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Analysis of Restructed Power System

(A Case Study of Punjab State)

Submitted in partial fulfilment of the requirement for the award of degree

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IN

POWER SYSTEM & ELECTRIC DRIVES

Submitted By

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DECLARATION

This is certify that the work presented in the Thesis titled, '**Analysis of Restructed Power System (A Case Study of Punjab State)**' being submitted by **Mr. Harpreet Singh**, in partial fulfilment of the requirements for the award of degree of MASTER OF ENGINEERING (Power System & Electric Drives) Submitted in the **Electrical and Instrumentation Engineering Department** at **Thapar University, Patiala** is an authentic record of the work done by undersigned during the period from **January 2012** to **July 2012** under the esteemed supervision of **Ms. Manvir Kaur.** The matter presented in this Thesis has not been submitted by me in any other University.

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ABSTRACT

The country's development is measured in terms of per capita consumption of electricity which in turn depends on electricity generated. In India per capita energy consumption is quite low and for the year 2007 it was only a measure 665 KWH per annum in comparison to about 12000 KWh for USA and 34000 in Norway, which indicates fairly low level of industrialization in the country. The current per capita power consumption is about 734 kWh per year while the world average is 2,782 kWh. As a result, regulators, worldwide are now implementing new regulatory schemes and organizational reforms in an effort to improve the incentives for efficient operation of electricity utilities. All these reforms are consistent with the view that competition should be introduced into the electricity supply industry, wherever, it is technologically feasible and India is not exception to these reforms. In this thesis, a case study of restructured power sector of Punjab, which is in the Northern Part of India, has been carried out. With enactment of Electricity Act 2003, there has been tremendous improvement in power sector of this state. There is significant improvement in the areas of transmission and distribution, tariff rationalization and in availability of power supply. The Electricity supply is traditionally viewed as a natural monopoly. There is growing dissatisfaction with limited incentives for efficient operation of a cost-of-service regulated or government owned electric utility. As a consequence, regulators, worldwide, are now implementing new regulatory schemes and organizational reforms in an effort to improve the incentives for efficient operation of electricity utilities. All these reforms are consistent with the view that competition should be introduced into the electricity supply industry wherever it is technologically feasible. Recently Indian Electricity Act, 2003 was enacted to consolidate the laws relating to generation, transmission, distribution, trading and use of electricity and largely for taking measures conducive to development of electricity industry, promoting competition, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficiency and environmentally benign policies. In this thesis various reformations made to the power system of Punjab state after restructuring are discussed. Transmission and Distribution losses, Commercial losses are discussed and the effect of restructuring is analyzed.

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LIST OF ABBREVATIONS

ISO	Independent System Operator
T & D	Transmission and Distribution Losses
GDP	Gross Domestic Product
CERC	Central Electricity Regulatory Commission
PSEB	Punjab State Electricity Board
PSPCL	Punjab State Power Corporation Limited
PSTCL	Punjab State Transmission Corporation Limited
SLDC	Punjab State Load Dispatch Centre
NTL	Non Technical Losses
AT & C	Aggregate Technical and Commercial Losses
SEB	State Electricity Board
SOEU	State Owned Electricity Utilities
IT	Information Technology
HVDC	High Voltage Direct Current
CERC	Central Electricity Regulatory Commission
SERC	State Electricity Regulatory Commission

Chapter-1

1. Introduction

1.1 Power System Structure

Power systems traditionally have been what are known as "vertically integrated utilities". In this type of structure, one utility handles the all functions of generation, transmission and distribution within a certain geographical area. The operation and coordination of such a system is somewhat simple, since all functions are controllable by a system operator. The operational objectives were to provide quality power (voltage and frequency nearly constant) to a consumer, while ensuring reliability and overall economy (low cost).The price of power was "regulated" and based on actual costs. An alternative is to treat power as a trade able commodity. The functions of generation and in many cases, distribution, are open to private participation. While the "technical objectives" are similar to those in a vertically integrated utility, the price is not regulated, but depends on market forces and competition between the participants. In a generation deficit scenario, price may still need to be regulated. Alternatively, the amount of loads should be price sensitive or else prices will spiral upwards. The cost of use of transmission lines (to which all players will have "open access" subject to the transmission constraints) would also be regulated. Therefore a "regulator" would still be required. However, a regulator would be an independent body. An independent system operator would perform the co-ordination functions required to operate the system reliably and ensure that voltage and frequency are within limits. The real and reactive power resources required maintaining voltage, frequency and reliability may be "purchased" and charged to all the players in a fair manner. We shall discuss these structures and their impact on power system operation in the following lectures. We begin by considering in detail, a vertically integrated utility.

1.2 Structure of a traditional Vertically Integrated electric industry

The electric power industry has over the years been dominated by large utilities that had an overall authority over all activities in generation, transmission and distribution of power within its domain of operation. Such utilities have often been referred to as vertically integrated utilities. Such utilities served as the only electricity provider in a region and were obliged to provide electricity to everyone in the region. The typical structure of a vertically integrated electric utility is shown in figure below. In the figure 1.1, the money flow is unidirectional, i.e. from the consumer to the electric company. Similarly, the information flow exists only between the generators and the transmission systems. In vertically integrated utilities, it was often difficult to segregate the costs involved in generation, transmission or distribution. So, the utilities often charged their customers an average tariff rate depending on their aggregated cost during a period.

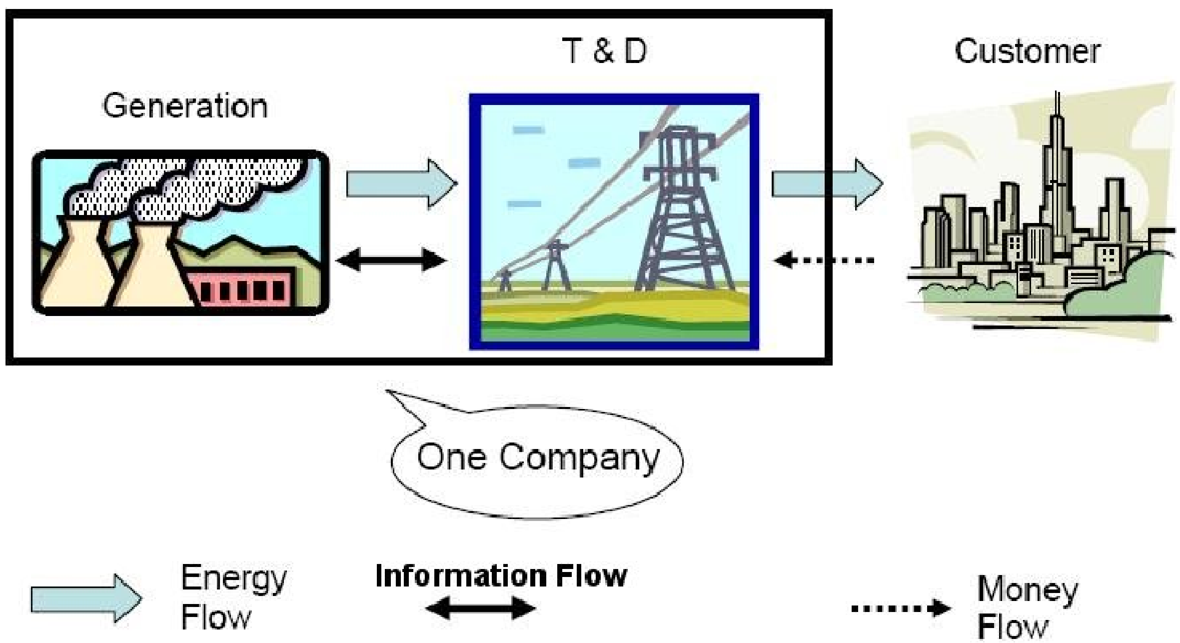

Fig. 1.1 Structure of Regulated Market

The state electricity boards (SEB) in India were examples of a vertically integrated utility; they are now being restructured.

1.2.1 Characteristics of a traditional Vertically Integrated electric industry:

- **Monopoly Franchise**

Only the local electric utility can produce, move, or sell commercial electric power within its service territory.

- **Obligation to serve**

The utility must provide service to all electric consumers in its service territory, not just those that would be profitable.

- **Regulatory Oversight**

The utility's business and operating practices must confirm to guidelines and rules set down by government regulators. The utility's rates are set in accordance with government regulatory rules and guidelines. The utility is assured a fair return on its investment, if it confirms to the regulatory guidelines and practices.

1.2.2 Reason for traditional electric utility industry structure:

During early days of the electric power industry, governments favored a regulated monopoly – vertically integrated utility structure. The reasons are manifold:

- This offered a risk free way to finance the creation of electric industry. Establishment of electric industry required large capital for infrastructure building. Thus for the purpose of risk minimization, a local monopoly and stable market was assured. The utility leaders could focus on building up their systems without having to worry about the competitors undercutting the prices to gain market share etc.
- To prevent exploitation of consumers due to monopoly, the government brought in regulation.
- This legitimized the electric utility business. Government franchises and regulation clearly implied to a possibly skeptical public that civic leaders thought electricity was a good thing.

- It gave electric utilities recognition and support from the government, which was necessary to solve problems like 'Right of Way' (i.e. the "right" to an exclusive corridor to build a transmission line).

- During the nineties, many electric utilities and power network companies world-wide have been forced to change their way of operation and business, from vertically integrated mechanisms to open market systems. This can be specifically observed in countries like UK, Sweden, Finland, Norway, US and some countries of South America. The reasons for change have been many and have differed over regions and countries [2].

1.3 Conditions which are leading to changes in traditional power system structure

Basic motivation for changes in power industry scenario:

There are many reasons that are leading to restructuring of power systems. One force was the change in generation economies of scale that occurred throughout the 1980's. Traditionally, electric utility systems evolved with the central station concept because of significant economy of scale in power generation. Very large generators produced power at less than half the cost per kilowatt of small generator units, and the bigger the generator, the more economical the power it produced. For the reasons stated below, the shift in economy of scale was observed:

- Technological innovation improved the efficiency of small units for gas turbines, combined cycle, hydro and fuel cells over that of large ones.

- Improvements in materials, including new high temperature metals, special lubricants, ceramics, and carbon fiber, permit vastly stronger and less expensive small machinery to be built.

- Computerized control systems have been developed that often reduce the number of on-sight personnel to zero.

- Data communications and off-site monitoring systems can control the units from remote operations centers, where one central operator can monitor a dozen units at various sites, as if present at each.

- Thus in some instances, it is possible to build new power plants that could provide energy at a lower price than what customers were paying. It became possible for the industrial and commercial users of electricity to build and operate their own plants also sell the excess power to small customers especially in generation deficit areas.

1.4 Inter Connected Power Stations

When large loads are to be supplied from two power stations, the power stations are required to be interconnected so that there is no overloading and loads are shared almost equally.

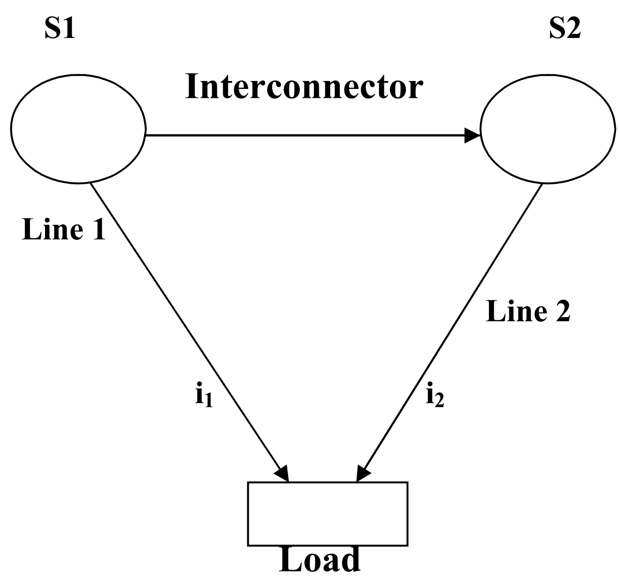

Fig. 1.2 Inter Connected Power Stations

Consider two power stations S1 and S2 supplying load currents i_1 and i_2 to the load through transmission lines 1 and 2 in addition to their local loads. The power stations are also interconnected by an interconnector, which is carrying current i1.The transfer of power taking place as shown by direction of arrows. Since local loads are also connected to power stations S1 and S2 voltages at their bus-bars have to be maintained constant at the same value as for consumers at load end.

In order that both Transmission lines 1 and 2 deliver equal power and the system operates at the same terminal voltage, it is necessary that active components of the line currents i_1 and i_2 are in equal. In order that the total current in lines 1 and 2 be a minimum it is necessary that they should also have reactive components equal. In order to achieve in this practice regulating equipment is required to be installed at the sending end of each transmission line and in the inter-connector. The regulating equipment installed at the sending end of each transmission line and in the inter-connector will look after the impedance drops in the transmission lines and the inter-connector.

As in case of alternators operating in parallel, for stable operation of the inter-connected generating stations, it is necessary that the two stations must be inter-connected through reactor. The incorporating of inter-connector introduces angular displacement between the two stations, enabling the power to flow from one station to other as required by operating conditions. The incorporating of impedance will cause an unnecessary loss of power [1].

1.5 Reasons for restructuring

The reasons for initiating the idea of deregulation (The word deregulation here describe changes in power system structures; however, it will be clear that these changes involve changes in regulations rather than deregulation.) in power industry are many. Following are the main reasons:

1. **The need for regulation changed**

   More fundamental than any other reasons for change was the fact that the basic needs for regulation of electric industry had died away before the end of 20th century. First, the original need for regulation, which was to provide risk free finance to build the infrastructure, did not exist anymore. Second, most of the major electrical infrastructure was paid for, decades ago. The revenues gained by the electric utilities was invested to renew their system, and the level of risk in doing so was less as compared to that existed in the initial era. Being a proved technology, the risk involved in investing money in such a technology was nullified. The electricity could now be thought of as an essential commodity, which can be bought and sold in the marketplace in a competitive manner, just like other commodities.

2. **Ideological Reason: Privatization**

   Usually the motive was the government's firm conviction that private industry could do a better job of running the power industry. This belief, of course came from better privatization experiences of the other industries. Deregulation does not necessarily have to be a part of privatization efforts.

3. **Cost is expected to drop**

   Competition is expected to bring innovation, efficiency, and lower costs.

4. **Customer focus will improve**

   Although monopoly franchise utilities have an obligation to serve all customers, that does not promote the proactive attention to customer needs. A monopoly franchise utility listens to its customers when they explain their needs, and then responds. A competitive electric service company anticipates customer's needs and responds in advance. The technological advances that will be applied under deregulation, address customer service. More important gain of competition in the electricity market is the customer value rather than lowering the cost.

5. **Encouragement for innovation.**

   The regulatory process and the lack of competition gave electric utilities no incentive to improve on yesterday's performance or to take risks on new ideas that might increase customer value. If a new idea succeeded in cutting costs, the utility still made only its regulated rate of return on investment; if it didn't work, the utility would usually have to 'eat' a good deal of the failed attempt, as imprudent expenses. Furthermore, a regulated utility does not want to use new ideas to lower its costs under a regulated rate of return framework.

Under deregulated environment, it was felt that the electric utility will try to innovate something for the betterment of service and in turn save its costs and maximize the profit. By means of this, the utility will try to ensure that it will maintain its customer base in spite of competition.

Chapter-2

2. Deregulation of Electrical Utilities

The success of privatization of the airline, telecommunications industries has motivated the deregulation and restructuring of electricity Industry. In 1989, the UK became one of the pioneers in privatizing its vertically integrated electrical industry. Norway and California followed in 1990 and 1996 respectively. The success of energy privatization in the UK and Norway has encouraged other countries worldwide to follow the trend. Countries that have been undergoing energy deregulation include Argentina, Australia, Brazil, Germany, New Zealand, Spain, Taiwan and Malaysia.

Occasionally the term ‘privatization’ is used to refer to what one would regard as ‘deregulation’ of electric utilities. While the two words are different literally, ‘deregulation’ often starts with the sale of State-owned utilities to the private sector. Ironically, neither is the term ‘deregulation’ correctly used in this context. In any Case, ‘deregulation’ is widely adopted to refer to the ‘introduction’ of competition.

Deregulation often involves ‘unbundling’, which refers to disaggregating an electric utility service into its basic components and offering each component separately for sale with separate rates for each component. As shown in Fig 2.1 Generation, Transmission and Distribution could be unbundled and offered as discrete services. However, deregulation involves not only unbundling, but also the separation of ownership and operation.

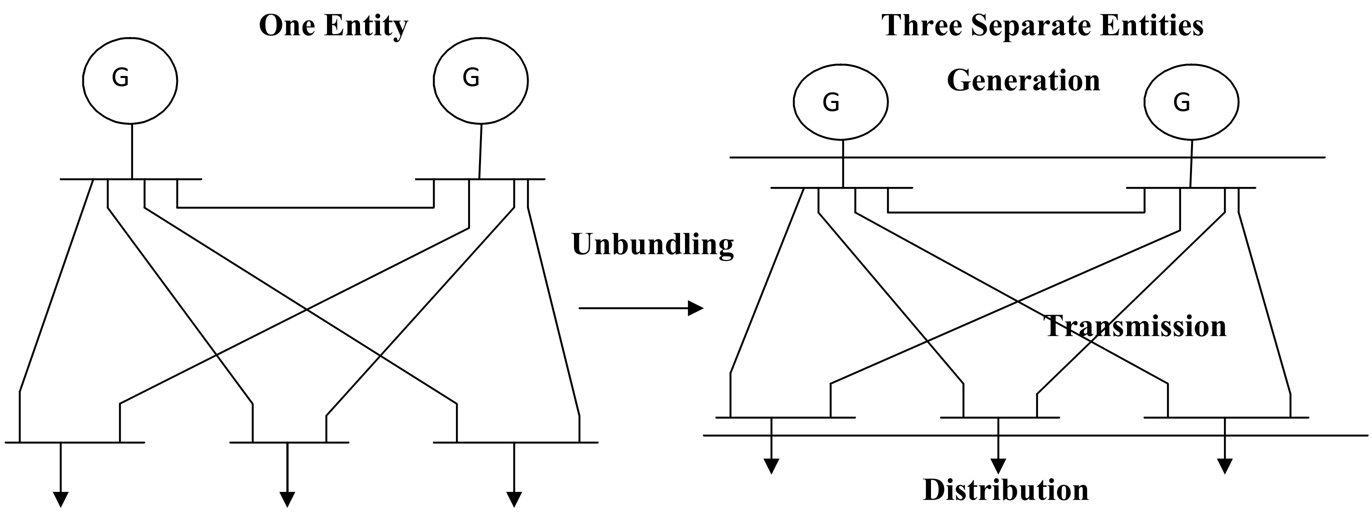

Fig. 2.1 Unbundling of Utilities

In many countries, a central independent body, usually called the independent system operator, is set up to cater for the matching of supply with demand and the maintenance of system reliability and security. Sometimes the system operator is also responsible for matching the bids of generators with the demand bids to facilitate exchange, as in the England and Wales Pool. In some markets, another entity is set up just for that purpose; the so-called Power Exchange in the California Pool is in Example.

The Establishment of the energy markets has brought a new dimension to the topic of power system economics. Economists design different forms of energy markets according to the characteristics of the electricity sector in a particular country. Most countries also learn from the lessons their precedents. The general success of energy privatization justifies the global trend of deregulation. However, in most cases, there is room for improvement [2].

In most cases, competition is introduced gradually form the wholesale market to the retail market. In most countries, retail competition is still underway, some small or residual customers have not yet benefited from the deregulation. In many countries, with existing regulations, it is difficult for new suppliers to enter the market and compete with the existing suppliers. Stringent regulations are required for mandatory third-party transmission access and the recovery of utilities' stranded costs.

Electricity, unlike many other commodities, cannot be stored easily and supply has to match demand at all times. The transportation of electricity is constrained by physical laws which need to be satisfied constantly in order to maintain the reliability and security of the power system. It soon became obvious that the transmission network is the main impediment to energy privatization.

2.1 Traditional Central Utility Model

Before covering the details of deregulation, it is essential to have a brief summary on the traditional central utility model. In the early days economies of scale manipulated the structure of the utility structure. Later on the industry transformed into monopolies and the price of electricity became regulated. Moreover, in traditional power systems, the utilities are most owned by governments. Vertically integrated utilities typically own Generation, Transmission and Distribution over a wide area. Each utility has one or more control centers that maintain security and reliability of a specific region. Since the utility has control over all generators, when a constraint becomes binding, re-dispatch can be scheduled through least cost optimization by using optimal power flow. The tariff is then the average of all the costs of the different services including Generation, Transmission and Distribution. Under these circumstances, utilities seek to maximize profit through cost minimization [2].

So far it appears that this monopolistic situation is just and sound, so why do we need deregulation? At the moment it is sufficient to consider two of the potential benefits resulting from deregulation. Firstly, the advance of technology makes low-cost power plants owned by independent power producers very efficient. These independent power producers would not emerge without the reform. Secondly, unbundling the services may result in fairer tariffs being assigned to individual services.

2.2 The Effect of Electricity Deregulation

An important factor behind the change towards greater flexibility has been the now generally accepted deregulation philosophy, which encourages the development of a competitive market, whereby energy providers and buyers have open access to the transmission services. In this new environment power generation and transmission are unbundled and the control of the grid is in the hands of an independent system operator. For competitive reasons, unbundling seems to discourage the generators from investing in equipment to provide effective reactive power control of the transmission system, and this has serious implications on voltage and power stability. Thus, without appropriate countermeasures, the reliability and security of the power system should deteriorate. These problems can, of course, be reduced by conventional transmission system reinforcement, but the cost and the difficulty of obtaining new rights of way discourage such an approach.

2.3 Basics Concept of Regulation and Deregulation

- **Regulation**: Regulation means that the government has set down laws and rules that put limits on and define how a particular industry or company can operate.
- **Deregulation**: Deregulation in power industry is a restructing of the rules and economic incentives that govt set up to control and drive the electric power industry.

2.3.1 Deregulated electricity market structure

The anatomy of deregulated power markets worldwide shows that the reform process has taken a number of different forms in various countries. Economic and political reasons, due to local conditions, have led to the adoption of different paradigms by the market restructure. However, there is a common basis and some similar characteristics that can be found to all of the competitive electricity markets. A first characteristic is that, generally, the generation, transmission and distribution services are the responsibilities of different companies. This unbundling of services results in a deregulated electricity market. The transform process as well as the period after transformation is supervised by a regulatory authority. The task of this authority is to set up the general guidelines under which the market will operate. After the restructure, the task of the regulatory body focuses on the performance of the market. Although some markets, as in Germany, operate without regulatory authority, this is rather exception than a rule.

In the restructured market, the power generation is a competitive sector, which is qualified generation companies are able to take part in the market and sell their production. A very important principle of deregulated electricity market is the nondiscrimination. According to this principle, all producers and consumers, holding some certain conditions, must have open and fair access to the network. While the generation is competitive the transmission remains a monopoly. The huge cost of investing in transmission network as well as ecological reasons does not allow the transform of this service into a competitive market. In order to ensure the open and fair access, the grid is operated by an Independent System Operator (ISO). The spectrum of ISO's responsibilities is quite wide. The ISO has the responsibility to make available information regarding the network, such as the Available Transfer Capability, for all market participants. Moreover, its task comprises the real time operation of the network. This operation consists of adjusting network situation and, if necessary, ordering of the ancillary services so as to keep the system balance. Some of the ancillary service may be obtained through a balancing market where the participants submit their bids for increase/decrease their power in case of balancing operations.

Another characteristic, which is a case in matured deregulated markets, is the numerous contracts that hedge the risk resulting by the fluctuation of electricity prices. The market participants have the opportunity to purchase such contracts from ISO or from the regulatory authority. Furthermore, a secondary market can be organized where these contracts are traded as any other commodity. The above described characteristics are common in the different types of deregulated market. Two basic market forms, the bilateral contract market and the pool market, are the common ground where the different types of markets are developed on. Besides these two types, a third alternative, based on multilateral agreements between the market participants, has been proposed. In the bilateral market, producers and consumers directly negotiate the price and the quantity of traded energy. The transaction agents submit their schedule to the ISO requesting for permission to carry out the transaction. If the system balance is not endangered by this transaction then the ISO is committed to accept the schedule. If the transaction is accepted the ISO requires from the transaction agents to cover the associated transaction losses either by payment or by providing the necessary power.

Furthermore, the ISO bills the transaction agents for using the network. In a pool market, there is no direct contact between producers and consumers. The ISO, or a Pool Operator if one exists, collects one day in advance the bids for power sell or purchase from the market participants. Then generators and loads are dispatched in such a way that leads to the economic optimum, i.e.

the minimization of costs. The majority of the deregulated markets are designed to include both two basic market forms. So, while a direct trading between consumer and producers is possible, the market participants can take part in the spot market where energy is traded as in a pool market. The experience to date evidences that markets, that offer to their participants the flexibility to choose between bilateral contracts and spot market, have the best performance. The entities that participate in the deregulated electricity markets include the generation companies or other commercial enterprises which can inject power into the network and they are described as suppliers. The side of consumers is represented by the distribution companies, the retail traders or directly by the end-consumers. In Figure 2.2, a general form of deregulated electricity market is illustrated.

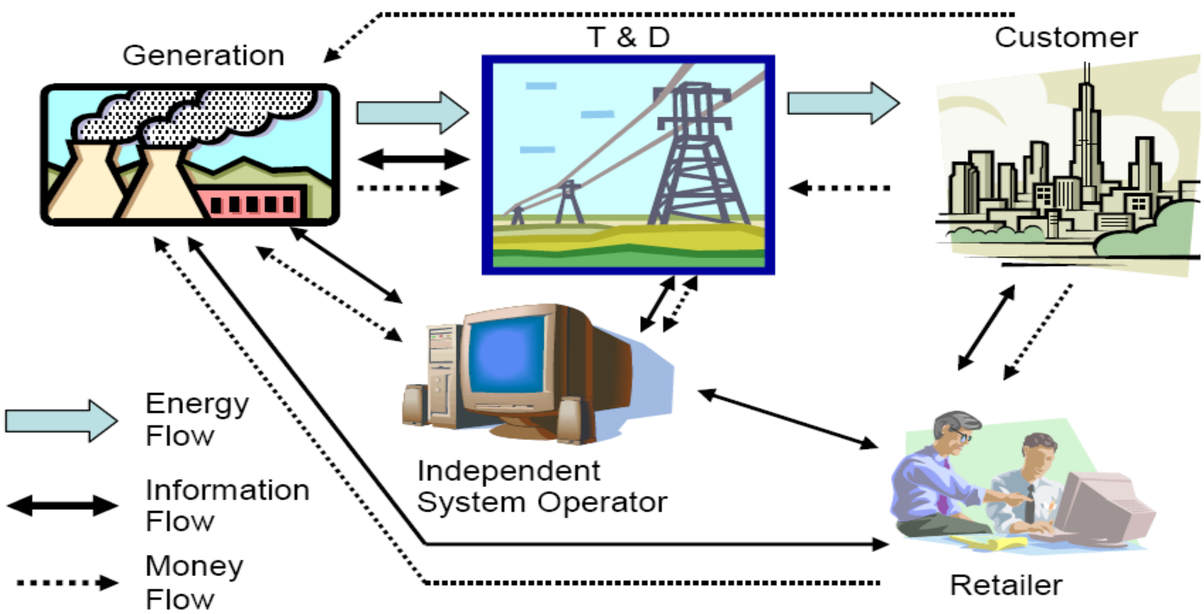

Fig. 2.2 Structure of Deregulated Market

2.3.2 Different Entities in Deregulated Market

1. **Genco (Generating Company):**

   Genco is an owner-operator of one or more generators that runs them and bids the power into the competitive marketplace. Genco sells energy at its sites in the same manner that a coal mining company might sell coal in bulk at its mine.

2. **Transco (Transmission Company):**

   Transco moves power in bulk quantities from where it is produced to where it is delivered. The Transco owns and maintains the transmission facilities.

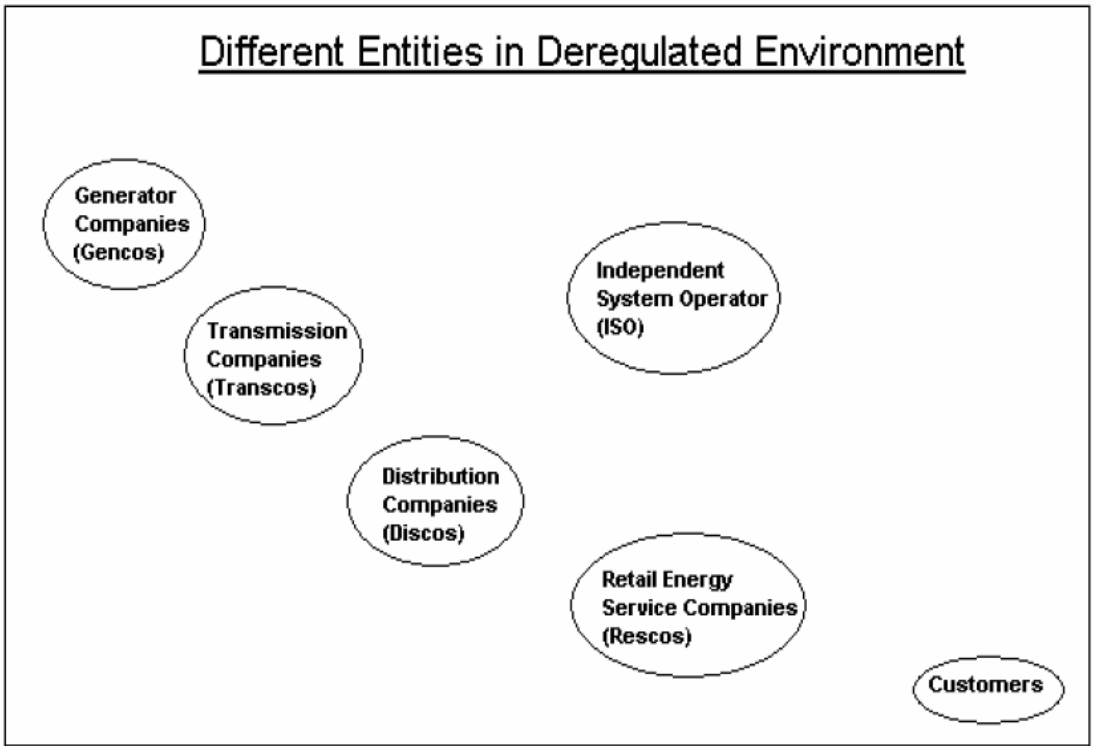

Fig. 2.3 Different Entities in Deregulated Market

3. **Disco (Distribution Company):**

   It is the monopoly franchise owner operator of the local power delivery system, which delivers power to individual businesses and homeowners. In some places, the local distribution function is combined with retail function, i.e. to buy wholesale electricity either through the spot market or through direct contracts with gencos and supply electricity to the end use customers.

4. **Resco (Retail Energy Service Company**):

   It is the retailer of electric power. Many of these will be the retail departments of the former vertically integrated utilities. Others will be companies new to the electric industry that believes they are good at selling services. Either way, a resco buys power from gencos and sells it directly to the consumers.

5. **Independent System Operator (ISO):**

   The ISO is an entity entrusted with the responsibility of ensuring the reliability and security of the entire system. It is an independent authority and does not participate in the electricity market trades.

6. **Customers:**

   A customer is entity, consuming electricity. In deregulated markets, the customer has several options for buying electricity. It may choose to buy electricity from the spot market by bidding for purchase, or may buy directly from a genco or even from the local distribution company.

2.3.3 Competition in Market

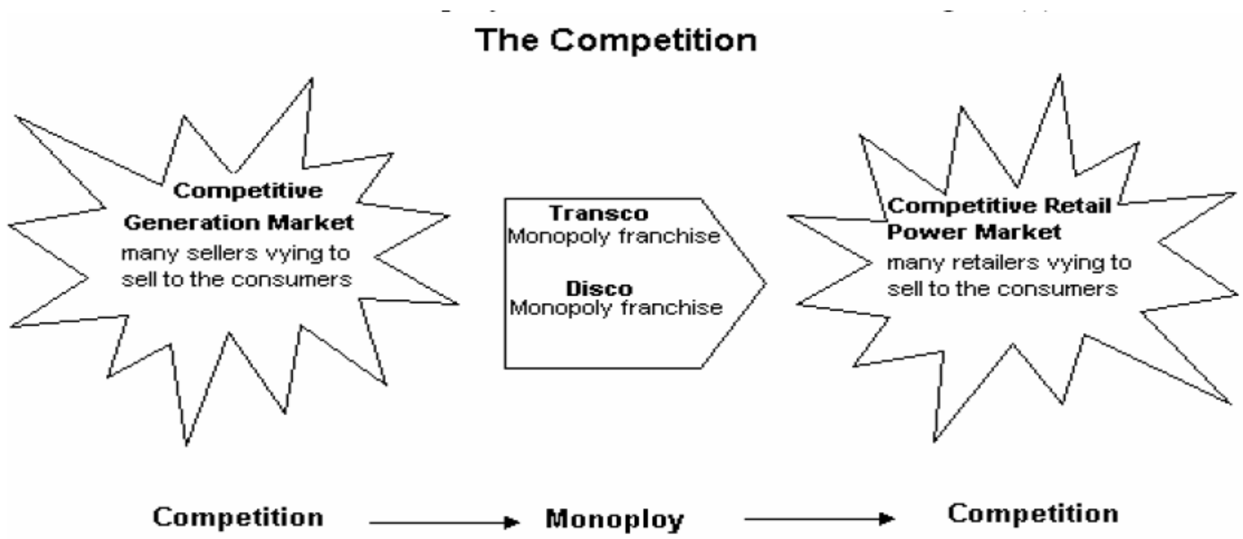

Fig. 2.4 Competition in Market

2.4 Transmission Open Access Model

The energy auction and future markets are conducted by an independent entity called Power Exchange (PX) and the system is operated by another independent body called Independent System Operator (ISO), who assures equal opportunities to all sellers and buyers through open access to grid.

2.4.1 Independent System Operator (ISO)

ISO is the central entity to have emerged in all deregulated markets with the responsibility of ensuring system security and reliability, fair and equitable transmission tariffs and providing for other system services.

2.4.2 ISOs could be placed in two categories:

1. The first is the pool structure in which the ISO is responsible for both market settlement including scheduling and dispatch, and transmission system management including transmission pricing, and security aspects. Here, ISO is also known as Poolco Operator.

2. The other structure is that of open access, one dominated by bilateral contracts. In this system, bulk of the energy transactions are directly organized between the generator and the customer, and the ISO has no role in generation scheduling or dispatch and is only responsible for system operation. The role of ISO is minimal and limited to maintenance of system security and reliability functions [2].

2.4.3 Basic Functions of ISO

- **System security:** Operator must assure that the power system continues to operate in a stable, economical manner.

- **Power Delivery:** The operator should provide the power transportation services requested of it by buyers and sellers.

- **Transmission pricing:** System operator must determine and post the prices for transmission usage, offer to reserve or sell usage, track, bill and settle with users, and pass on revenues to transmission owners.

- **Service quality assurance:** The system operator must assure the quality of service it provides.

- **Promotion of Economic efficiency and equity:** The overall operations of system operator should obey economic efficiency and also it should have fairness and equity in its dealing and should not benefit only some players in the system.

2.5 Motivation for restructuring

Historically, the electricity industry was a monopoly industry with a vertical structure. In a vertically integrated environment, enterprises were responsible for the generation, transmission and distribution of electrical power in a given geographical area. Such companies could be state owned as well as private. But the last two decades, and especially during the 1990s, the electricity supply service has been undergoing a drastic reform all over the world. The old monopolist power markets are replaced with deregulated electricity markets open to the competition. Different forces have driven the power market towards the deregulation. Not all of them are behind the reform in all these countries. Furthermore, in each different country the same reason has to be studied taking into consideration the local circumstances. However, it is possible to categorize all these various causes in technical, economical and political. The technological development of high voltage networks during the 1960s and 1970s made possible transmission of bulk power over long distances. This is a necessary condition in order the power market to be opened to producers that are located far from the main customers. Despite this achievement the electricity industry remained a monopoly for the next twenty years. So, there is another technical factor which has given a stronger impulse towards the deregulation. This factor is the improved power generation technologies. In 1960s and 1970s the typical size of thermal power plant units was between 600 and 1000 MW.

The average construction time for such power plants was four to five years. In case of nuclear power plant this time was double. For this reason, the decisions of generation expansion could be taken only by a monopolist utility so as to make the necessary investments. The monopolist regime was also acting as protection against investment errors which could have dramatic consequences because of the investment size. The development of gas power plants, and especially of combined circle gas turbines, led to an optimal size of power production unit up to 300 MW. Besides the reduction in the investment cost, the construction time of such power plants is essentially shorter than it was before. Hence, it is now possible the generation expansion decisions to be taken by smaller enterprises. The expansion of gas network is an additional reason that makes investments in gas power plants easily realizable. Another mixed technical-ecological cause is the inclination of modern society for an increase in power produced by renewable sources. The emerging of independent producers who operate, mostly, wind power units gives a further competitive character to the power industry despite the fact that such producers survive still due to the subsidies.

The improvement of transmission technologies result in an efficient grid operated by the transmission companies. Devices such as FACTS enable a better control over the electrical features of the grid. Thus, the separation of generation and transmission decisions can be easier. Beyond the technical improvements, a set of economical reasons may be considered as the main force behind the electricity market reform. The key economical idea, which led to the deregulation, was that a well operated competitive market can guarantee both cost minimization and average energy prices hold at a minimum level. The economists believe that an open market provides stronger incentives to the supplier in order to apply cost-minimizing procedures than a regulated market. The second positive characteristic of a competitive market is its ability to drive the prices towards the marginal costs. Of course, in order this advantage to appear the market has to be well designed. Another economical reason was the inability of countries with high national debt to meet the necessary investments in state owned power sector. So, the only solution for these countries was the privatization of the electricity industry.

Through this process these countries achieved two objectives. Firstly, to free up public funds and make them available to serve the national debt or other demands. Secondly, the governments of these countries collected an essential amount from the sale of state owned utilities. The third category of electricity industry restructure causes consists of political factors. The first deregulated power markets have acted as an example showing that the electricity sector can also be operated in a competitive environment. Thus, it was easier for many countries to overcome hesitation and reform their electricity markets. The liberalization in USA of many economical sectors in 1970s such as transportation, gas and telecommunications was a sign that the power sector would also be reformed. The acceptance of open market mode in some economic sectors by the most governments world-wide was a further factor which enabled the restructuring. In

1980s, the social-democratic governments in many countries have accepted the introduction of competition in many economic sectors as a development tool. Among the political circles, the idea that the private companies apply more efficient practices than the public ones, in certain economic sectors, was getting more acceptances. Hence, the deregulation of power market was made possible in many countries. A further reason, which led to the deregulation, is the pressure of some multilateral organizations such as World Bank. These organizations set as a requirement the opening of markets including the power sector in order to support financially a country. Consequently, the electricity industry of many countries financed by the World Bank opened to the competition.

Chapter-3

3. Electricity Sector in India

The electricity sector in India is predominantly controlled by government sector entities via central public sector corporations, such as: National Hydroelectric Power Corporation, National

Thermal Power Corporation and various state level corporations (state electricity boards - SEBs). The transmission and distribution is managed by the State Electricity Boards (SEBs) or private companies. The current per capita power consumption is about 734 kWh per year while the world average is 2,782 kWh.

State	2007-08 (ACTUAL)	2008-09 (Actual)	2009-10 (Prov.)	2010-11 (RE)	2011-12 (AP)
Punjab	6.10	6.18	6.36	6.08	6.41

Table 3.1 Auxiliary Consumption (Owned Units) (%)

India is world's 5th largest energy consumer, accounting for 3.5% of global energy consumption. Due to India's economic rise, the demand for energy has grown at an average of 3.6% per annum over the past 30 years. More than 50% of India's commercial energy demand is met through the country's vast coal reserves. About 76% of the electricity consumed in India is generated by thermal power plants, 21% by hydroelectric power plants and 4% by nuclear power plants [3].

Per capita consumption of electricity in India increased from 178 kWh in 1985-86 to 338 kWh in 1996-97 (GOI, 2002) and to 665 kWh in 2005-06 (General Review, 2007). This level of per capita consumption is less than 1/20 of that prevailing in the US, less than half that in China against the world average of 2400 kWh and the OECD(Organization for Economic Co-operation and Development) average of 6900 kWh (International Energy Agency data) [4]. The current per capita power consumption is about 734 kWh per year while the world average is 2,782 kWh.

3.1 Generation

Grand Total Installed Capacity is 1, 86, 655 MW [6]**.** The Installed Capacity of the country as on 31st December, 2011 was 1,86, 655 MW as depicted in the Fig 3.1 as follows: The Installed Capacity of the country as on 31st December, 2011 was 1,86, 655 MW as depicted in the Fig. 3.1 as follows:

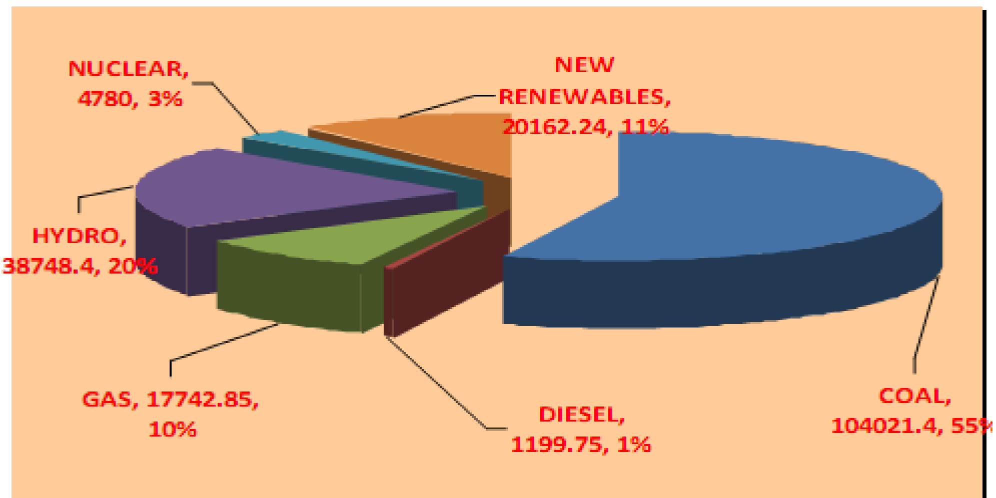

Fig. 3.1 All India Installed Capacity

The country has significant potential of generation from renewable energy sources. All efforts are being taken by Government of India to harness this potential. The Installed capacity as on 31st December, 2011 from renewable energy sources is 20,162 MW which comprises of 3225.92 MW in the State sector and 16936.32 MW in the Private sector. The Total Renewable Installed Capacity comprises of 14104.62 MW from Wind, 3120.83 MW from Small Hydro Plants, 2787.63 MW from Biomass Power & Biomass Gasifiers and 149.16 MW from Solar power & Urban & Industrial waste. India ranks fifth in the world in terms of installed capacity of wind turbine power plants [5].

3.1.1 Thermal Power

- Current installed base of Coal Based Thermal Power is 104021.4 MW which comes to 55% of total installed base.
- Current installed base of Gas Based Thermal Power is 17742.85 MW which is 10% of total installed base.

- Current installed base of Oil Based Thermal Power is 1199.75 MW which is 0.9% of total installed base.

The state of Maharashtra is the largest producer of thermal power in the country.

3.1.2 Hydro Power

India was one of the pioneering states in establishing hydro-electric power plants; the power plant at Darjeeling and Shimsa (Shivanasamudra) was established in 1898 and 1902 respectively and is one of the first in Asia. The installed capacity as on 31st December, 2011 was approximately 38748.4, which is 20% of total installed base.

The public sector has a predominant share of 97% in this sector.

3.1.3 Nuclear Power

Currently, seventeen nuclear power reactors produce 4,780.00 MW (3% of total installed base).

3.1.4 Renewable Power

Current installed base of Renewable energy is 20162.24 MW which is 11% of total installed base with the southern state of Tamil Nadu contributing nearly a third of it (4379.64 MW) largely through wind power. Table 3.2 shows the All India region wise generating installed capacity (MW) of power utilities including allocated shares in joint and central sector utilities.

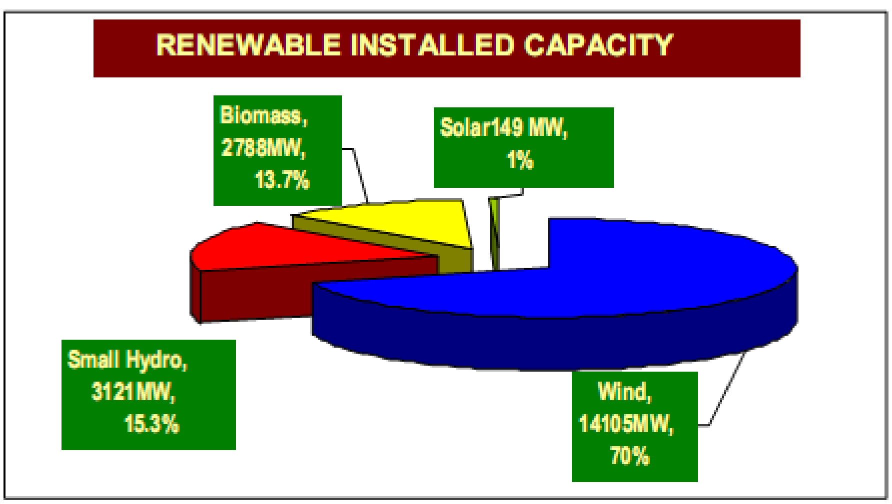

Fig 3.2 All India Installed Capacity (Renewable)

S. No.	Region	Thermal				Nuclear	Hydro (Renewable)	R.E.S. @ (MNRE)	Total
		Coal	Gas	Diesel	Total				
1.	Northern	18867.5	3531.19	12.99	22411.68	1180	13425.15	1766.37	38783.2
2.	Western	25402.5	6600.72	17.48	32020.7	1840	7448.5	4023.62	45332.82
3.	Southern	16682.5	3646.1	939.32	21267.92	1100	10724.18	7047.9	40140
4.	Eastern	16446.38	190	17.2	16653.58	0	3933.93	227.41	20814.92
5.	N.Eastern	60	766	142.74	968.74	0	1116	171	2255.74
6.	Islands	0	0	70.02	70.02	0	0	6.11	76.13
7.	All India	77458.88	14734.01	1199.75	93392.64	4120	36647.76	13242.41	147402.81

Table 3.2 All India generation capacity

State	2006-07	2007-08	2008-09	2009-10	2010-11
Punjab	24107.43	26314.64	27710.86	23458.27	22515.64
State Sector	24107.43	26148.85	27566.04	23458.27	22515.64
Private Sector	0	165.79	144.82	0	0

Table 3.3 Gross Generation (Mkwh)

3.2 Transmission

Transmission of electricity is defined as bulk transfer of power over a long distance at high voltage, generally of 132kV and above. In India bulk transmission has increased form 3,708 km in 1950 to more than 265,000 km today [6]. The entire country has been divided into five regions for transmission systems, namely, Northern Region, North Eastern Region, Eastern Region, Southern Region and Western Region. The Interconnected transmission system within each region is also called the regional grid.

The transmission system planning in the country, in the past, had traditionally been linked to generation projects as part of the evacuation system. Ability of the power system to safely withstand a contingency without generation rescheduling or load-shedding was the main criteria for planning the transmission system. However, due to various reasons such as spatial development of load in the network, non-commissioning of load centre generating units originally planned and deficit in reactive compensation, certain pockets in the power system could not safely operate even under normal conditions. This had necessitated backing down of generation and operating at a lower load generation balance in the past. Transmission planning has therefore moved away from the earlier generation evacuation system planning to integrate system planning.

High Voltage Direct Current (HVDC) technology has also been used for interconnection of all regional grids across the country and for bulk transmission of power over long distances. Certain provisions in the Electricity Act 2003 such as open access to the transmission and distribution network, recognition of power trading as a distinct activity, the liberal definition of a captive generating plant and provision for supply in rural areas are expected to introduce and encourage competition in the electricity sector.

Electricity is a concurrent subject in India i.e., both the central and state governments are responsible for the development of the electricity sector. NTPC, NHPC, THDC, NEEPCO, SJVNL, NLC etc. are the central generation utilities and POWERGRID is the Central Transmission Utility. At the State level, there are Gencos and Transco in the respective States.
The country has been demarcated into five electrical Regions viz. Northern (NR), Eastern (ER), Western (WR), Southern (SR) and North Eastern (NER). However, NR, ER, WR and NER have been synchronously interconnected and operating as single grid – Central Grid (capacity about 110,000MW). The Southern region is asynchronously connected to the Central Grid through HVDC links. Power map showing present National Grid is given at Fig.3.3.

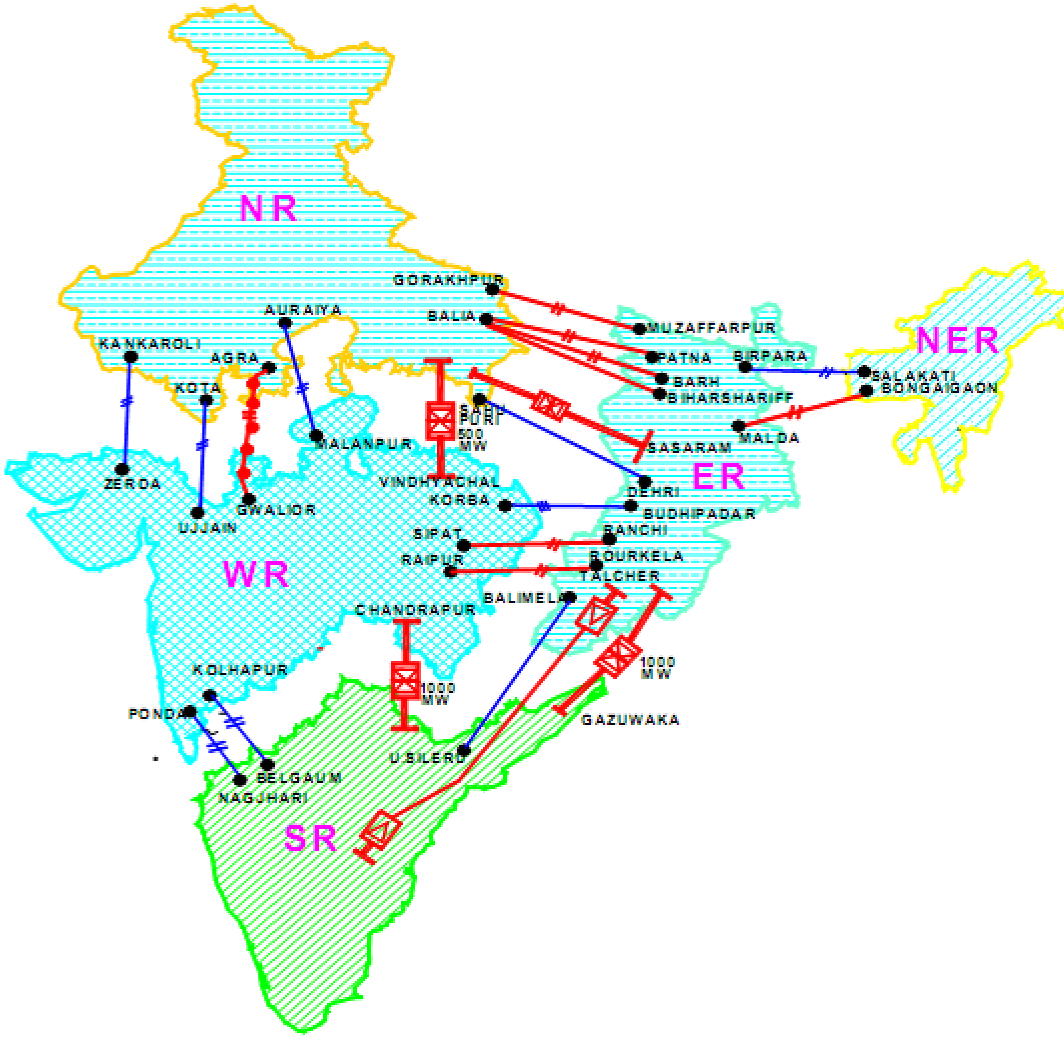

Fig 3.3 Power map showing National Grid at present

The backbone transmission system in India is mainly through 400 kV AC network with approximately 90,000 circuit kilometers (ckm.(=2xroute km)) of line length. Highest transmission voltage level is 765kV with line length of approximately 3120 ckm. There are about 7,200 ckm of 400 kV systems, 5500 MW, +/- 500 kV long distance HVDC systems, an HVDC Monopole of 200 MW and four HVDC Back-to-Back links of 3000MW capacity. These are supported by about 1, 23,000 ckm of 220kV transmission network. As mentioned above, all the five regions are interconnected through National Grid comprising hybrid AC/HVDC system. Present inter-regional transmission capacity of the National Grid is about 20,800 MW [28].

3.3 Distribution

The total installed generating capacity in the country is over 135,000MW and the total number of consumers is over 144 million. Apart from an extensive transmission system network at 500kV HVDC, 400kV, 220kV, 132kV and 66kV which has developed to transmit the power from generating station to the grid substations, a vast network of sub transmission in distribution system has also come up for utilization of the power by the ultimate consumers. However, due to lack of adequate investment on T&D works, the T&D losses have been consistently on higher side, and reached to the level of 32.86% in the year 2000-01.The reduction of these losses was essential to bring economic viability to the State Utilities [6].

As the T&D loss was not able to capture all the losses in the net work, concept of Aggregate Technical and Commercial (AT&C) loss was introduced. AT&C loss captures technical as well as commercial losses in the network and is a true indicator of total losses in the system. High technical losses in the system are primarily due to inadequate investments over the years for system improvement works, which has resulted in unplanned extensions of the distribution lines, overloading of the system elements like transformers and conductors, and lack of adequate reactive power support.

The commercial losses are mainly due to low metering efficiency, theft & pilferages. This may be eliminated by improving metering efficiency, proper energy accounting & auditing and improved billing & collection efficiency. Fixing of accountability of the personnel managers may help considerably in reduction of AT&C loss. With the initiative of the Government of India and of the States, the Accelerated Power Development & Reform Programmed (APDRP) was launched in 2001, for the strengthening of Sub–transmission and distribution network and reduction in AT&C losses.

The main objective of the program was to bring Aggregate Technical & Commercial (AT&C) losses below 15% in five years in urban and in high-density areas. The program, along with other initiatives of the Government of India and of the States, has led to reduction in the overall AT&C loss from 38.86% in 2001-02 to 34.54% in 2005-06. The commercial loss of the State Power

Utilities reduced significantly during this period from Rs. 29331 Crore to Rs. 19546 Crore. The loss as percentage of turnover was reduced from 33% in 2000-01 to 16.60% in 2005-06.

The distribution segment continues to carry electricity from the point where transmission leaves off, that is, at the 66/33 kV level. The standard voltages on the distribution side are therefore 66kV, 33 kV, 22 kV, 11 kV and 400/230 volts, besides 6.6 kV, 3.3 kV and 2.2 kV. Depending upon the quantum of power and the distance involved, lines of appropriate voltages are laid. The main distribution equipment comprises HT and LT lines, transformers, substations, switchgears, capacitors, conductors and meters. HT lines supply electricity to industrial consumers while LT lines carry it to residential and commercial consumers. In the Tenth Plan, the state utilities added 855,059 ct. km of distribution lines' infrastructure. The number of step-down and distribution transformers also increased by 13,961 and 1,250,038 respectively. This represented a capacity addition of 192,369 MVA and 86,512 MVA respectively during the Tenth Plan, at the end of which (March 2007), distribution infrastructure stood at 6,580,949 C /Km of line network and a transformer capacity of 863,462 MVA.

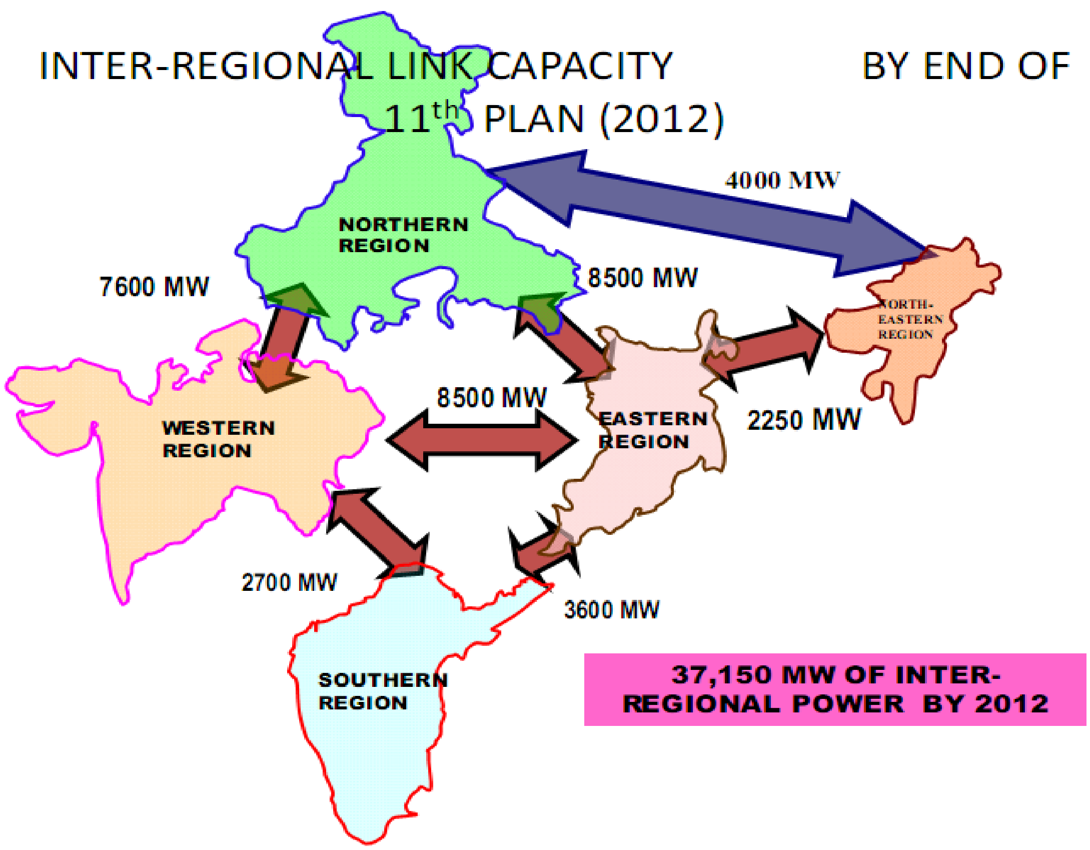

Fig. 3.4 The Five Electricity Regions

3.4 Level of T& D Losses

According to Central Electricity Authority guidelines the losses in various elements of the T&D system are to be reduced to the order as indicated below:

S. No.	System element	Power Losses (%)	
		Minimum	Maximum
1.	Step-up transformers & EHV transmission system	0.5	1.0
2.	Transformation to intermediate voltage level, transmission system & step down to sub-transmission voltage level	1.5	3.0
3.	Sub-transmission system & step-down to distribution voltage level	2.0	4.5
4.	Distribution lines and service connections	3.0	7.0
5.	Total Losses	7.0	15.5

Table 3.4 Level of T& D Losses

The losses in any system would, however, depend on the pattern of energy use, intensity of load demand, load density, and capability and configuration of the transmission and distribution system that vary for various system elements. According to CEA vide its publication (July 1991) 'Guidelines for Reduction of Transmission and Distribution Losses', it should be reasonable to aim for total energy losses in the range of 10 - 15% in the different states in India.

3.5 The Electricity Act, 2003

Recognizing the need for the Reform process covering the entire facets of the electricity sector comprising generation, transmission and distribution to the consumers, a comprehensive Electricity Bill was drafted in 2000 following a wide consultative process [4]. After a number of amendments, the bill finally sailed through the legislative process and was enacted on 10 June, 2003. It replaces the three existing legislations governing the power sector, namely Indian Electricity Act, 1910, the Electricity (Supply) Act, 1948 and the Electricity Regulatory Commissions Act, 1998. The Electricity Act, 2003 mandates that Regulatory Commissions shall regulate tariff and issue of licenses and that State Electricity Boards (SEBs) will no longer exist in the existing form and will be restructured into separate generation, transmission and distribution entities. Regulatory function has been taken away from the purview of the government [27]. The Electricity Act, 2003 mandates licensee-free thermal generation, nondiscriminatory open access of the transmission system and gradual implementation of open access in the distribution system which will pave way for creation of power market in India. The main provisions of the act are:

- De-licensing of thermal generation and captive generation.
- Open access in distribution to be introduced in phases
- Provision for license-free generation and distribution in rural areas and provision for management of rural distribution by Panchayats, Cooperative Societies, nongovernment organizations, franchisees, etc.
- Non-discriminatory open access in transmission.
- Multiple licensing in distribution.
- Mandatory metering of all electricity supplies.
- Adoption of multi-year tariff principles.
- Provision for cross-subsidy surcharge on direct sale to consumers.
- Power Trading recognized as a distinct activity with ceilings on trading margins to be fixed by the Regulatory Commissions.
- Upfront payment of subsidies by the States.
- Setting up of an Appellate Tribunal to hear appeals against the decisions of the CERC and the SERCs.

The Act is aimed at providing an investor friendly environment for potential developers in the power sector by removing administrative hurdles in the development of power projects and shall provide impetus to distribution reform to be undertaken in India. Provisions like de-licensing of thermal generation, open access and multiple licensing; no surcharge for captive generation shall be the basis for a competitive environment in the Indian power sector. Provisions of open access would be instrumental in the development of competitive power markets, and multi year tariffs shall bring in necessary incentives for performance improvement and to reduce regulatory risk.

3.6 The Electricity (Amendment) Act, June 2007

In May 2007, the government passed the Electricity (Amendment) Bill, 2007 recommending amendments to the Electricity Act (EA), 2003. Subsequent to this, it passed the Electricity (Amendment) Act in June 2007. Certain sections of the EA 2003 were amended, after considering views of the affected parties. The amendments broadly relate to:

- The term 'elimination' has been omitted in relation to cross-subsidies.
- Captive units will not require a license to supply power to any user.
- Strict action against unauthorized usage of power.
- Power theft has been recognized as a criminal offence, punishable under Section 173 of the Code of Criminal Procedure, 1973.

The government has omitted the term 'eliminated' in the context of cross-subsidies. (Earlier, the Act stated that 'the cross-subsidy surcharge and cross subsidies shall be progressively reduced and eliminated'.) In the earlier Tariff Policy of January 2006, the government suggested that by the end of 2010-11, tariffs should be +/- 20 per cent of the cost of supply, in conjunction to the EA, which envisaged a complete elimination of cross subsidies. For this, the policy suggested that State Electricity Regulatory Commissions (SERCs) prepare a road map to achieve this target. However, the amendment suggests that cross-subsidies would be reduced gradually, and not completely eliminated, as per the earlier provision of 'elimination of cross-subsidy'. Hence, the amendment is likely to make states more lenient in setting targets for cross-subsidy reduction. Consequently, this may act as a setback to the reformation process, as elimination of cross-subsidies is an important pre-requisite for tariff rationalization and improving the financials of state utilities.

The amendment specifies a gradual reduction of cross-subsidy, and does not stipulate a strict timeframe or set targets (except reduction of cross-subsidies to +/- 20 per cent of the cost of supply by 2011) for reducing the same. Going forward, the respective State Regulatory Commissions will have to set the targets and timeframes. In the past, most states have missed deadlines with respect to unbundling, open access implementation, multi-year tariffs, intra-state availability based tariffs (ABT), etc. Therefore, in such a scenario, the omission of a strict measure like 'elimination of cross-subsidies' will only ensure continued slow pace of reforms. Hence, CRISIL Research expects this amendment to have a moderately negative impact on the power sector.

The Amendment Act has added a provision to Section 9, which discusses captive generation. The new provision of the Act states that licenses will not be required to supply electricity generated from captive generating plants to any licensee. Further, the amendment seeks to clarify ambiguity regarding a captive plant being a deemed generator that can sell electricity directly to a distribution licensee or a consumer (as a generator). However, charges related to open access and cross-subsidy would still be applicable to a captive generator, in the event where electricity is sold to a consumer directly as defined under Section 42 (2).

Amendments related to penalties for unauthorized usage of power and recognition of power theft as an offence punishable under Section 173 of the Code of Criminal Procedure, 1973, are to ensure strict action against power theft. These amendments would simplify the process of identifying those consumers stealing power, as well as increase the assessment amount, which would help curb losses in the system. This is expected to further strengthen the drive by respective state utilities to eliminate power theft and improve operational efficiencies. The country faces T&D losses of around 30 per cent, which implies that one third of the power is lost due to theft, pilferage and technical inefficiencies. In fact, a large part of the power lost is through theft and unaccounted agricultural consumption. Therefore, focused efforts towards eliminating theft of power can help reduce distribution losses substantially.

3.7 Power for All By 2012

The Government of India has an ambitious mission of Power for All By 2012. This mission would require that our installed generation capacity should be at least 200,000 MW by 2012 from the present level of 144,564.97 MW. Power requirement will double by 2020 to 400,000MW [4].

3.7.1 Objectives

- Sufficient power to achieve GDP growth rate of 8%.
- Reliable power.
- Quality power.
- Optimum power cost.
- Commercial viability of power industry.
- Power for all.

Chapter-4

4. Literature Review

J.T. Cain [7] presented a panelists focused on the present and future state of the electric power sector, future expansion of Asian and Australian power systems, interconnections and power exchanges, cooperation, new capacity, direction of reforming the industry, interstate relations in the fuel and energy complex, and the impact of privatization on electric supply. They addressed electricity and energy issues in both developing and developed Asian countries and in Australia as seen by the United Nations (UN), the World Energy Council (WEC), The World Bank, Japan, Australia, India, China, East Russia, Vietnam, and Malaysia.

Dr. C. Palanichamy at al. [8] presented an India's strong economic performance of recent years requires continuing effort from the newly formed Government to widen the ambit of economic reform. Though the Government has given higher priority for the power development projects, the Indian Power sector is struggling with formidable difficulties of meeting the heavy demands of electricity due to higher amount of power losses and energy thefts. To give a supporting hand to the Government, the paper suggests restructuring of the Power sector with energy conservation as the main motive to achieve economical and environmental benefits. The capabilities of the Energy Conservation Policies developed are illustrated via tests by three distinct ways on a State Grid a like Test System and the test results conform the suitability of the proposed policies for real-time implementation on the Indian Power sector.

Sajal Ghosh [9] presented to examine the Granger causality between electricity consumption per capita and Gross Domestic Product (GDP) per capita for India using annual data covering the period 1950–51 to 1996–97. Phillips–Perron tests reveal that both the series, after logarithmic transformation, are non-stationary and individually integrated of order one. This study finds the absence of long-run equilibrium relationship among the variables but there exists unidirectional Granger causality running from economic growth to electricity consumption without any feedback effect. So, electricity conservation policies can be initiated without deteriorating economic side effects.

Yog Raj Sood et al. [10] presented a Power industry is moving rapidly from regulated conventional setup to a deregulated environment. There is an urgent need to keep a track of international experiences and activities taking place in this emerging field. The paper gives a bibliographical survey and general backgrounds of research and development in the field of power system wheeling under deregulated environment based on over 170 published articles. Wheeling in general and the establishment of wheeling rate in particular, are subjects of extensive debate today. This will be very much useful for all countries, especially those developing countries which are moving toward the unbundling of electricity supply industry (ESI). The collected literature have been divided into many section, so that new researchers do not face any difficulty for obtaining literature particularly in the area of wheeling of power under deregulated environment.

A. Srivastava et al. [11] presented the interest in restructuring and reform of the power sector is a worldwide phenomenon that is being pursued in different formats, depending on the structure and condition of the economy and political institutions in those countries. Yet the core of therefore remains the same, i.e., the establishment of a transparent regulatory structure, unbundling of the power sector, creation of national and state grids with a transparent and efficient dispatch, entry and exit systems for participants, wholesale market in the power sector, more choices regarding the sales to consumers, and other measures that can improve the competition and the efficiency of the sector. A three-phase, nine-step action plan for reform encourages an integrated national grid, tariff setting, DSM options, energy conservation, and T&D loss reduction as possible strategies to overcome the problem of power deficit.

S.N. Singh et al. [12] presented a Power industry restructuring, around the world, has a strong impact on Asian power industry as well. Indian power industry restructuring with a limited level of competition, since 1991, has already been introduced at generation level by allowing participation of Independent Power Producers (IPPs). The new Electricity Act 2003 provides the provision of competition in several sectors. It is felt that the prevailing conditions in the country are good only for wholesale competition and not for the retail competition at this moment. A suitable model is suggested based on the current and future market participants.

Tripta Thakur et al. [13] presented an overview of the recently enacted Electricity Act 2003 and evaluate the implications of the provisions of the Act for the Indian Power sector. The Act has introduced major policy shift and is likely to have far reaching implications for the power generation, transmission and distribution scenario within India, and more importantly, is likely to act as a model for other countries to adapt and adopt. The paper details theses provisions, analyses them and evaluates their impacts and shortcomings.

S. A. Khaparde [14] presented a Power sector across the world is undergoing a lot of restructuring; India is no exception to this. The whole of the power industry in India is undergoing a state of flux. The need for restructuring the power sector was felt due to the scarcity of financial resources available with Central and State Governments, and necessity of improving the technical and commercial efficiency. In some States of India there are multiple private utilities, which are technically and financially in a position to enter the phase of a competitive electricity market. Hence, in 1998 the Regulatory Commissions were formed under the Electricity Regulatory Commissions Act 1998 (Central Law) to promote competition, efficiency and economy in the activities of the electricity industry. Central Electricity Regulatory Commission (CERC) has a key role in rationalizing tariff of generating companies owned or controlled by the Central Government. Ministry of Power has undertaken Accelerated Power Development and Reform Programmers (APDRP) from the year 2000-01 with the twin objectives of financial turn-around in the performance of the power sector especially in electric distribution and improvement in quality of supply. Electricity Act 2003 has come into force from June 2003. As the act allows third party sales, it introduces the concept of trading bulk electricity. The act also provides open access to transmission as well as distribution of electricity. Some of the important issues addressed by this Act and their impact on power system restructuring are discussed.

A. Pahwa at al. [15] presented the electricity industry in India is going through a major change with the Electricity Act-2003 coming into force on June 10, 2003. The Act is stated to be the "distilled wisdom" of a series of commissioned international and national consultancy studies and seminars and conferences held at the all-India level for three years. The paper is an attempt to study the changes going on in the Indian electricity market, its components, salient features, and the challenges that are poised for future development. A brief overview of some electricity markets in other countries is presented and some comparisons are made with the Indian electricity market.

T. J. Hammons [16] presented the examine power market restructuring in Asia, principally in Russia, China, India and Japan. It considers economic convergence points of Russian, Russian Common wealth of Independent States (CIS) and Asian Power Markets; Russia's power industry restructuring current state and problems; and power industry restructuring in China: regional electricity markets, investment, planning, and challenges. Also considered is development of the power market in India; and restructuring of the electric power industry and current state of the power market in Japan: progress, outline of revisions, and an assessment of institutional reforms.

A.M. Ilahi et al. [17] presented a picturesquely depicts the deregulated trend in the developed and developing countries as a comparison. All the three major sectors i.e. Generation, Transmission & Distribution of electrical power are discussed but the focus is on the transmission system network. This is because of the reason that this sector has not been explored fully and no documented guidelines are available in this sector. A clear elaboration regarding the role of regulatory body is also narrated with its responsibilities. The major problems are also discussed of the developed and developing countries with special reference to deregulation and restructuring practices going in Pakistan and also indicating the bottle necks, hindrances coming on the way as not to implement the deregulation in its clear concept.

R.C. Bansal et al. [18] presented during the past few years Indian power sector has experienced major changes in power sector. The paper discusses the restructuring/privatization of Indian power sector addressing how it affects the reliability of power system. Key issues related with the performance of the power sector like privatization of power sector, renovation and modernization (R&M) of old plants, metering problems, increase of hydro power and non conventional energy sources to overcome pollution problems have been discussed. Advantages of information technology (IT) and major areas in which IT can be used, have also been discussed.

0. P. Rahi et al. [19] presented the country's development is measured in terms of per capita consumption of electricity which in turn depends on electricity generated. In India per capita energy consumption is quite low and for the year 2007 it was only a meager 665 KWH per annum in comparison to about 12000 KWh for USA and 34000 in Norway, which indicates fairly low level of industrialization in the country. The peak power shortage of 16.6% and average energy shortage of 9.8 % has been plaguing Indian power sector for 2007-08. As a result, regulators, worldwide are now implementing new regulatory schemes and organizational reforms in an effort to improve the incentives for efficient operation of electricity utilities. All these reforms are consistent with the view that competition should be introduced into the electricity supply industry, wherever, it is technologically feasible and India is not exception to these reforms. In this a case study of Himachal Pradesh, which is a hilly state with difficult terrains in the Northern Part of India has been carried out. This state has distinction of achieving 100% electrification way back in 1989 and rapid load growth. With enactment of Electricity Act 2003, there has been tremendous improvement in power sector of this state. There is significant improvement in the areas of transmission and distribution, tariff rationalization and in availability of power supply.

R. N. Datta [20] presented the cities grows and expands the peri-urban areas become part of the cities and new Peri-urban areas are formed. This phenomenon in India is creating severe problems in terms of infrastructure delivery both in the fringe areas of the cities and the peri-urban areas. The District Planning Committees (DPCs) need to consider the special requirements of the peri-urban areas, while planning and coordinating developments of panchayats located within 5 to 10 kilometer of towns and the Metropolitan Planning Committees (MPCs) should give equal importance to the fringe areas of the municipalities and the peri-urban areas for planning and development. The central assistance for rural infrastructure is in adequate to meet the requirements of the peri-urban areas. All financing, management and capacity building instruments meant for urban areas should be made applicable to panchayats within peri-urban areas.

Dr. Tripta Thakur et al. [21] Presented a framework for accessing efficiency analysis of State Owned Electric Utilities (SOEUs), which have been mainly responsible for the generation, distribution and transmission of electricity in India. Efficiency Performance of Thirty four state owned generation companies was evaluated using the Data Envelopment Analysis (DEA) for the time periods 2006-07. This efficiency performance of regulated electric utilities of India is very important for future requirement. The result shows that SOEU generation companies are inefficient in operation and need improvement.

J.Anitha Roseline et al. [22] presented the Electricity is backbone for almost all economic activities in present times and it is a proven fact that access of this precious perishable commodity to people bears direct impact on pace of development of the country. The country's development is measured in terms of per capita consumption of electricity, which in turn depends on electricity generated. India has the fifth largest installed power capacity in the world and is one of the top power consumers. In this a case study of Tamil Nadu has been carried out, which is bordered on the north by the states of Andhra Pradesh and Karnataka and on the west by the state of Kerala. Kanya-kumari, the southernmost tip of this land is the meeting point of the Bay of Bengal, the Arabian Sea and the Indian Ocean. In India, Tamil Nadu state ranks third in Electricity generation, Transmission and Distribution. Tamil Nadu is the first state in the country to achieve 100 % electrification of all villages as early as 1992. With the enactment of Electricity Act 2003, there has been tremendous improvement in the areas of transmission and distribution, tariff rationalization and in availability of power supply.

Chapter-5

5. Case Study of Restructured Power System (With reference to Punjab State)

5.1 Generating Capacity of Punjab

It has three types of Plant:-

5.1.1 Existing Thermal Plant

S. No.	Plant	Total Generating Capacity	Total energy contribution annually
1.	Guru Nanak Dev Thermal Plant Bhatinda	4 x 110 MW = 440 MW	2266 MUs
2.	Guru Gobind Singh super thermal plant Ropar	6 x 210 MW = 1260 MW	6942 MUs
3.	Guru Har Gobind Thermal Power Plant Lehra Mohabbat (Bhatinda)	920MW	220.8 Lac units daily

Table 5.1 Existing Thermal Plant

5.1.2 Existing Hydro Plant

S. No.	Plant	Total Generating Capacity	Total energy contribution annually
1.	Ranjit Sagar Dam Project, Shahpurkandi	600 Mw	2013.19 MUs
2.	Shanan Power House, PSEB, Joginder Nagar	110 Mw	597.98 MUs
3.	Anandpur Sahib Hydel Project	134 Mw	788.198 MUs
4.	Mukerian Hydel Project, Stage-I	207 Mw	1069.73 MUs
5.	U.B.D.C Power Houses, Stage-I & Ii	91.35 Mw	410.0 MUs

Table 5.2 Existing Hydro Plant

5.1.3 Micro Hydel Projects

S. No.	Plant	Total Generating Capacity	Total energy contribution annually
1.	Nidampur	800	0.08
2.	Daudhar	1500	0.36
3.	Rohti	800	-
4.	Thuhi	800	-

Table 5.3 Micro Hydel Projects

5.2 Transmission System of Punjab

Transmission lines organization has been assigned the work of construction of 66/132/220KV Transmission lines and up-gradation/augmentation of 33KV lines to 66KV lines. Works are carried out as per list of works approved by CE/Planning. In addition to the above, 66/132/220KV lines are also being constructed for Private Consumers and also to restore supply which gets disturbed during natural calamities/heavy storms.

Sr. No.	**Year**	**220KV Lines (ckm)**	**132KV Lines (ckm)**	**66KV Lines (ckm)**	**33/66KV (ckm)**	**Total (ckm)**
1	1997-98	225.592	11.006	179.052	45.856	461.506
2.	1998-99	532.99	23.642	213.904	35.877	806.413
3.	1999-2000	132.736	15.422	237.542	35.678	421.378
4.	2000-01	281.977	42.393	212.495	39.518	576.383
5.	2001-02	111.35	13.286	177.043	48.578	350.257
6	2002-03	129.405	24.057	44.01	10.783	208.255
7	2003-04	137.915	14.971	148.352	47.142	348.38
8.	2004-05	88.814	17.366	183.958	40.01	330.148
9.	2005-06	193.287	13.578	203.126	67.105	477.096
10	2006-07	79.650	14.604	507.318	-	601.572
11	2007-08	79.968	15.735	611.087	1.149	707.939
12	2008-09	158.654	13.167	436.768	1.900	610.489
13	2009-10 Up to 7/09/10	14.590	21.424	138.610	-	174.624

Table 5.4 Year wise Progress of Transmission Lines

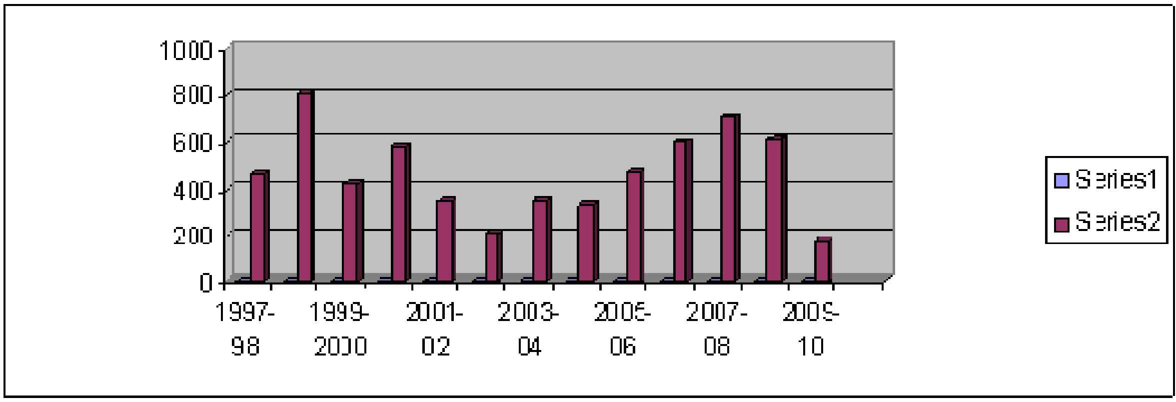

Fig 5.1 Year wise Progress of Transmission Lines

5.3 Distribution Zones of Punjab

1. **South zone**

   The Distribution Zone(South) is spread over an area of approx. 11900 Sq. Kms. comprising of Patiala, Sangrur and Ropar Districts and parts of Fatehgarh Sahib, Ludhiana, Nawan Shahar, Districts. Patiala and Sangrur Districts under this Zone are pre-dominantly agriculture based and cover 2/3rd of the area of this Zone having 2.17 lacs agriculture connections.

   The DS Zone (South) has four DS Circles, headquartered at Patiala, Sangrur, SAS Nagar Mohali and Ropar. This Zone is catering to approx. 12.96 lacs consumers of different categories who are being fed through 12 No. 220KV, 109 No. 66KV, 5 No. 132KV and 5 No. 33KV Grid Sub Stations, located at various load centers. The Distribution network comprises of approx. 29000 Km. of 11KV line and 43000 Km. of LT line with approx. 60000 Distribution transformers of various ratings.

2. **Central zone**

   The Central Zone comprises of Suburban, Khanna, and Ludhiana.

Salient Features of Customer Care Centre

- Computerized Customer Care Centre has been opened in the office of CE/Op. Central Ludhiana to provide Single Window Service to consumers of East & West circle (Ludhiana city) to provide following services at single point. From 1/2007 and running successfully.

  - Time bound redressel of consumer grievances/complaints.
  - To provide other services such as registration of applications for new/extensions cases in respect of all categories of connections at single point.
  - Providing facility of deposit of bills for senior citizens, ladies, Government employees, PSEB employees, handicapped persons etc at one place under single window

- All works registered at Customer Care Centre Ludhiana are being monitored by this office till the clearance of case and consumer/applicant is also being kept duly informed about the progress of his/her case.

3. **West zone**
   The West Zone comprises of Bathinda.

4. **North zone**
   The North Zone comprises of Hoshiarpur, Kapurthala Circle.

5. **Border Zone**
   The Border Zone comprises of Amritsar, Gurdaspur Circle.

5.4 Restructuring of Punjab State Electricity Board

The government of India has initiated reforms for liberalizing the power sector in the country to contain T&D losses, burgeoning subsidy burden and rampant corruption & for improving overall efficiency by making every individual accountable. The enactment of Indian Electricity Act 2003 was the first step in this direction.

Joining the league of other states in India, regarding implementation of Power sector reforms, Punjab Government has also unbundled **Punjab State Electricity Board (PSEB),** which was a statutory body formed on 01/02/1959 responsible for Generation, Transmission and Distribution of electricity in the state of Punjab.

Vide Notification No 1/9/08-EB(PR)196, dated-16.04.2010 Govt. of Punjab carved out following two corporations out of erstwhile PSEB:

- **Punjab State Power Corporation Limited (PSPCL)**
- **Punjab State Transmission Corporation Limited (PSTCL)**

Punjab State Load Dispatch Centre (SLDC), now a separate accounting unit of Punjab State Transmission Corporation Limited (PSTCL), is a state of art Computerized Control centre established in August 2002 at Ablowal, Patiala. It ensures integrated operation of the power system of Punjab with the Northern Region Load Dispatch Centre of India.

Under Section 31 of the Indian Electricity Act, 2003 it is mandatory for the States to establish their own Computerized State Load Dispatch Centers for performing the following functions (as specified under Section 32 of Indian Electricity Act 2003): -

- To ensure integrated operation of the Power System in the State.
- Optimum dispatch of Electricity.
- Monitoring and control of system parameters to maintain healthiness of the Power System at all times.
- SLDC shall keep accounts of the quantity of electricity transmitted through State grid.

5.5 Provisions Made For Power Sector Reforms in Punjab

1. **Manpower Rationalization**

   There was over employment leading to high establishment costs in the state. Punjab has endeavored to progressively reduce the surplus manpower, thus making the utility more efficient and viable organization

2. **Management Information System**

Punjab is on the way to develop an effective Distribution Management Information System. Lot of efforts is being put in this direction.

3. **Energy Audit**

Punjab has undertaken energy audit at all levels in the past also. To achieve this, the electromechanical energy meters have been replaced by electronic meters on all 11 KV distribution feeders and LT side of distribution transformers. Frequent energy audits are being carried out for energy conservation and efficient use of electricity.

The efforts are in progress to replace all electro-mechanical meters by electronic meters for domestic as well as commercial consumers in a phased manner.

4. **Demand Side Management**

Punjab is implementing a program in the field of demand side management through energy efficient bulbs, tube lights, time of the day metering etc. PSPCL is educating consumers to improve the efficiency on DSM by organizing exhibitions in the entire District, State level festivals and also used to organize workshops in this direction.

5. **Computerized and On-line Billing**

Punjab already has computerized billing for most of its consumer in the state and some urban consumers have been provided the facility of on-line billing and payment thereof. There are of course some difficult as well as remote areas where still conventional billing by meter readers is being done. These efforts have improved the overall efficiency of the organization and in addition to this all accounting and auditing works have also been computerized.

6. **Facility of Open Access**

This procedure, terms and conditions and charges will also be applicable to embedded Open Access customers of PSPCL who use transmission and/or Distribution system of PSTCL / PSPCL in conjunction with the Central Transmission System through bi- lateral or collective transactions through power exchange, in line with PSERC and/or CERC regulations for Short Term Open access, as amended from time to time.

This procedure shall be applicable for reservation of Transmission and Distribution capacity for short term sale or purchase of power by Open Access customer or existing consumers of PSPCL as well as bulk consumers/CPPs/IPPs or a state utility or an intrastate entity as a buyer or seller as entitled to avail short term Open Access under Open access Regulations, referred to as "Short Term Open Access Customer.

5.6 Losses in Electrical Power Systems

Technical losses on distribution systems are primarily due to heat dissipation resulting from current passing through conductors and from magnetic losses in transformers. Technical losses occur during transmission and distribution and involve substation, transformer, and line related losses. These include resistive losses of the primary feeders, the distribution transformer losses (resistive loses in windings and the core losses), resistive losses in secondary network, resistive losses in service drops and losses in kWh meter [23]. Losses are inherent to the distribution of electricity and cannot be eliminated. Technical losses are due to current flowing in the electrical network and generate the following types of losses:

- Copper losses those are due to I^2R losses that are inherent in all inductors because of the finite resistance of conductors
- Dielectric losses that are losses that result from the heating effect on the dielectric material between conductors
- Induction and radiation losses that are produced by the electromagnetic fields surrounding conductors.

5.6.1 Technical losses:

These Losses are possible to compute and control, provided the power system in question consists of known quantities of loads. The following are the causes of technical losses:

- Harmonics distortion
- Improper earthing at consumer end
- Long single phase lines
- Unbalanced loading
- Losses due to overloading and low voltage
- Losses due to poor standard of equipments.

Technical losses are naturally occurring losses (caused by actions internal to the power system) and consist mainly of power dissipation in electrical system components such as transmission lines, power transformers, measurement systems, etc. Technical losses are possible to compute and control, provided the power system in question consists of known quantities of loads.

5.6.2 Non-technical losses (NTL):

These Losses are on the other hand; occur as a result of theft, metering inaccuracies and unmetered energy. NTLs, by contrast, relate mainly to power theft in one form or another. They are related to the customer management process and can include a number of means of consciously defrauding the utility concerned [24]. Theft of power is energy delivered to customers that is not measured by the energy meter for the customer. This can happen as a result of meter tampering or by bypassing the meter. Losses due to metering inaccuracies are defined as the difference between the amounts of energy actually delivered through the meters and the amount registered by the meters. All energy meters have some level of error which requires that standards be established. The most probable causes of Non Technical Losses (NTL) are:

- Tampering with meters to ensure the meter recorded a lower consumption reading
- Errors in technical losses computation
- Tapping (hooking) on LT lines
- Arranging false readings by bribing meter readers
- Stealing by bypassing the meter or otherwise making illegal connections
- By just ignoring unpaid bills
- Faulty energy meters or un-metered supply
- Errors and delay in meter reading and billing

- Non-payment by customers.

5.7 Transmission and Distribution Losses

In India, average T & D (Transmission & Distribution) losses; have been officially indicated as 23 percent of the electricity generated. However, as per sample studies carried out by independent agencies including TERI, these losses have been estimated to be as high as 50 percent in some states. In a recent study carried out by SBI Capital Markets for DVB, the T&D losses have been estimated as 58%. This is contrary to claims by DVB that their transmission and distribution losses are between 40 and 50 percent. With the setting up of State Regulatory Commissions in the country, accurate estimation of T&D Losses has gained importance as the level of losses directly affects the sales and power purchase requirements and hence has a bearing on the determination of electricity tariff of a utility by the commission.

S. No.	Description	2007-08	2008-09	2009-10	2010-11	2011-12 up to 12/11
1	Energy Loss (MUs)	8796.28	7416.03	8142.85	6063.938	6241.77
2	% age of T &D Losses	22.53	19.91	20.12	18.71%	17.54%

Table 5.5 Transmission and Distribution Losses

5.7.1 Components of T&D losses

Energy losses occur in the process of supplying electricity to consumers due to technical and commercial losses. The technical losses are due to energy dissipated in the conductors and equipment used for transmission, transformation, sub- transmission and distribution of power. These technical losses are inherent in a system and can be reduced to an optimum level. The losses can be further sub grouped depending upon the stage of power transformation & transmission system as Transmission Losses (400kV/220kV/132kV/66kV), as Sub transmission losses (33kV /11kV) and Distribution losses (11kV/0.4kv). The commercial losses are caused by pilferage, defective meters, and errors in meter reading and in estimating unmetered supply of energy [25].

5.7.2 Reasons for high T&D Losses

Experience in many parts of the world demonstrates that it is possible to reduce the losses in a reasonably short period of time and that such investments have a high internal rate of return. A clear understanding on the magnitude of technical and commercial losses is the first step in the direction of reducing T&D losses. This can be achieved by putting in place a system for accurate energy accounting. This system is essentially a tool for energy management and helps in breaking down the total energy consumption into all its components. It aims at accounting for energy generated and its consumption by various categories of consumers, as well as, for energy required for meeting technical requirement of system elements. It also helps the utility in bringing accountability and efficiency in its working.

5.7.3 Reasons for high technical losses

The following are the major reasons for high technical losses in our country: -

- Inadequate investment on transmission and distribution, particularly in sub-transmission and distribution. While the desired investment ratio between generation and T&D should be 1:1, during the period 1956-97 it decreased to 1:0.45. Low investment has resulted in overloading of the distribution system without commensurate strengthening and augmentation.
- Haphazard growths of sub-transmission and distribution system with the short-term objective of extension of power supply to new areas.
- Large scale rural electrification through long 11kV and LT lines.
- Too many stages of transformations.
- Improper load management.
- Inadequate reactive compensation
- Poor quality of equipment used in agricultural pumping in rural areas, cooler air-conditioners and industrial loads in urban areas.

State	2007-08 (ACTUAL)	2008-09 (Actual)	2009-10 (Prov.)	2010-11 (RE)	2011-12 (AP)
Punjab	22.36	19.76	19.97	17.87	16.88

Table 5.6 Aggregate Technical & Commercial losses (within state)

5.7.4 Reasons for commercial losses

Theft and pilferage account for a substantial part of the high transmission and distribution losses in India. Theft / pilferage of energy is mainly committed by two categories of consumers i.e. non-consumers and bonafide consumers. Antisocial elements avail unauthorized/unrecorded supply by hooking or tapping the bare conductors of L.T. feeder or tampered service wires. Some of the bonafide consumers willfully commit the pilferage by way of damaging and/ or creating disturbances to measuring equipment installed at their premises [26].

Some of the modes for illegal abstraction or consumption of electricity are given below:

- Making unauthorized extensions of loads, especially those having "H.P." tariff.
- Tampering the meter readings by mechanical jerks, placement of powerful magnets or disturbing the disc rotation with foreign matters.
- Stopping the meters by remote control.
- Willful burning of meters.
- Changing the sequence of terminal wiring.
- Bypassing the meter.
- Changing C T ratio and reducing the recording.
- Errors in meter reading and recording.
- Improper testing and calibration of meters.

5.7.5 Expected AT&C loss (%)

- It is the difference between units input into the system and the units for which the payment is collected.
- T&D Loss do not capture losses on account of non-realisation of payments.
- AT&C Loss is the clearest measure of overall efficiency of the distribution business as it measures technical as well as commercial losses.

- AT&C Loss(%) = $\dfrac{(\text{Energy Input} - \text{Energy Realised}) \times 100}{\text{Energy Input}}$
- Energy Realised = Energy Billed X Collection Efficiency

- Collection Efficiency (%) = $\dfrac{\text{Amount Realised X100}}{\text{Amount Billed}}$

Region	**State**	**2009-10**		**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
		Input Energy (MU)	**AT&C Loss (%)**					
Northern	Punjab	38806	17.73	16.23	14.73	13.23	11.73	10.23

Table 5.7 Expected AT&C loss (%)

Table 5.11 is showing the Expected AT&C loss (%). According to this the AT & C losses are reducing year wise.

Chapter-6

6. Conclusion and Future Scope

6.1 Conclusion

As a result of restructuring Electricity Act 2003, the power scenario in Punjab in particular and all over India in general has improved significantly and hopefully will overcome the present grim power situation in future. From the case study of restructured power system of Punjab state, it is found that due to restructuring of the system their comes different benefits in terms of reduction in losses, efficiency improvement and reliability.

The reduction in the losses occurs due to identification of the weakest areas in the distribution system and strengthening them so as to draw the maximum benefits of the limited resources. The power quality and reliability of power supply in the state has also improved markedly. The computerization and implementation of information technology has resulted transparency in commercial business of power utility in state.

Transmission & Distribution losses which were at the level of approximately 22% during 2007-08 have been successfully reduced to the level of 17.5% by 2011-12. The AT&C losses in 2007-08 were of the level 22% are successfully reduced to 17.8%. The AT&C losses will drop to 10%, as found from the calculations of expected losses and under this condition the state will come under the level of minimum Transmission and distribution losses, according to Central Electricity Authority guidelines. The transmission and distribution losses are gradually reducing in Punjab after the restructuring of power sector. These losses are the areas of major concern in any power utility in the state. Lot of energy generated and transmitted goes unmetered in the form of losses, pilferage and theft of energy. This area need to be addressed at the priority level.

6.2 Scope of Future Work

In this thesis analysis of restructured power system of Punjab state is done. Here various losses (T&D, AT&C) are compared and effect of restructuring is analyzed. The main future work is by the use of new analysis tools for comparison purpose. Further the following improvements could be added to the work:

1. Addition of non-technical losses for comparison.
2. Different techniques could be purposed to reduce non-technical losses.
3. Congestion on transmission lines could be found.
4. Remote monitoring of the site could be proposed, depending upon the condition analysis.

References

[1] J. B. Gupta '*Power Systems*, S. K. Kataria & Sons, Publishers of Engineering & Computer Books.'

[2] Loi Lei Lai '*Power System Restructuring and Deregulation*, John Wiley & Sons Ltd. Publishers'

[3] Electricity sector in India. "*Key World Energy Statistics", 2007*.

[4] H.L. Bajaj and D Sharma, "*Power Sector Reforms in India*", Government of India, New Delhi, India.

[5] "Controlling Electricity Theft and Improving Revenue", *World Bank report on reforming the power sector, 2005.*

[6] "Electricity Scenario in India", A report issued by Central Electric Authority, *Ministry of Power, Government of India, 2008.*

[7] J.T. Cain 'Asian and Australian Power Policy, *IEEE Power Engineering Review, February 1996.'*

[8] Dr. C. Palanichamy at al. 'Restructuring the Indian Power Sector with Energy Conservation as the motive for Economic and Environmental Benefits, *Vol.-14, No. 4**,** pp. 1589-1596, IEEE Transactions on Energy Conversion December 1999.'*

[9] Sajal Ghosh 'Electricity consumption and economic growth in India, *Volume 30, Issue 2, pp. 125–129, Research in Business and Economics Journal January 2002.'*

[10] Yog Raj Sood et al. 'Wheeling of Power under Deregulated Environment of Power System - A Bibliographical Survey, *Vol-17, No 3 pp. 870-878, IEEE Transactions on Power Systems, August 2002.'*

[11] A. Srivastava et al. ‘Restructuring Choices for the Indian Power Sector*, IEEE Power Engineering Review, November 2002.’*

[12] S.N. Singh et al. ‘Electric Power Industry Restructuring in India: Present Scenario and Future Prospect, pp. 20-23, *IEEE International Conference on Electric Utility Deregulation, April 2004 Hong Kong.’*

[13] Tripta Thakur et al. ‘Indian Electricity Act 2003: Implications for the Generation, Transmission and Distribution Sectors, *Volume-1, pp. 54-58, IEEE International Conference, and 5-8 April 2004.’*

[14] S. A. Khaparde ’Power Sector Reforms and Restructing In India, *volume-2, pp. 2328-2335, IEEE Power Engineering society general meeting, 10 June 2004.’*

[15] A. Pahwa at al. ‘Electricity Industry Restructuring in India, *pp. 99-105, IEEE 2006*.’

[16] T. J. Hammons ‘Power market restricting in Asia: Russia, China, India and Japan, *Volume 1, pp. 26-35, UPEC 6-8 Sept. 2006.’*

[17] A.M. Ilahi et al. ‘Deregulation of Electrical Power System Network as Utility in Developing Countries with Special Reference to Pakistan*, pp. 1-5, ICEE 11-12 April 2007*.’

[18] R.C. Bansal et al.’ A Discussion on the Restructuring of Indian Power Sector, *pp. 1-6, IEEE 2007.’*

[19] 0. P. Rahi et al. ‘Power Sector Reforms in India: *A Case Study, IEEE 2008*.’

[20] R. N. Datta ‘Financing and Management of Infrastructure in Peri-Urban Areas of Indian Cities, *Journal No 6 - 3, pp. 26 – 34, July – Sep 2009.*’

[21] Dr. Tripta Thakur et al. 'Technical Efficiencies for State owned Electricity Generation Companies in India, *pp. 1-4, ICPS'09 International Conference 27-29 Dec 2009.*'

[22] J. Anitha Roseline et al.' Tamil Nadu power sector reform and restricting- *A case study, pp. 1205-1210, IEEE 2011.'*

[23] Fourie, J.W. and Calmeyer, J.E., "A statistical method to minimize electrical energy losses in a local electricity distribution network," *AFRICON, 2004. 7th AFRICON Conference in Africa, vol.2, no., pp. 667-673, 15-17 Sept. 2004.*

[24] "*Distribution Line Loss*", A report presented in Exhibit a Tab 15 of Schedule 2, Centre Government in August 17, 2005.

[25] P. N Khare MSEB, '*Power Theft – A Root Cause of T& D Losses.*'

[26] Mr.M.H.P. Rao '*Power Sector bogged down by T&D Losses'* in Financial Express, dated July 9 ,1999.

[27] '*State Electricity Boards & Electricity Departments'*, Power & Energy Division, Planning Commission Government of India June, 2001.

[28] '*National Electricity Plan', Vol-1 Generation,* Government of India, Ministry of Power Central Electricity Authority, January 2012.