No. of transactions			Approved Energy in MUs		
Year	Bilateral	Collective	Total	Bilateral	Collective	Total
2004-05	778	-	778	16441	-	**16441**
2005-06	3938	-	3938	22526	-	**22526**
2006-07	5933	-	5933	23598	-	**23598**
2007-08	9560	-	9560	29831	-	**29831**
2008-09	11781	3633	15414	27756	2765	**30521**
2009-10	8154	9974	18128	32371	7086	**39457**
2010-11	6154	13729	19883	41693	13539	**55232**
Total	**46298**	**27336**	**73634**	**194216**	**23390**	**217606**

2.3.6 Transmission Congestion

As self dispatched entities, seasonal trading is done by the distribution utilities to meet their seasonal demand or sell their seasonal surplus. Short term trading on day-ahead basis is required for balancing the demand with supply. Short term trading is also required for meeting contingency requirement. Normally, there should be regular pattern of short term trading which may vary depending on uncertain factors like weather. However, in India the pattern of short term trading is erratic and depends on many extraneous factors particularly availability of funds with deficit Discoms etc. Sometimes a State may suddenly decide to reduce load shedding and resort to heavy short term purchase through trading. In such a situation, the drawal has to be restricted to the margins available in the planned transmission capacity. It is not possible to plan transmission system for catering to such a situation. In the Northern Region the congestion has often occurred due to heavy reactive power drawal during agricultural season and dry weather by some States like Haryana and Punjab.

2.3.7 Trading of Electricity

Short term trading is an essential tool for optimization of resources and plays an important role in a deficit scenario for harnessing additional / captive sources of generation for meeting the peak demand. Trading of electricity in India has picked up considerably after the advent of Electricity Act 2003 which recognizes trading as a distinct licensed activity. In future the quantum of electricity traded in the short term market is likely to grow considerably as the new generating capacity of many IPP's plants is not tied up in long term PPAs. The volume of electricity traded and its average price are depicted in the Table 2.5 below. The declining trend of prices in later years is an indication of increased competition and increasing availability of supply.

Table 2.5

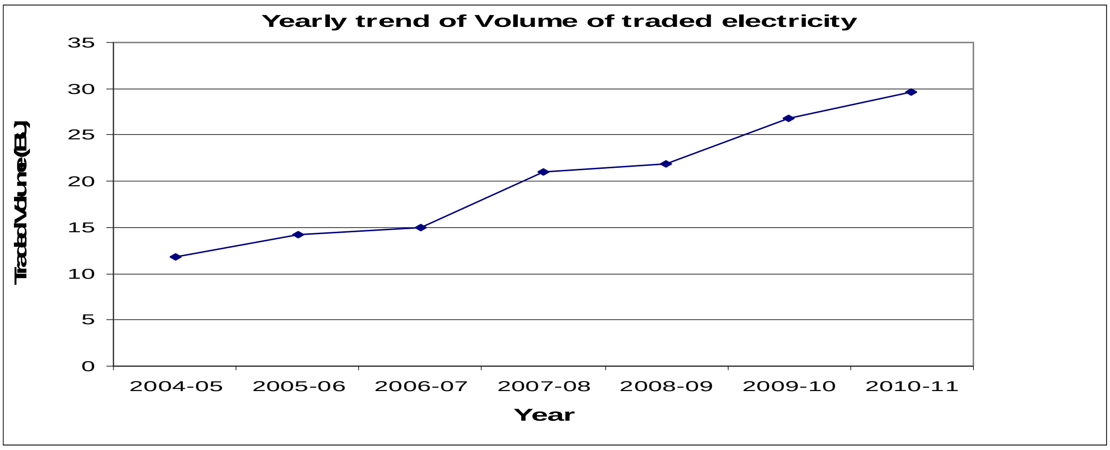
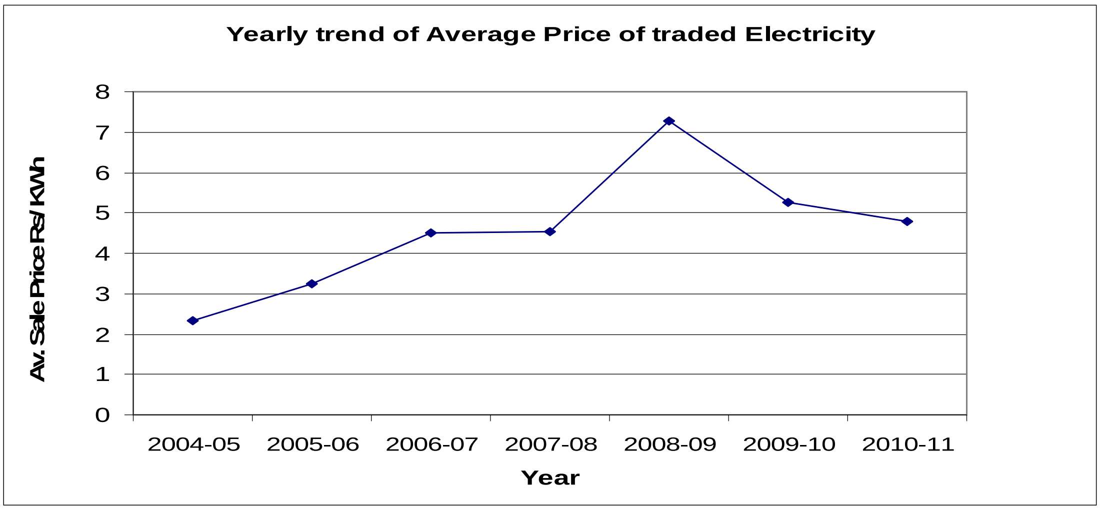


Table 2.6



2.3.8 Power Exchanges

At present there are two power exchanges in the country, namely IEX and PXIL which separately operate Day-ahead Spot market for electricity. These two exchanges work on identical principle of price discovery as specified by CERC. The Day-ahead market operates on the principle of voluntary participation, double sided closed auctions, uniform price discovery and zonal market splitting in case of transmission constraint. The yearly volume and average price of electricity of the two power exchanges is indicated in the table below:

Table 2.7

Volume and Price of Electricity Transacted through Power Exchanges in Day Ahead Market				
Period	Volume (Million Units)		Average Sale Price(Rs)	
	IEX	PXIL	IEX	PXIL
2008-09	2623.22	149.36	7.48	7.6
2009-10	6170.93	915.3	4.98	4.79
2010-11	11800.58	1740.18	3.38	3.87

The increasing volume and declining price is indicative of improved liquidity of supply. The number of participants in the two exchanges has been growing rapidly due to the entry of bulk Open Access consumers particularly from the states of Punjab and Tamil Nadu. The average number of active participants in the two exchanges was more than 600 during June 2011, which is a clear trend of bulk industrial consumers sourcing reliable or cheaper supply through power exchanges.

In addition to above, two power exchanges also separately operate term-ahead market. Each exchange follows its own market rules for the same. Term-ahead market particularly for ‘one month’ and ‘one year’ contracts has great potential in the future with the entry of merchant plants into the fray.

2.4 12TH PLAN TRANSMISSION PROGRAMME

2.4.1 Evolving the Transmission System for 12th Plan

Identification of transmission expansion requirement for a Plan period is done based on power system studies corresponding to the generation expansion programme and forecasted demand scenario expected at the end of that Plan. The implementation programme is worked out keeping in view identification of projects, schemes and transmission elements that should be implemented matching with programme of generation capacity addition and load growth on yearly basis during the Plan. Timely development of transmission network requires firming-up of the specific transmission schemes corresponding to specific generation projects, which, particularly in respect of inter-state transmission system, need to be done 3 to 5 years ahead of the target date of completion. Meeting this requirement, most of the 12th Plan schemes have already been identified, discussed in the Regional Standing Committees on Power System Planning, finalized, scheme formulated and process of implementation initiated. Of the identified schemes, many are under construction, particularly those which are required to be completed during first half of the 12th Plan.

2.4.2 Inter-Regional Transmission Capacity Programme

2.4.2.1 The Bursur- Lower Sileru HVDC monopole, which was included upto 10th Plan in the list of Inter-regional (IR) capacity, is currently not in operation; as such this link of 200 MW between WR-SR would not be available by the end of 11th Plan. Thus, the Inter-regional transmission capacity of All-India grid at the end of 11th Plan is expected to be 25,650 MW. During 12th Plan period a number of inter regional transmission links either associated with generation projects or as system strengthening schemes have been planned. These links would be implemented depending upon the progress of associated generating stations. Considering a capacity addition of about 76,000 MW during 12th Plan over & above 62,374 MW target for 11th Plan, the inter-regional transmission links of about 38,000 MW may be added during 12th Plan period. Details are given in Table-2.8 below. Thus inter-regional transmission capacity at the end of 12th Plan is expected to be of the order of 63,000 MW.

Table 2.8

(All figures are in MW)

Name of System	Existing as on 31.03.2011	Balance program for 11th Plan	Expected at the end of 11th Plan i.e. 31.03.2012	12th plan Additions	Expected at the end of 12th Plan
ER – SR :					
Gazuwaka HVDC back to back	1000		1000		1000
Balimela-Upper Sileru 220kV S/C	130		130		130
Talcher-Kolar HVDC Bipole	2000		2000		2000
Upgradation of Talcher–Kolar HVDC bipole **(not to be included since 11th Plan)**	500		500		500
ER-SR total	**3630**	**0**	**3630**	**0**	**3630**
ER –NR :					
Muzaffarpur - Gorakhpur 400kV D/C (Quad Moose) with TCSC	2000		2000		2000
Dehri-Sahupuri 220kV S/C	130		130		130
Patna-Balia 400kV D/C quad	1600		1600		1600
Biharshariff-Balia 400kV D/C quad	1600		1600		1600
Barh-Balia 400kV D/C quad #	1600		1600		1600
Gaya–Balia 765kV S/C (LILOed at Varanasi in 12th Plan)		2100	2100		2100

Name of System	Existing as on 31.03.2011	Balance program for 11th Plan	Expected at the end of 11th Plan i.e. 31.03.2012	12th plan Additions	Expected at the end of 12th Plan
Sasaram-Allahabad/Varanasi 400kV D/C line (Sasaram HVDC back to back has been bypassed)	1000		1000		1000
Gaya-Varanasi 765kV S/C				2100	2100
Sasaram-Fatehpur 765kV S/C				2100	2100
Barh-Gorakhpur 400kV D/C quad				1600	1600
ER-NR total	**7930**	**2100**	**10030**	**5800**	**15830**
ER - WR :					
Rourkela-Raipur 400kV D/C	1000		1000		1000
TCSC on Rourkela-Raipur 400kV D/C	400		400		400
Budhipara-Korba220kV D/C+S/C	390		390		390
Ranchi-Sipat 400kV D/C (40% SC)	1200		1200		1200
Ranchi-Rourkela-Raigarh-Raipur 400kV D/C with fixed series capacitor, TCSC in parallel line		1400	1400		1400
Ranchi – WR(Bilaspur)Sipat Pooling Point 765kV S/C via Dharamjaigarh during 12th plan				2100	2100
Ranchi- Dharamjaigarh 765kV S/C				2100	2100
Jharsuguda -Dharamjaigarh- 765kV D/C				4200	4200
ER-WR total	**2990**	**1400**	**4390**	**8400**	**12790**
ER - NER :					
Birpara -Salakati 220kV D/C	260		260		260
Malda-Bongaigaon 400kV D/C	1000		1000		1000
Bongaigaon-Siliguri 400kV D/C Quad to be LILOed at Alipurduar in 12th/13th plan				1600	1600
ER-NER total	**1260**	**0**	**1260**	**1600**	**2860**
NR - WR :					
Vindhyachal HVDC back to back	500		500		500
Auria-Malanpur 220kV D/C	260		260		260
Kota-Ujjain 220kV D/C	260		260		260
Agra-Gwalior 765kV S/C line-1 at 765 kV(earlier at 400kV)	1100		1100	1000	2100
Agra-Gwalior 765kV S/C line-2 at 765kV(earlier at 400kV)	1100		1100	1000	2100
Kankroli-Zerda 400kV D/C	1000		1000		1000
Gwalior-Jaipur 765kV S/C#1				2100	2100

Name of System	Existing as on 31.03.2011	Balance program for 11th Plan	Expected at the end of 11th Plan i.e. 31.03.2012	12th plan Additions	Expected at the end of 12th Plan
Gwalior-Jaipur 765kV S/C#2				2100	2100
RAPP C&D-Nagda 400kV D/C				1000	1000
Champa-Kurukshetra +/-800kV 6000MW HVDC bipole line, Phase-I				3000	3000
NR-WR total	**4220**	**0**	**4220**	**10200**	**14420**
WR-SR :					
Chandrapur HVDC back to back	1000		1000		1000
Bursur –L. Sileru 200kV HVDC mono pole @	200	(-200)	200		--
Kolhapur-Belgaum 220kV D/C	260		260		260
Ponda – Nagajhari 220kV D/C	260		260		260
Narendra (GIS) – Kolhapur (new) 765kV D/C line (initially charged at 400 kV)				2200	2200
Raichur-Sholapur 765kVS/C #1				2100	2100
Raichur-Sholapur 765kV S/C #2				2100	2100
WR-SR total	**1720**	**(-200)**	**1520**	**6400**	**7920**
NER/ER-NR/WR :					
Bishwanath Chariyali – Agra +800 kV, 3000 MW HVDC bipole.				3000	3000
LILO of + 800kV Bishwanath Chariyali – Agra HVDC Bipole at new pooling station in Alipurduar and addition of second 3000 MW HVDC				3000	3000
NER/ER-NR/WR total	**0**	**0**	**0**	**6000**	**6000**
TOTAL ALL INDIA (220kV & above)	**21750**	**3300**	**25050**	**38400**	**63450**
132kV/110kV Inter-Regional links $ (not to be included in 12th Plan)	600	0	600	(-600)	----
TOTAL ALL INDIA	**22350**	**3300**	**25650**	**37800**	**63450**

Note:
@ - 200 MW HVDC Monopole is currently not in operation.
$ - 132/110kV lines are operated in radial mode from time to time. (not to be included for 12th plan period)
# - Barh-Balia line has been completed but is yet to be commissioned.

2.4.2.2 Transmission Capacity of Inter-Regional links v/s Transfer Capability between two regions:

The National Grid constitutes the complete transmission network, including transmission system for evacuation of power from generating stations, the inter-regional links and complete Inter State transmission system and right upto Intra-State transmission of STU with DISCOMs. In view of this, development of national grid is an evolutionary process. The summation of the transmission capacities of inter-Regional links is a figurative representation of the bonds between the regions. These aggregate numbers do not indicate actual power transfer capability across different regions/States. The power transfer capability between any two points in a grid depends upon a number of variable factors, such as - load flow pattern, voltage stability, angular stability, loop flows and line loading of weakest link in the grid. For instance, present aggregate inter-regional transmission capacity of Northern Region is 9320 MW (6330 MW with ER and 2990 MW with WR), whereas, simultaneous transfer import capability of NR may work out to about 5000 - 6000 MW depending upon operational conditions. The system operator has to assess the transfer capability between two points of the grid from time to time and restrict the power flow accordingly.

2.4.3 Growth in 765kV Transmission System up to 12th Plan / Early 13th Plan Period:

During 11th Plan, a number of 765kV lines and substations have been added and a few more are under-construction. The trend of increasing 765kV system in the grid is going to continue in the 12th Plan as well. A number of new 765kV lines and substations have been planned for evacuation of bulk power in the range of 3000 – 6000 MW to longer distances. Their actual realization would depend upon progress of associated generation projects. The planned 765kV transmission systems are expected to be implemented during 12th Plan or early 13th Plan period. Some of the planned 765 kV systems would be initially operated at 400 kV. Their 765 kV operation depends upon associated generation projects, which could be in 12th plan or beyond.

2.4.4 Growth in HVDC Transmission System up to 12th Plan / Early 13th Plan Period:

During 11th Plan, Balia-Bhiwadi 2500 MW HVDC Bipole and upgradation of Talcher-Kolar Bipole by 500 MW has been completed. Another HVDC bipole as Dedicated Transmission line, i.e. Mundra-Mohindergarh 2500 MW is being constructed under private sector by Adani group. This line is expected to be completed within 11th Plan period. Three more HVDC systems have been planned for completion during 12th Plan or early 13th Plan. These are Biswanath Chariyali -Alipurduar-Agra 6000 MW, Champa-Kurukshetra Phase-I 3000 MW and Raigarh-Dhule 4000 MW. Details of HVDC system in India and its plan are given in the following Table:

Table 2.9
HVDC Capacity (bipole / back-to-back) Existing and Planned
(values in MW)

HVDC	Type	Agency	As at the end of 10th Plan	Expected at the end of 11th Plan	Planned for 12th / early 13th Plan	Expected at the end of 12th/early 13th Plan
Chandrapur-Padghe	bipole	MSEB	1500	1500		1500
Rihand-Dadri	bipole	PGCIL	1500	1500		1500
Talcher-Kolar	bipole	PGCIL	2000	2500		2500
Balia-Bhiwadi	bipole	PGCIL		2500		2500
Biswanath-Agra	bipole	PGCIL			3000	3000
Champa– Kurukshetra	bipole	PGCIL			3000	3000
Raigarh(Kotra)-Dulhe	bipole	PGCIL			4000	4000
LILO of Bishwanath– Agra at Alipurduar	bipole	PGCIL			3000	3000
Mundra - Mohindergarh	bipole	Adani		2500		2500
Sub-total (bipole)			**5000**	**10500**	**13000**	**23500**
Vindhyachal	b-to-b	PGCIL	500	500		500
Chandrapur	b-to-b	PGCIL	1000	1000		1000
Gazuwaka	b-to-b	PGCIL	1000	1000		1000
Sasaram	b-to-b	PGCIL	500	500		500
Sub-total (b-to-b)			**3000**	**3000**	**0**	**3000**
TOTAL – HVDC Terminal Capacity, MW			**8000**	**13500**	**13000**	**26500**

2.4.5 1200kV transmission system: The Aurangabad - Wardha 400 kV Quad D/C line which is part of the transmission system for evacuation of power from Mundra UMPP has been planned and designed in such a way that this line would be converted into a 1200kV S/C line at a later date.

2.4.6 Transmission Schemes Planned for 12th Plan Period

CEA, in coordination with all the stake-holders i.e. Central Transmission Utility, State Transmission Utilities and Central Sector Generation Companies, have planned transmission systems required for evacuation of power from various generation projects which are in the pipeline and likely to yield benefit during 12th Plan period or early 13th Plan period, and also the transmission systems required for strengthening of regional and inter-regional transmission networks. Most of these schemes have been firmed up, however these also include some schemes, which are yet to be firmed up depending upon progress of associated generation project.

A few transmission schemes, particularly those required for generation projects coming up towards the last years of the 12th Plan and having common transmission system, could be altered depending upon progress of generation capacity linking to a common pooling point. Transmission systems for some of the 12th Plan generation capacities under the State sector (or private sector but giving benefit to only home State) have also been tentatively considered for integrated system planning process, however, these transmission schemes are required to be firmed up by the respective State Transmission Utilities.

2.4.7 Assessment of transmission system addition during 12th Plan Period: During 12th Plan period, a total of about 1,09,000 circuit kilometers(ckm) of transmission lines, 2,70,000 MVA of AC transformation capacity and 13,000 MW of HVDC systems are estimated to be added. Highlights of this transmission expansion are addition of three new HVDC Bipole systems of 13,000 MW capacity and quantum jump in 765kV transmission systems. During 12th Plan about 27,000 ckm of 765kV lines and 1,49,000 MVA transformation capacity addition is expected. This huge increase in the 765kV system is due to a number of pooling and de-pooling 765/400kV stations that have been planned to evacuate power from cluster of generation projects mainly in pit-head and coastal areas and transfer their power through long distance transmission lines up to load centers in the country. In addition to above, 400kV lines of 38,000 ckm, 220kV lines of 35,000 ckm and transformation capacity of 45,000 MVA and 76,000 MVA, respectively is estimated to be added during 12th Plan period.

Following Tables give development of the transmission system in India in 11th Plan period and expected to be added during 12th Plan period. These estimates are considering about 76 GW generation capacity addition for 12th Plan over and about 63 GW capacity addition target for 11th Plan:

Table: 2.10
Transmission Lines

Transmission Lines (both AC and HVDC systems) for 11th Plan and expected in 12th Plan (values in ckm)	As at the end of 10th Plan	Addition during first four years of 11th Plan (2007-11)	Expected at the end of 11th Plan	Expected addition during 12th Plan	Expected by end of 12th Plan
HVDC Bipole lines	5872	1580	9452	**9440**	18892
765 kV	1704	1636	4164	**27000**	31164
400 kV	75722	26856	114979	**38000**	152979
220 kV	114629	19780	140976	**35000**	175976
Total Transmission Line, ckm	**197927**	**49852**	**269571**	**109440**	**379011**

Table 2.11
Substations

Substations(AC) and HVDC Terminals for 11th Plan and expected in 12th Plan (values in MVA / MW)	As at the end of 10th Plan	Addition during first four years of 11th Plan (2007-11)	Expected at the end of 11th Plan	Expected addition during 12th Plan	Expected by end of 12th Plan
HVDC Terminals:					
HVDC back-to-back	3000	3000	3000	**0**	3000
HVDC Bipole terminals	5000	5500	10500	**13000**	23500
Total- HVDC Terminal Capacity, MW	**8000**	**8500**	**13500**	**13000**	**26500**
AC Substations					
765 kV	0	4500	8500	**149000**	157500
400 kV	92942	40920	142587	**45000**	187387
220 kV	156497	50655	221807	**76000**	297807
Total- AC Substation capacity, MVA	**249439**	**96075**	**372894**	**270000**	**642894**

2.4.8 Fund Requirement for development of transmission system during 12th Plan Period:

Considering 76 GW generation capacity addition for 12th Plan over and about 63 GW target (the Mid-term assessment for 11th plan by Planning commission) for 11th Plan, total fund requirement for development of transmission system is estimated to be of the order of Rs 1,80,000 crore (Rs 1,00,000 Cr in Central Sector, Rs. 55,000 Cr in State Sector and Rs. 25,000 Cr in Private Sector).

In the Central Sector, there is no problem of capital resources for setting up transmission facilities. However, in the State Sector some of the STUs require financial support, especially for building transmission system for renewable energy sources such as wind, solar and small hydro. In case of conventional hydro and renewable generation, the plant load factor is low and as a result the cost of transmission per kWh becomes high. Therefore, it is proposed that viability gap funding may be provided on case to case basis for building intra-State transmission system for renewable generation and conventional hydro stations.

2.4.9 Investment through Private Sector participation in development of transmission system during 12th Plan Period:

It may be noted that transmission schemes for the projects identified for 12th Plan have been mostly planned, firmed up in the Standing Committees for Power System Planning and the transmission agreements (BPTA) have been signed with the CTU as the nodal agency for Long Term Transmission Access to ISTS prior to the cut-off date of 5th January 2011. As such most of the ISTS schemes would be implemented by POWERGRID as central sector schemes. In addition Dedicated Transmission Lines from the inter-State Generating Stations would mostly be built by the generation developers as private sector lines. Some schemes, under the direction of the Empowered Committee for developing ISTS through competitive bidding have been identified and are in the various stages of implementation. These would materialize during 12th Plan period. Further, barring a few exceptions, new transmission schemes required for system strengthening, drawl of power by the states and for power evacuation to be identified in future would be implemented through competitive bidding process as far as possible. POWERGRID would also participate in the competitive bidding. Similarly in the State sector also it is likely that majority of the schemes during 12th Plan period would be implemented by the STUs.

2.5 TRANSMISSION EXPANSION ASSESSMENT FOR 13TH PLAN

As explained above, transmission system for a number of generation projects have been planned under the LTA process, majority of which are expected to materialize during 12th Plan and the rest would be implemented during 13th Plan depending upon actual progress of the generation project. Based on progress and development of generation projects and transmission system during 12th Plan, some of the already planned transmission systems would have to be reviewed. This review would be carried out alongwith planning for new transmission requirements for specific generation projects coming in 13th Plan. Under such scenario, only a broad assessment of transmission capacity addition for 13th Plan can be made considering probable load growth and indicative generation capacity addition scenarios for 13th Plan. Accordingly, following assessment has been made for transmission capacity addition during 13th Plan period:

Transmission capacity addition for 13th Plan (220kV and above system):		
1.	Transmission lines	130 Thousand ckm
2.	Substation (Transformation) Capacity	300 Thousand MVA
3.	Fund requirement	Rs 200,000 Crore

2.6 MEETING CHALLENGES IN TRANSMISSION SECTOR

2.6.1 In order to meet the growing power demand of various regions, power transfer capacity of the grid is being enhanced continuously. This expansion poses few challenges that need to be met through planning and adoption of new technologies. Following are some of the challenges:

- **Right Of Way (ROW):** It is the most notable challenge that the transmission sector is facing today. The need is to develop high intensity transmission corridor (MW per meter ROW) in an environmental friendly manner.

- **Flexibility in Line Loading and Regulation of Power:** Due to wide variation in demand on a daily as well as seasonal basis there is increased need to regulate power flow on the transmission network for grid security and optimization.

- **Improvement of Operational Efficiency:** Power system is required to be operated at the rated capacity with security, reliability and high availability. This can only be achieved through reliability based on-line condition monitoring, repair and maintenance in advance and making forced outage as zero.

2.6.2 Following measures are being implemented to meet above challenges:

- **Increase in transmission voltage:** Power density of transmission corridors (MW per meter ROW) is being enhanced by increasing the voltage level. It is 3 MW/m for 132kV and 45 MW/m for 765kV. Transmission voltage upto 765kV level are already in operation. A ±800 kV, 6000 MW HVDC system as a part of evacuation of bulk power from North Eastern Region (NER) to Northern Region (NR) over a distance of around 2000 km is under implementation. In addition, increasing the AC voltage level at 1200kV level has been planned. Research work for 1000kV HVDC system has also been commenced.

- **Upgradation of transmission line:** Upgradation of 220kV D/C Kishenpur- Kishtwar line in J&K to 400 kV S/c, which was first time in India, has resulted in increase of power transfer capacity of the exist transmission corridor with marginal increase in ROW (from 35m to 37m).

- **Upgradation of HVDC Terminal: Upgradation of Talcher(ER) –** Kolar(SR) ±500kV HVDC terminal from 2000MW to 2500MW has been achieved seamlessly without changing of any equipment. That has been achieved with enhanced cooling of transformer and smoothing reactor with meager cost.

- **High capacity 400kV multi-circuit/bundle conductor lines:** POWERGRID has designed & developed multi circuit towers (4 Circuits on one tower with twin conductors) in-house and the same are implemented in many transmission systems, which are passing through forest and RoW congested areas e.g. Kudankulam and RAPP-C transmission system.

- **High Surge Impedance Loading (HSIL) Line:** In order to increase the loadability of lines, development of HSIL technology is gaining momentum. POWERGRID is building up one HSIL line viz. 400kV Meerut – Kaithal D/c where SIL is about 750 MW as against nominal 650MW for a normal quad bundle conductor line.

- **Compact towers:** Compact towers like delta configuration, narrow based tower etc. reduce the space occupied by the tower base are being used. First 765kV Sipat – Seoni 2xS/c line with delta configuration tower is under operation. Further, 400kV Pole structure is also being used in high population density areas. Pole type structures with about 1.85 m base width as against 12-15m base width of a conventional tower were used in transmission line approaching Maharani Bagh, Delhi substation to address Right-of-way problem in densely populated urban area.

- **Increase in current: High Temperature Low Sag (HTLS) conductor line:** High temperature endurance conductor to increase the current rating are in use for select transmission corridors and urban/metro areas. POWERGRID has already implemented twin INVAR conductor line for LILO portion (15kms stretch) of 400kV Dadri-Ballabgarh quad conductor line at Maharanibagh substation. Further, the Siliguri – Purnea, twin Moose conductor line is being re-conductored with high temperature low sag (HTLS) conductor.

- **Reduction in land for substation:** With scarce land availability there is a growing need for reduction of land use for setting up of transmission systems, particularly in Metros, hilly and other urban areas. Gas Insulated Substations (GIS), requires less space (about 70% reduction) i.e. 8-10 acres as compared to conventional substation which generally requires 30-40 acres area.

- **Regulation in Power Flow/ FACTS devices:** With electricity market opening up further, more and more need has been felt to utilize the existing assets to the fullest extent as well as regulate the power. This could be possible through use of power electronics in electricity **network.**

- **Improvement of operational efficiency**

  - **Condition Based Monitoring:** POWERGRID has adopted many state of the art condition monitoring & diagnostic techniques such as DGA, FRA, PDC, RVM etc. for transformers, DCRM for CBs, Third Harmonic Resistive current measurement for Surge Arrestors etc. to improve Reliability, Availability & Life Extension. Further, on-line monitoring systems for transformers have been implemented to detect faults at incipient stage and provide alarms in advance in case of fault in the transformers.

  - **Preventive Maintenance:** Preventive State-of-the-art maintenance techniques for various equipment applied in our system include On line monitoring of various components of transformers and reactors, Circuit Breakers, Instrument transformers, Lightening arrester etc.

- **1200kV Test Station:** In order to increase the power density of the corridor, development of 1200kV AC system as next higher AC voltage level has been decided. However, 1200kV AC technology is relatively a new one in the world.

Therefore, to develop this technology indigenously, a unique effort has been made by POWERGRID through a collaborative research between POWERGRID and Indian manufacturers to establish a 1200kV UHVAC Test Station.

2.7 SMART TRANSMISSION GRID

2.7.1 Smart Transmission Grid Implementation in India

WAMS (Wide Area Measurement System) based technology is to be implemented as a part of the Smart Transmission Grid implementation. WAMS requires installation of Phasor Measurement Units (PMUs) at the substations and power plants. The process for installation of PMUs has already been started. Eight (8) PMUs (at Moga, Kanpur, Dadri and Vindhyachal in first phase and Agra, Bassi, Hisar and Kishenpur in second phase) have already been commissioned in the Northern Region and proposal for installation of PMUs in other regions is also in the pipeline. Full implementation of WAMS technology would require installation of hundreds of PMUs in each region and reliable communication network with very high band width and with least latency. Phasor data concentrators (PDC) are to be installed at National, Regional and major State Load Despatch Centre (in states having 400 kV transmission system).

Availability of PMU at strategically located 400 kV/ 765kV sub-stations / power stations and a robust fiber optic communication network will facilitate situational awareness (especially dynamic state of the grid in terms of angular stability and voltage stability), control and regulation of power flow to maintain grid parameters**,** Remedial action scheme(RAS) and system integrated protection scheme(SIPS) and identifying corrective actions to be taken in the event of severe contingency to prevent grid disturbances.

2.7.2 Need for fiber optic based communication system:

With the restructuring & liberalization of power sector and the advent of new regulations, open access, power exchange etc reliable voice & data communication has become critically important. The requirement of effective communication system has increased with the advent of special protection schemes, wide area measurement technology, SCADA system and remote operation. Getting real time data of various power system elements ie, substations, generating plants, HVDC links, Interstate transmission lines etc has become an essential prerequisite for successful operation of modern power system as a 'Smart Transmission Grid'. Presently three modes of communication are being used viz, PLCC, Microwave and Fiber optic in power system operation. The Microwave links operating in 2.3 to 2.5 GHz band is being withdrawn by Ministry of Communication. The PLCC is considered an integral part of power system and its usage for power system are protection of the power system and providing speech communication in limited area. All these requirements can be met by fiber optic based communication system.

In view of issues brought out above, it is considered desirable that an institutional arrangement be mandated for planning, implementation and maintenance of dedicated high band width, fiber optic communication network connecting the existing and new substations and power plants under central sector, IPPs, UMPP, Merchant Power Plants coming under the control area of Load Despatch Centres. The mandate should address the communication requirements in power sector in all associated areas such as Smart Transmission Grid, Protection, data, speech, audio/video etc.

The CTU and STUs own the existing communication network including Optic fibre network over their respective power networks. Under Section 38 of the Act, CTU is responsible for all functions of planning and co-ordination related to ISTS. Further, under Indian Electricity Grid Code clause 4.6.2 the associated communication system to facilitate data flow up to appropriate data collection point on the CTU system is to be established by the concerned user or STU as specified in the connection agreement. In view of above, the CTU may be mandated by CERC regulations to perform the following functions:

i. CTU in consultation with POSOCO, CEA, STUs and SLDCs to prepare a comprehensive communication plan for connecting the existing and upcoming ISTS, State grid substations and existing and new power stations in the country. For new power stations and grid substations the communication network should be planned and developed simultaneously with the associated power transmission lines. The communication system of a new generating station or EHV substation should be ready at least one month before commissioning of the same.

ii. For the transmission projects through tariff based competitive bidding, the laying of communication network wherever required shall be decided in consultation with the CTU and shall be implemented as part of the project.

iii. The communication equipments at generating station and substations shall be installed by the owner agencies as per the technical parameters decide by the CTU.

iv. To ensure implementation of the planned communication network through POWERGRID, Private transmission developers, STUs, Generation developers etc.

v. Monitoring the progress of implementation of the planned communication network.

vi. Monitoring the availability of the communication network and coordinating its repair and maintenance.

The proposed CERC regulation in this regard should have provisions for CTU to recover cost in performing above functions.

All new 400 kV and above substations, irrespective of ownership (state sector, private sector, central sector) and type (ISTS, dedicated, intra-state) should have optical fibre communication (OFC) facility, unless specifically exempted by CTU, as a requirement for smooth grid operation.

A Standing Committee comprising of CTU, POSOCO and CEA should be constituted to identify (i) strategic lines where OFC shall be mandated (ii) strategic locations in the grid where PMUs and PDCs need to be placed. As a first step, this committee should identify all such locations in the existing grid within six months. It should meet periodically at least once in a year to review and identify new locations.

Presently, POWERGRID has built some optic fibre communication (OFC) network as part of telecom business and it is partly leased to RLDCs and NLDC for grid operation. Investment is not serviced by RLDCs. On the other hand POWERGRID has to give some normative revenue credit to its long term customers for using the RoW of transmission lines for telecom business. In future POWERGRID may be required to install optical fibre as per requirement of grid operation without assurance of telecom business. In such cases the investment should be serviced by the users/POSOCO as determined by CERC. Similar arrangements may be made for each STU/SLDC through their respective SERCs.

Grid communication users should have priority over the telecom customers of POWERGRID mandated for the smart transmission grid.

2.8 TRANSMISSION PLANNING FOR RENEWABLE GENERATION

The renewable generation capacity addition in the country, up to the end of 9th Plan i.e. 2001-02 was just 3,475 MW which, owing to conducive policies and programmes of central and state governments, has reached nearly 20,000 MW in just 9 years. Most of this renewable capacity is in the renewable potential rich states of Tamil Nadu, Maharashtra, Karnataka, Gujarat and Rajasthan. These five states contribute more than 80% of total renewable capacity installation in the country.

During the 12th Plan a tentative target for grid interactive renewable power addition of 18,500 MW (wind-11,000 MW, Solar-3800 MW, Small hydro-1600 MW and biomass/baggasse etc-2100 MW) has been estimated. In this estimated capacity addition the wind power concentration is more in Tamil Nadu, Gujarat and Rajasthan. The solar power would be available mainly in the states of Rajasthan and Gujarat. Similarly small hydro would be available in Himachal Pradesh, Uttrakhand, Sikkim and Arunachal Pradesh. State wise estimate of above capacity addition is yet to be assessed.

In the absence of information on location and type of renewable energy only broad transmission requirement for these resources can be assessed at this stage. As most of the renewable energy generation in terms of MW are smaller in size ranging from few MW to 25 MW or 50 MW, therefore their integration with the grid is normally done at 11kV, 22 kV, 33kV or 66 kV. The EHV transmission system beyond first connection point is either at 110 kV, 132 kV, 220 kV or 400 kV depending on the quantum power being pooled at EHV substations. Generally the power would be absorbed within the DISCOM area or at the most within the state for meeting the states RPO. As the RPO requirement of each state would be increasing on an yearly basis along with the increasing capacity addition of renewable energy generation, only a few RES rich states would have renewable energy additions beyond their RPO requirements. This would require augmentation of the State's transmission system and interconnection with inter-state transmission system in some cases. In case of large scale renewable generation,it is not possible to absorb the energy locally particularly during off peak hours and a transmission system is required to be planned integrating renewable generation with the state grid as well as with inter-state grid. Integrated planning approach would ensure that renewable generation does not have to back down during off peak hours and local load centers are provided with uninterrupted supply even when renewable generation is not available

The transmission planning for renewable energy generation projects has to be done on a case to case basis depending upon the topology of the local grid, spatial distribution of renewable sources and the total quantum of power to be evacuated. The State Transmission Utilities of renewable rich states of Himachal Pradesh, Rajasthan, Gujarat and Tamil Nadu have prepared comprehensive long term transmission plans totaling to about 8200 crores and submitted them to MNRE for financial support. These reports are being examined by MNRE and CEA. Details of these plans are as follows:

- **Transmission proposal of Gujarat**: Capacity addition of 4500 MW wind energy and 960 MW of solar energy is planned. An investment of Rs. 900 crores in transmission infrastructure is proposed for evacuation of wind energy.

- **Transmission proposal of Rajasthan**: Capacity addition of 1500 MW wind energy and 1300 MW of solar energy is planned. An investment of Rs. 2350 crores in transmission infrastructure is proposed for evacuation of wind and solar power.

- **Transmission proposal of Himachal Pradesh**: Capacity addition of 560 MW small hydro projects is planned with an investment of Rs. 407 crores in transmission infrastructure.

- **Transmission proposal of Tamil Nadu**: Capacity addition of 4000 MW wind generation projects are planned with an investment of Rs. 3800 crores in transmission infrastructure.

- As per CERC (Grant of Connectivity, Long-term Access and Medium-term Open Access in inter-state transmission and related matters) Regulation 2009, a group of generating stations using renewable sources with capacity between 50 MW and 250 MW can also apply to the CTU for direct connectivity with inter state transmission system. Transmission charges for transfer of power from Renewable Energy Sources shall be as per the applicable CERC tariff norms. In case of solar plants which are to be commissioned by 2014, ISTS charges/losses are exempted.

Action has already been taken by CEA and CERC through appropriate technical standards and regulations for harnessing of wind and solar generation. CERC has amended Indian Electricity Grid Code to allow flexibility to wind and solar plants in scheduling and dispatch. CEA has issued draft amendment to connectivity standards specifying the technical requirements from wind generators to be synchronized with the grid, as per which, generating stations shall be capable of supplying dynamically varying reactive power support so as to maintain power factor within limits of 0.95 lagging to 0.95 leading. Also the generating stations shall have fault ride through capability of not less than 300 milli-seconds so that grid is not destabilized due to sudden outage of renewable generation in the event of a grid disturbance. Standards for maximum harmonic distortion have also been specified.

2.8.1 Need for grant – Grant needs to be made available for setting up transmission system for evacuation of power from renewable energy source. Major reasons are as follows:

- High cost of RPO: Since the preferential tariff for renewable energy particularly for solar energy is quite high, the consumers may not be burdened additionally with higher transmission tariff.

- Low Load Factor of RES: Generally, load factor of thermal generation is about than 80% and that of hydro is about 40%. However, in case of renewable energy, it is about 20% for Wind and Solar and about 40% for Small Hydro. As a result the cost of transmission per unit of energy becomes high. It is estimated that cost of transmission built for RES would be about double the cost of that built for a conventional hydro-thermal mix generation. When transmission system is built for substantive amount of renewable power, it would increase the overall transmission tariff of the State, which would have to be mostly borne by its consumers. This may discourage investment in transmission for renewable.

There is a need to encourage RES rich states to build transmission over and above their RPO requirement by providing grant.

2.9 EXCHANGE OF POWER WITH NEIGHBOURING COUNTRIES

Integration of Indian Electricity Grid with countries such as Bhutan, Nepal would result in optimization of electricity resources on a large scale and provide additional benefits and opportunities to the buying and selling countries. Cross border electricity transaction particularly with Nepal and Bhutan may be facilitated through Inter Governmental framework agreements. The cross country grid interconnection may be developed on a case to case basis based on assessment of electricity to be exchanged. There is also a need to develop coordinated procedures for scheduling and dispatch of cross border power and for financial settlement of electricity transactions.

India's Himalayan neighbors namely Nepal and Bhutan are endowed with immense hydro power potential of the order of 40,000 MW and 30,000 MW, respectively. The hydro potential of Nepal and Bhutan can be harnessed to mutual advantage and in overall interest of development of South Asia as a whole. The benefits of power exchange with Nepal and Bhutan are listed below:

- Enhanced energy security of South Asia.
- Lesser dependance on fossil fuels.
- Better hydro-thermal mix in generation.
- Reduction in carbon emissions and carbon intensity.
- Economic benefits to the countries of South Asia.

2.9.1 India-Bhutan: India and Bhutan already have agreed terms of cooperation for exchange of power between the two countries. Bulk of power generated at Hydro Electric Projects at Chukha (336MW), Kurichu (60MW) and Tala (1020MW) in Bhutan, is exported to India after meeting the internal demand of Bhutan. The associated cross- border transmission system (ATS) for evacuation and transfer of power from these HEPs has been developed and is operated in synchronism with the Indian Grid. Bhutan is planning to harness its hydro potential of about 1,20,00MW capacity by 2020. Among the various HEPs, Punatsangchhu-I (1200MW), Punatsanchhu-II (990MW), Mangdechhu (720MW) HEPs are under development stage and expected during 2015-17. After meeting its internal requirement, power will be exported to India. Power from these projects will be pooled at Alipurduar in India, for further transmission within India.

2.9.2 India-Nepal: Bilateral exchange of power between India and Nepal started in 1971 with exchange of about 5 MW of power on the principle of catering to the power needs of isolated local areas on both sides of the border. The power exchange takes place between Nepal Electricity Authority and utilities on the Indian side namely Bihar State Electricity Board (BSEB), Uttar Pradesh Power Corporation Limited (UPPCL) and Uttaranchal Power Corporation Ltd. (UPCL). India supplies 70MU from Tanakpur HEP (120MW) to Nepal under the Mahakali Treaty and under the bilateral power exchange, 50MW is exported to Nepal by BSEB. For further exchange of power on a bulk scale from the electricity markets of the two countries, Dhalkebar-Muzaffarpur 400 kV D/C 130 km line has been planned. This line would be initially charged at 220kV and proposed to be executed through joint venture companies. Construction of the line will commence after finalization and signing of Power Sale Agreement (PSA) and Implementation & Transmission Service Agreements (ITSA).

2.9.3 India-Bangladesh: An electrical grid interconnection between India and Bangladesh through a 400 kV Baharampur (India)- Bheramara (Bangladesh) 400 kV D/C 125 km line along with 1x500MW HVDC Back-to-Back asynchronous link at Bheramara is being developed for facilitating exchange of power up to 500 MW between the two countries. Due to asynchronous link any fluctuations or disturbances on one side would not affect the other side. Government of India has agreed to provide 250 MW power to Bangladesh under a long term PPA. Bangladesh would be able to procure additional 250 MW power from the Indian Electricity market. In future the transfer capacity of the interconnection can be upgraded by adding a new HVDC module.

2.9.4 India-Sri Lanka: A proposal to inter link India and Sri Lanka is under study. Under this proposal, feasibility of establishment of a HVDC transmission system of 1000 MW capacity using overhead lines and undersea cables from Madurai in India upto Anuradhapura in Sri Lanka is being studied. The India – Sri Lanka transmission link is tentatively envisaged to be a + 400kV HVDC Bipole line. The proposed link would consist of : (i)Overhead line from Madurai to Panaikulam in India - 130 km, (ii)Panaikulam(India) to Thirukketiswaram (Sri Lanka) submarine cable - 120 km, and (iii)Overhead line from Thirukketiswaram to New Anuradhapura in Sri Lanka - 110 km. The techno feasibility study is in progress and based on the same this link could materialize in future.

2.10 FOREST CLEARANCE AND ROW ISSUES AND THEIR MITIGATION

2.10.1 Forest Clearance

CERC has specified a fixed time schedule for commissioning of Inter State Transmission (ISTS) of different voltage levels ranging from 18 months to 42 months. Transmission projects are planned along with the upcoming generation projects and any delay/mismatch in commissioning of associated evacuation lines may result in bottling up of power. While finalizing the route alignment, emphasis is on avoidance of forest, National Parks, Wildlife Sanctuary etc., However, it is not possible to avoid such areas completely. Forest Clearance is a mandatory requirement for the portion of the line traversing through the forest. Getting Forest Clearance takes considerable time due to the lengthy process and involvement of different levels of officials at State and Central Government level.

2.10.2 Proposed measures- Measures to reduce the time for forest clearance are as follows:

i. The transmission projects have negligible impact on forest / environment and its habitants including the tribal people. Therefore, it is suggested that transmission projects may be exempted/relaxed from the preview of the circular for obtaining consent of the Gram Sabhas under Forest Conservation Act 1980, as a special case.

ii. Delegation of powers of Regional office of MoEF (RMoEF) for approval should be enhanced from present 5 hectares to 30 hectares, for transmission projects as a special case.

iii. The power of RMoEF for processing, which at present is up to 40 hectares, may be enhanced to 200 hectares for speedy approval.

iv. Expediting the Stage-II approval after Stage-I in principle approval:

2.10.3 Right of Way (ROW) for Transmission line

As per the provisions of Electricity Act, 2003 and Indian Telegraph Act 1885, land is not to be acquired to lay transmission lines but full compensation towards damages sustained is required to be paid. There is no specific mention of compensation towards diminution of land value and the term damages have also not been elaborated. Under Section 16 of Indian Telegraph Act 1885, the local authorities / District Magistrate have the powers to fix the compensation and adjudicate during the dispute for compensation. The Indian Telegraph Act 1985 was conceived mainly for Telecom purpose. When electricity was initially introduced in the country the nominal transmission voltage was quite low and the transmission lines were mainly pole type structure which required very little area and ROW. With increase in transmission voltage, the requirement of land for tower footing and ROW has increased substantially.

The following table indicates the range of land required for tower footing at different voltage levels depending on conductor configuration, type of tower and wind zone.

S.No.	Voltage level	Tower Base Area (in sq. meters)
1	220 kV	29 to 149
2	400 kV	61 to 306
3	500 kV	110 to 256
4	765 kV	156 to 588
5	800 kV	199 to 484
6	1200 kV	248 to 324

Norms for evaluation and fixing of compensation vary from state to state. Hon'ble Kerala High Court gave its opinion regarding compensation towards diminution of land value and observed that owners can claim compensation for diminishing of land value. The said judgment was challenged in the Hon'ble Supreme Court of India. The Supreme Court while staying the Kerala High Court order has taken a view that each case is required to be taken on its own merit on following parameters and reffered the case back to Kerala High Court:

- Situation of land;
- Distance between high voltage electricity line laid there over;
- Extent of the line there on as also the fact whether the high voltage line passes over a small track of land or through the middle of land and other similar relevant factors;
- The land value is also a relevant factor and whether the owner of land losses its substantial right to use the property.

Despite adoption of latest technological solutions to optimize the ROW requirements, difficulties in getting ROW results in delay in implementation of transmission projects.

Suggested measures to mitigate the Right of Way issues are given below:

i. As the patch of land occupied by the transmission tower would have zero resale value, it stands to reason that compensation for diminution of value of land occupied under tower base should be the full value of the private land at prevailing market rate as determined by the revenue authorities. It is suggested that Central Government may issue a notification in this regard in consultation with the states.

ii. Transmission corridors needs to be identified and reserved in high density population areas like metros and other upcoming urban areas to meet the future growing demand.

iii. **Land for Substations**: The land for substations is normally government land or private land acquired through Land Acquisition Act 1984. While doing town planning for new suburban area and industrial centers, provision for laying of substation and transmission line should be kept in mind. To reduce the requirement of land for constructing substation use of Gas Insulated Substations (GIS) which requires about 30 % land compared to conventional substation is being increasingly adopted in metro, hilly and other urban areas**.**

2.11 POWER SYSTEM OPERATION

2.11.1 Development of system operation

The power system in the country is demarcated into five regions and there is a three-tier structure for Load Despatch. State Load Despatch Centres (SLDCs) in states form the foundation block. The control centres at the regional level, known as Regional Load Despatch Centres (RLDCs) are at the intermediate level and the control centre at National level, known as the National Load Despatch Centre (NLDC) is at the top most tier. The functions, responsibilities and powers of the National/Regional/State Load Despatch Centres are clearly defined in the Electricity Act 2003 and the Indian Electricity Grid Code. The Bhakra Beas Management Board (BBMB) has a separate control centre at Chandigarh that coordinates water releases and despatch of hydropower from the stations that are jointly owned by the States of Punjab, Haryana, Rajasthan and Himachal Pradesh. Likewise the Damodar Valley Corporation (DVC) has a well-defined control area in the Eastern Region (covering portions of West Bengal and Jharkhand) with its own generation, transmission and distribution system to meet its load.

At the inter-state level, the boundary points have been fully metered with Special Energy Meters, scheduling of Inter State Generating Stations has been streamlined and a transparent and robust settlement system has been implemented. Open Access in Inter State Transmission System has been reasonably successful despite several technical and administrative challenges. Empowerment of SLDCs has been recognized as the key to implementing similar reforms at the state level.

2.11.2 Government of India's interventions to empower system operation

A committee headed by Shri Gireesh Pradhan was constituted by the Ministry of Power, Government of India in February 2008 to examine issues relating to manpower, certification and incentives for the personnel employed on System Operation at various levels and also for ring-fencing the load despatch centres to ensure their functional autonomy and give recommendations. The Committee recognized load despatching as a 'mission critical activity' for uninterrupted and reliable power supply and recommended several strategic interventions for imparting functional autonomy to LDCs and establishing independent and sustainable revenue streams for them. The report of the Committee submitted in August 2008 was endorsed by the Central and State Governments and Electricity Regulatory Commissions. Ministry of Power constituted four task forces for effective monitoring and implementation of the recommendations of the Committee.
The recommendations of the above Committees and task forces are being actively implemented at the Central level. A new organization, namely Power System Operation Corporation Limited (POSOCO) was formed as a 100% subsidiary of POWERGRID in March 2009. The Government of India notified POSOCO as the designated entity to operate RLDCs/NLDC wef 1st October 2010. A Forum of Load Despatchers (FOLD) has been constituted as approved by the Forum of Regulators (FOR) in January 2009 for harmonizing practices across the different LDCs. Likewise, the National Power Training Institute (NPTI) has been designated as the agency for training and certification of system operators.

2.11.3 Achievements on the market front

Empowerment of RLDCs/NLDC and their designation as nodal agency have led to the following significant developments on the electricity market front:

1. Successful implementation of Availability Based Tariff (ABT) in all the regions since 2002-03 at the inter-state level.
2. Successful implementation of inter state open access since May 2004 leading to choice for market players and promoting competition.
3. Successful operation of two Power Exchanges since June 2008 leading to a robust price discovery mechanism and investment signals.
4. Successful implementation of the Renewable Energy Certificates (REC) mechanism since October 2010 to fulfill Renewable Purchase Obligation (RPO) of DISCOMs.

2.11.4 Suggested measures to improve system operation

Sub-LDC for Renewable energy: Apart from transmission planning, system operation also needs a paradigm shift to accommodate the increased quantity of renewable generation. With effect from 1st April 2012, wind farms of 10 MW and above and solar plants of 5 MW and above connected at 33 kV level (and not under any PPA as on 3rd May 2010) and above are expected to forecast their generation up to accuracy of 70%. It is important that the State Load Despatch Centre (SLDC) under whose jurisdiction the renewable generation is operating has access to the following data:

1. Forecast data of temperature, wind speed and direction, solar insolation
2. Actual temperature, wind speed, direction and MW, MVAR and voltage from each wind farm
3. Metered energy data 15-minute time block wise

It is recommended that:

- A separate Load Dispatch Centre for renewable energies shall be set up to carry out above tasks The collated data from such sub-LDCs can be transferred to the respective SLDC and RLDC so that the grid can be operated in a secure manner as well as ensuring that the renewable generation is absorbed to the fullest extent.
- Such sub-LDCs may be set up in renewable energy rich States e.g Tamil Nadu, Gujarat and Rajasthan.
- These sub-LDCs may be set up with grant from clean energy fund.
- To start with such a sub-LDC may be set up in Tamil Nadu which has about 6000 MW of installed wind capacity.

2.11.5 Peaking Power

The DISCOMS/State utilities are self dispatch entities and responsible for maintaining their load generation balance. Yet in real time there are imbalances which cause frequency excursions particularly due to shortage of peaking power. The incremental short and any short fall in their peaking power requirement may be met through harnessing peaking power sources. The Power Exchanges could invite bids from peaking generators in the evening for the next day, stack these bids and forward it to the National Load Despatch Centre (NLDC). On the day of operation, in case these resources are required to be pressed into service, the system operator would requisition their services at say an hour's notice. The generator whose services are requisitioned would be provided a certainty of say two hours for which it could generate. Payments would be made to the generator from the Unscheduled Interchange (UI) Pool Account. Any shortfall in the Pool Account could be made up from the Power System development Fund (PSDF). It is recommended that:

Detailed guidelines in respect of this 'peak power harnessing service' need to be formulated by CERC.

2.12 ANCILLIARY SERVICES

2.12.1 Voltage Support Service

Presently there is no legal binding on the generator for this facility and very often generators get away from this issue by citing contractual reasons for not commissioning this facility. There is an urgent need to operate large hydro plants as synchronous condensers when the water inflows are low. Operation of such generators as synchronous condensers will help in supporting the voltage and keeping the transmission system intact. It is recommended that:

The Grid Standards for Connectivity to the grid notified by CEA be amended to make it mandatory for hydro power stations to commission the synchronous condenser facility and test it periodically as prescribed by the system operator.

CERC to come out with guidelines/regulation for compensating the generator for the energy consumed during synchronous condenser operation, MVARh generated or absorbed by the generator and the extra Operation and Maintenance (O & M) costs associated with synchronous condenser operation.

Black-start Service: In case of black-out or partial blackout of certain areas expeditious restoration of the system is possible only if the hydro and gas power stations in the isolated portion are able to black start their units, supply local load till supply from the grid is available for synchronization. It is recommended that:

The Grid Connectivity Standards notified by CEA must make black start capability mandatory for all new hydro generating units and gas turbine units.

2.12.2 Creation of Reserve and Back Up Power in the System

The Optimal power system should have adequate reserves in order to meet the contingency of outage of certain operating generation capacity. Therefore, creation of adequate reserve and back up power in the system need to be planned along-with related evacuation networks.

2.13 RELIABILITY STANDARDS

The existing Grid Codes need to be complemented by Reliability Standards. These Reliability Standards are to be adhered by all utilities for maintaining grid security of the grid. It is recommended that:

POSOCO may constitute a Standing Committee for - formulation of 'Reliability Standards and their approval from CERC/regulators.

2.14 NEED FOR A SEPARATE MARKET OPERATION (MO)

There would be an explosion in number of control areas at the regional level from the level of nearly one hundred (100) control areas today to over three fold in the coming years. The number of long term, medium term, and short term and PX transactions would grow manifold. Metering and settlement system would become more complex with the above explosion in control areas. Hitherto, the Central Transmission Utility (CTU) is providing the meters at all inter utility exchange points at the inter-state level and RLDCs are collecting, validating and processing the meter data. This data is forwarded to Regional Power Committee (RPC) Secretariat for issuing the accounts. Payments to and from the Pool Account were managed by RLDCs. With the explosion of control areas, Fund Administration and Pool Account operations would also become more voluminous. These developments bring out the need for a Market Operator (MO) to co-ordinate all the transactions and inform the System Operator (SO) a day in advance for physical delivery. Since the work load of RLDCs has become enormous and complex, it is desirable in the interest of efficient system operation that the work of RLDC may be segregated between a 'System Operator' and a 'Market Operator'. Therefore, the following steps are suggested:

- POSOCO, in consultation with CERC, CEA and CTU shall prepare a detailed organizational proposal for segregation of 'System Operation' and 'Market Operation' functions within six (6) months.
- The proposal shall be submitted to the Government for approval and issue of enabling orders.

2.15 CONCLUSIONS AND RECOMMENDATIONS (TRANSMISSION)

(i) All new 400 kV and above substations, irrespective of ownership (state sector, private sector, central sector) and type (ISTS, dedicated, intra-state) should have optical fibre communication (OFC) facility, unless specifically exempted by CTU, as a requirement for smooth grid operation. A Standing Committee comprising of CTU, POSOCO and CEA should be constituted to identify (i) strategic lines where OFC shall be mandated (ii) strategic locations in the grid where PMUs and PDCs need to be placed. As a first step, this committee should identify all such locations in the existing grid within six months. It should meet periodically at least once in a year to review and identify new locations.

(ii) In future POWERGRID may be required to install optical fibre as per requirement of grid operation without assurance of telecom business. In such cases the investment should be serviced by the users/POSOCO as determined by CERC. Similar arrangements may be made for each STU/SLDC through their respective SERCs. Grid communication users should have priority over the telecom customers of POWERGRID mandated for the smart transmission grid.

(iii) Grant needs to be made available for setting up transmission system for evacuation of power from renewable energy source. There is a need to encourage RES rich states to build transmission over and above their RPO requirement by providing grant.

(iv) It is proposed that viability gap funding may be provided on case to case basis for building intra-State transmission system for renewable generation and conventional hydro stations.

(v) As the patch of land occupied by the transmission tower would have zero resale value, it stands to reason that compensation for diminution of value of land occupied under tower base should be the full value of the private land at prevailing market rate as determined by the revenue authorities. It is suggested that Central Government may issue a notification in this regard in consultation with the states.

(vi) Transmission corridors needs to be identified and reserved in high density population areas like metros and other upcoming urban areas to meet the future growing demand.

(vii) While doing town planning for new suburban area and industrial centres, provision for laying of substation and transmission line should be kept in mind. To reduce the requirement of land for constructing substation use of Gas Insulated Substations (GIS) which requires about 30 % land compared to conventional substation is being increasingly adopted in metro, hilly and other urban areas.

(viii) The Grid Standards for Connectivity to the grid notified by CEA may be amended to make it mandatory for hydro power stations to commission the synchronous condenser facility and test it periodically as prescribed by the system operator. CERC shall come out with guidelines/regulation for compensating the generator for the energy consumed during synchronous condenser operation, MVARh generated or absorbed by the generator and the extra Operation and Maintenance (O & M) costs associated with synchronous condenser operation.

(ix) POSOCO may constitute a Standing Committee for formulation of 'Reliability Standards and their approval from CERC/regulators.

(x) POSOCO, in consultation with CERC, CEA and CTU shall prepare a detailed organizational proposal for segregation of 'System Operation' and 'Market Operation' functions within six (6) months. The proposal shall be submitted to the Government for approval and issue of enabling orders.

(xi) During 12th Plan period, a total of about 1,09,000 circuit kilometers(ckm) of transmission lines, 2,70,000 MVA of AC transformation capacity and 13,000 MW of HVDC systems are estimated to be added.

(xii) The total fund requirement during 12th Plan for evacuation of power works out to about Rs.1,80,000 Cr.

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