CHAPTER II
WORKING DEFINITIONS
AND
REVIEW OF LITERATURE
Chapter –II

2.0: Review of Literature and working Definitions

In the power sector and it’s related study it is pertinent to acquaint with various definitions and work pattern. These are explained in this chapter along with pre and post reform studies made in the sector.

2.1 Working Definitions:

**Capacity and Capacity addition:** Capacity of the power plant is the maximum amount of power in Mega watt that a plant can produce. It is indicated by Mega Watt (MW), say 10 MW, 100 MW, 1000 MW and 2000 MW etc. One MW capacity of a plant should generate $1000 \times 24 \times 365$ Kwh or 8.76 million Kwh (Kilo watt per hour) or units of electricity per year. But in practical it is not possible to get 100% generation. Capacity addition is the process of installing power plants of a particular capacity, both in thermal, hydro, nuclear, wind and in other sources. It may be new plants or increasing capacity of old plants.

**Generation:** Electricity or power is the flows of electrons are a source of energy that can create motion, light and heat is called electricity. They are produced from various base sources, (such as Coal, gas, oil) in thermal
power – Water by their potential and kinetic energy create hydro power-atomic fusion and fission forms nuclear power- wind, tidal, solar in non conventional sources also create power. These sources are called power generation sources. Generation of power is made in their plants specifically set up for the purpose. Power generation is measured by Kilo Watt per hour (Kwh) as a unit of power. Powers generated are sent to end users such as domestic, industrial, agriculture and commercial purposes. Power generation plants are generally having capacities in mega watts indicated by MW.

**Power Transmission:** Power generated are forwarded or transported for end users through a special conducting wire lines are called transmission process. Transmission of power is sent for consumer distribution. The transmission network is done by over head line conductors (on steel towers) or underground line conductors- cables. This is done for bulk power transmission. Extra high voltage (EHV) and high voltage (HVDC) direct current are the best transmission practices in commercial way of power transmission methods.

**Distribution of Power:** Generated power from generated source is transmitted in lines for consumer to end use is distribution. A distribution system is sub divided into feeders, distributors and service mains. Feeders
are conductors of large current carrying capacity from bulk quantity to feeding points. Distributors are conductors from which current is tapped off for supply to consumers. The service main are the small cables between the distributor and the consumer’s premises. Power distribution is like a commodity distributed to its consumer.

**Plant Load Factor (PLF):** PLF is the most important performance indicator for thermal plants. It is the ratio between the energy that a power plant in Kwh has produced during the period considered and the energy could have produced at maximum capacity under continuous operation during that entire period. This is indicated in percentage. Main reasons for low PLF are planned shutdowns for periodic overhauling, normal maintenance, breakdowns, higher forced outages due to break downs, tripping and more time taken for planned periodic overhauling. Some times forced to back down during off-peak periods of lower demand. Decline in PLF are mainly due to shortage on account of gas and coal and water storage position in hydel plants.

**Operating Availability:** Operating Availability is another important performance indicator. It measures the percentage of time the plant is available for generation. This may be due to unavailability of or failure of boilers and auxiliaries, turbines and auxiliaries, generators etc.
**Forced Outages:** Forced Outages is an unplanned component failure or any other condition that requires the generating units to be removed from services immediately or within a short period of time. Outages are caused by boiler and its auxiliary being on the higher side compared to generator problems. Turbine outages also cause substantially. Reserve shutdowns accounts for general outages.

**Preventive Maintenance:** Planned maintenance and its availability and unavailability of the plant for power generations are indicated in percentages. These are the other important performance indicators. This is an efficiency indicator of maintenance plan of a plant. Various factors of quality of maintenance, wear and tear, repairs and breakdowns, re-equipment of these repairs, lubrications, rectification of repairs play a role.

**Partial Loss or Availability:** Partial Loss or Availability are caused primarily due to internal and external constraints from deficiency in achieving full rating of the units either in equipment or auxiliary as a result of which the operating units cannot deliver the rated output. On the other hand, external constraints arise from causes external to power station equipments such as shortage of fuel and cooling water. This results in generation or complete shutdown of one or more of the units. Partial loss
are indicated in percentages. Major partial losses are due to mechanical constraints followed by boiler and auxiliaries.

**Plant Availability:** Plant Availability is the percentage of available plant for generation of power. This depends on reduction of unplanned unavailability. Better usage of planned outages and improved preventive maintenance practices improves plant availability.

**Technical Loss:** Every element in a power System (a line or a transformer etc) offers resistance to power flow and thus consumes some energy while performing the duty expected of it. The cumulative energy consumed by all these elements in classified as “Technical Loss.”

**Commercial Loss:** Losses occur on account of non-performing and under performing meters, wrong applications of multiplying factors, defects in CT & PT circuitry, meters not read, pilferage by manipulating or by passing of meters, theft by direct tapping etc. These are all due to non-metering of actual consumption and are called commercial losses. The totals of “Technical” and “Commercial” losses are termed are T&D loss.

It is unfortunate that in addition to the above, there is also a loss in revenue due to non-realization of billed demand. This is in addition to commercial losses and the aggregate of T&D loss and revenue loss due to non-
realization is termed as “AT & C loss” (Aggregate technical and Commercial loss). Therefore AT &C loss to the utility is the sum total of technical loss, commercial losses and shortage due to non-realization of total billed demand.
2.2: Review of Literature

2.2 Historical Backdrop and related studies

Kandula Subramaniam (2004) explains that recognizing that electricity was the most convenient form of energy and an essential prerequisite for industrial development, the Indian Industrial Commission, which reviewed the industrial development of the country from 1916-1918, stressed the importance of power development in the country and emphasized the need for a detailed hydroelectric survey to enable systematic development of water power resources. Responding to these recommendations, the central government instituted a survey of hydro-development potential. The period between the two World Wars witnessed the development of the Pykara, Mettur and Papanasanam hydroelectric projects in Madras (now Tamil Nadu); the Uhl river project in Punjab; the chain of power stations along the Ganga Canal in the United Provinces (now Uttar Pradesh); the Pallivasal Project in Travancore (now Kerala); and the expansion of the Sivasamudram Project in Mysore (now in Karnataka). In these states, grid systems began to emerge, as electricity from the hydroelectric projects was carried to distant load centers.

In 1989, the World Bank estimated that the requirements of the electricity sector in developing countries added up to US $100 billion per year. By contrast, only about US $20 billion was available from multilateral lending
institutions, leaving a gap of about US $80 billion (Churchill and Saunders, 1989).

The requirement for additional power capacity to meet the projected demand for electricity formed the underlying basis of the power sector liberalization process when the policy was announced in 1991. The growth of the Indian economy could not be held ransom for lack of electricity. Thus, in order to support an annual GDP growth rate of approximately 7 percent, the power supply needed to increase by over 10 percent annually (Ministry of power website, 2005).

Private investors entered the power sector as Independent Power Producers (IPPs). IPPs faced immediate worries about receiving payments in full and on time for the sale of power they made to the SEBs. Put simply, the private sector “will not take the risk of not being paid (Ahluwalia and Berry, 1996)

Any such risk factor was unacceptable because infrastructure projects yield relatively low returns and have long payback periods. Power plants are perceived to be commercially less profitable. Such projects had therefore been undertaken by the public sector. Private promoters faced difficulties when trying to obtain funding, as bankers were unlikely to agree to loans with maturity longer than three years, to match the tenure of their deposit liabilities.
Even financial institutions (FIs) find it difficult to extend loans commensurate with the long payback periods of power projects (Antonette D' Sa, Murthy and Reddy, 1999)

A number of factors influence the heat of a generating plant, the choice of technology, size and fuel puts a limit on the thermal efficiency achievable. Other factors like vintage of the plant also play a role in determining the upper limit of efficiency. This heat rate is specific to each of the generating units and is known as the design heat rate. The design heat rate is supplied by the equipment manufacture. In practice, it has been found that the actual heat rate is higher that design heat rate. Studies carried out on selected plants at the state level have reported significant deviations of the actual heat rate from the designed one (Alagh, Shah and Shah, 1998). A number of factors like ownership of the plant, management practices, maintenance schedule, quality of fuel etc. lead to this difference between the actual and design heat rates.

Study that examine the policy incentive for adoption of energy efficient technologies, considering that these efficient technologies help in reducing emissions, are relatively fewer in number (Verhoef and Nijkamp, 1999).

The reforms have not only led to the entry of private players in generation, but have led to the mergence of various ownership structures, which were not present earlier. In addition to federal plants, state plants and plants owned by
licenses, new structures like purely private initiatives and cooperative ventures between the government and private players have come. In addition, private organizations pooling resources for setting up generating plants and sharing the electricity over the state grid has become a unique feature of the state (Shukla, Debashish Biswas, Tirthankar Nag, Amee Yajnik, Thomas Heller and David G. Victor, 2004).

The driving forces behind the electricity sector reforms in developed and developing countries have been different. In developed countries, the main aim of the reforms has been to improve the performance of relatively efficient systems. In developing and transition countries, the burden of price subsidies, low service quality, low collection rates, high network losses, and poor service coverage have meant that many governments are no longer willing or able to support the existing arrangements (Newbery, 2002; Joskow, 1998). The reforms have sought to transform the state-owned and centralized electricity sectors into decentralized, market-oriented industries with private sector participation, competition in generation and supply businesses, and regulation of natural monopoly activities. In order for the decentralized industry to function, the reform and regulatory design must establish appropriate structural, institutional, and operational framework. The main steps of a stylized reform are to (i) restructure the sector, (ii) establish regulatory authorities, (iii) organize markets for generation, (iv) regulate transmission and distribution
networks, (v) privatize existing assets and promote new investments, and (vi) allow for cost-reflective electricity tariffs (Newbery, 2002; Joskow, 1998).

Electricity sector reforms in developing countries have taken place within diverse political, economic, and structural contexts. In addition, many reforms were initiated at a time when the international experience with such initiatives was limited. Consequently, the reforms have taken a variety of forms and followed different paths (Bacon and Besant-Jones, 2001; Millan et al., 2001). Within this background, it is perhaps not surprising that many reforms have encountered unexpected problems and the degree to which they have achieved their goals varies across the countries (Fischer and Serra, 2000).

The international experience with electricity sector reform in developing countries has shown that achieving workable reforms is considerably more complicated than anticipated. Electricity systems in developing countries vary considerably with regard to size, structure, and resource mix. In addition, many of these countries are constrained by institutional endowment of their political and economic systems and lack of human resources with regulatory skills and experience (Stern, 2000).

It is generally recognized that regulatory design and implementation strategy should take the specific characteristics of the sector in question into
consideration. However, the reform models adopted have not always fitted the sectors of these countries and many reforms have encountered unexpected problems and unintended outcomes. The experience has shown that regulatory design is crucial to success and failure of reforms (IADB, 2001).

2. Private Sector Participation in Electricity Sectors of Developing Countries

Private sector participation is arguably the most important element of electricity sector reforms. For many reforming countries faced with increasing burden of capital requirements for expansion of publicly owned electricity systems, private participation is an alternative source for securing the much-needed investments in the sector. In addition, to the extent that the required public expenditures are financed through taxation, the marginal cost of public funding in terms of the associated dead-weight loss constitutes an added social welfare loss. In developing countries, the magnitude of such losses can be significantly higher than 1. For example, the dead-weight loss in Malaysia, Philippines, and Thailand have been estimated at 1.2, 2.5, and 1.2-1.5 respectively (Beato and Laffont, 2002; World Bank, 1997).

Private ownership together with competition (and incentive-regulated networks) is expected to result in cost efficiency, lower prices, reduced system losses, and improved revenue collection (Newbery, 2002).
Electricity supply industry is no longer viewed as a vertically integrated natural monopoly activity. Rather, the industry is regarded separate as separate but inter-related activities with distinctive economic characteristics. The new view of the electricity sector is that the generation and supply activities are potentially competitive while the transmission and distribution activities can, exhibiting natural monopoly characteristics, be subject to incentive-based regulation. The main focus of electricity sector reforms has been on liberalization of electricity generation. However, many reforming countries have experienced difficulties in enforcing effective competition in this market. It has now become evident that regulatory design is crucial for achieving effective competition in the sector. Lack of competition results in market power to existing actors that (i) reduces pressure on cost-saving efforts, (ii) limits consumer choice, (iii) distorts investments in new generation capacity, and (iv) prevents new entries. Several conditions can lead to lack of real competition and market power. First, in the restructuring phase, the reform must ensure that existing generation resources are split into a sufficient number of potentially competitive units. The main issues here are to avoid establishment of dominant firms and ensure a balanced resource mix among the competing firms while taking the size of the sector into account. In the UK, the problem of market power became apparent shortly after the reform. It was only after a lengthy process of new entries by IPPs and forced divestiture of generation capacity by
the incumbents that a more competitive market was achieved (Newbery, 1999).

Economic theory suggests that cost-reflective prices result in net social welfare gain. This implies that the welfare economic gains by those who benefit from lower prices exceed the welfare losses incurred by those who stand to lose from price increases. However, without public interference no automatic transfer from gainers to (targeted) losers will take place to compensate the latter. At the same time, mapping and measurement of distributional aspects of tariff adjustments is an inherently complex task (Chang, 1997).

In some circumstances a price increase to efficient levels may also be socially defendable. For example, in countries with very low rates of access the service is often only available to richer consumers. Therefore, a rate increase that eliminates the system’s deficit financed by the whole population and frees resources for improving access to others can be justifiable. For example, two important questions are the intensity and distribution of gains and losses across different groups of consumers. Welfare losses to some disadvantaged consumer groups can be much larger than the benefits accrued to many gainers. Also, in poorer countries losers generally constitute a very large portion of the population while the number of gainers can be far fewer. In addition, the higher the level of existing subsidies is the more noticeable are the distributional
impacts of tariff re-balancing. There is considerable scope for efficiency improvement in distribution utilities. At the same time, tariff adjustments can play an important role in financial health of electricity distribution utilities and their ability in achieving these efficiencies. Price adjustments are therefore closely linked to the issue of privatization of distribution utilities. However, in many developing countries, the need for subsidies will be present for the foreseeable future. The important issue is to design subsidy schemes that address undesirable social impacts while limiting price distortions and adverse impacts on the economic efficiency of reforms. Some subsidy schemes can be either very costly as they also tend to benefit ineligible consumer groups (inclusivity issue), or that they do not reach the targeted groups (exclusivity issue). Inadequate attention to the distributional implications of price increases can severely affect the progress of the reform process. In India, the state of Orissa restructured and privatized the distribution companies. Despite substantial and politically difficult tariff increases (11% in 1997, 9.3% in 1998, and 4.5% in 2000), the privatized utilities experience severe financial difficulties. The companies are unable and lack incentives to invest in efficiency improvement measures (TND, 2002; Business Line 2001).

The experience form the past two decades has shown that achieving sustainable private participation and market-oriented electricity sector reforms
are more complex than initially anticipated. The cases of the UK and California have demonstrated that even in developed economies reforms encounter problems and exhibit intended consequences. Developing countries have had to reform technically and financially less efficient systems with less developed private sectors, weak economic and political institutions, and shortage of human resources and regulatory experience (Tooraj Jamasb, 2002).

In developing countries, the experience with electric power markets has been quite different. In the late 1980s and early 1990s, all of the largest developing countries, along with many of the smaller developing countries and nations in transition in the midst of rapid economic growth, announced plans to restructure their power systems. In the years since, most actually attempted some market-inspired restructuring. Yet the electric power systems that are in place today bear little resemblance to the theoretical market-oriented idea (Thomas C. Heller and David G. Victor, 2003).

Thomas C. Heller and David G. Victor, (2003) focus on five countries—Brazil, China, India, Mexico and South Africa. Their study reveals that the difficulty of reform stems from the nature of state-centered systems—their financing, the many ancillaries social functions that are performed by SOEs, and their systems of governance and control. Those attributes, we suggest, lead to predictable patterns of behavior in the reform process. We suggest that they
will explain why efficiency alone is unlikely to be an adequate motivator for reform. They also suggest that the process of reform is likely to become intertwined with reforms in other aspects of the economy, such as fuel markets. Financing, in particular, would appear to be the key variable.

During more than fifty years, the Brazilian power industry was developed by state owned companies, operating under a cost plus tariff regime. During this long period, the interconnection of the regional grids was explored to improve economic and technical performance of the system. The large availability of domestic fiscal funds and international soft loans has been a key element in the successful trajectory of the industry in this period. However, the interconnection had a corollary: centralization of generation and transmission in the federal government companies, a process that found opposition in the state (provincial) companies. The reaction to this process came in the 1980's, when successive unsuccessful macroeconomic stabilization produced a disastrous economic effect in the electricity companies. Until 1998, it seemed that the reform was a success but looking from today the reform is a complete failure. This shift in perception is the result of the fact that at the beginning of the process, the fundamental regulatory flaws of the reform have had no time to show up their detrimental effect. These flaws became visible during the rationing period. Chiefly among these problems are the need of mitigation risk mechanisms for private investors and the regulatory interlink between the
natural gas industry and the power industry. In other words, the reform was unable to generate the climate for private investment, particularly in thermal power plants. The new government is promising radical changes in the industry but statization is not in its agenda so far. However, the new government offers signals that it will not favor competition and intends to roll back to government a substantial role in the decision making process, particularly as far as investments is concerned (Adilson de Oliveira, 2003).

India’s energy sector revolves around State Electricity Boards (SEBs), which own and operate vertically integrated monopolies—in generation, transmission and distribution. Although SEBs were guaranteed a rate of return on their investments, in practice all have sustained heavy losses that the state and central governments in India are increasingly incapable of bearing. Large losses in the system are due especially to theft as well as to a transmission and distribution system that is not engineered for optimal reduction in transmission losses. In addition, the tariff-setting mechanism has been politicized and structured in ways that, in effect, subsidize agricultural consumption; now that agricultural interests favoring cheap electricity (used mainly for pumping water) are entrenched, the challenges to reformers have mounted.

Reform started in India in 1991 with a series of “fast-track” projects aimed to attract new generation capacity. Conceived at a time of broader reforms in
India that were designed to open capital and trade to foreign competition, these Independent Power Producers (IPPs) were expected to operate on the basis of long-term power purchase agreements (PPAs) with highly profitable tariff structures that were intended to attract outside investors. Among these were the notorious Dabhol project, plagued by negotiations that lacked transparency and guaranteed tariff that was extremely high—leading to allegations of corruption that are a shadow over the project even today. In the end, few "fast track" projects were actually built, and the focus on generation has proved to be misplaced. The root cause of India's power crisis is the lack of profitability in the final distribution and billing for power—a problem that requires a focus on the SEBs (Rahul Tongia, 2003).

India needs to focus on capacity expansion, policy-makers should look more carefully at all the options available at the local level. In particular, the possibility to franchise rural service areas to private companies deserved to be investigated more thoroughly. With regard to the environment as well, new options to modernize the sector and provide environmental protection could be explored, specifically by: (1) exploring gas as an end-use energy alternative (use for cooking, etc. rather than for thermal energy production); (2) exploring decentralized generation; (3) increased efforts to support demand-side management; and (4) investigate carbon subsidies. However, all of these options depend critically on new financing and significant regulatory capacity.
The third speaker provided an investor perspective on IPPs. First off, he mentioned that there is an unprecedented melt-down currently going on in the share values of power developers. Rather than the poster child, energy developers and utility companies in general are now seen as risky investments by the financial capital markets. A previous speaker cited economic force majeure as the major cause for the investment slump, but investors usually regard these factors as part of the normal business cycle. And while it is true that power purchase agreements are changing, this speaker commented that investors saw PPAs only as stepping stones to a competitive market and not as solutions that were sustainable in the long run (The Political Economy of Power Market Reform, Conference Report, Stand Ford University, 2003).

(Arul Raj & Raja Sekaran 2006) explained that due to shortages of power generation and supply in India export of power from neighboring countries which has huge hydro potentials that can be developed along with neighboring countries in the BIMSTEC nations, (Bay of Bengal League of Nations for economic co-operation) energy co-operation policy. These countries include Bangladesh, India, Myanmar, Srilanka, Thailand, Nepal and Bhutan.

The study elaborate further in profile of study area in Chapter - III