CHAPTER- 6

SUMMARY AND CONCLUSIONS

In the process of economic development and growth, various economies are critically dependent on energy sources. Among the various energy resources, electricity is the most preferred form of energy. It is becoming increasingly a key energy input to economic growth and for improving the quality of life. Thus, in the developing economies, the demand for electricity has been increasing at a fast rate. This situation calls for a huge increase in the power infrastructure.

The 16th Electric Power Survey of India (2000) has projected a peak demand of 1,57,107 MW and energy requirement of 9,75,222 MU by the year 2012 in the country. To meet this projected demand, India aims to add 1,00,000 MW of generation capacity by the year 2012, much of this from fossil- based fuels, which result in huge quantities of pollutants, including particulates, sulfur dioxide, nitrogen oxide and carbon dioxide etc.

The enormous amounts of capital would be required for this capacity addition for the generation, transmission and distribution components. However, various experts have expressed their reservations in mobilizing such a massive amount of capital for this capacity addition. It has been pointed out that in the present scenario of capital shortages, the required amount seems to
be beyond the financial capacities of states as well as central government in the country. Various studies have also showed that financial and technical performance of existing electricity undertakings were also in a bad shape, which constrained capacity of the electricity undertakings to generate resources for further investment. Thus, public sources to finance generating facilities are not expected to be adequate to meet the estimated power needs.

Moreover, private capital is also not expected to come forward in desired quantity in the power sector. As the past experience shows that even after attracting private capital, the private sector investments have not materialized to the extent envisaged. This situation indicates that the availability of capital for these investments would be inadequate.

In addition to capital constraints, the efforts to make massive additions to generation capacity are also likely to be constrained by the environmental considerations which are becoming increasing important and if not already, would soon be difficult to ignore in future. In the past, environmental issues have been considered secondary to economic growth in developing and industrialized nations. Recently, however, both local and global environmental impacts have been identified as a potential constraint to development.
Such a state of affairs warrants complete reconsideration and review of the functioning of the power system in the country. In these circumstances, one alternative has been to restructure the SEBs and improve its technical and financial efficiency. Some experts have argued to the extent of completely privatizing power utilities and let the market bring in competitiveness and efficiency in the industry.

Another school of thought has argued that the existing supply-oriented paradigm has resulted in low efficiency in power use at consumer end. The existing consumption pattern is not socially desirable as it is environmentally unsustainable. The inefficiencies in power use have resulted again in higher demand for power. Thus, the conventional paradigm led us into a vicious circle. The circle was complete with the demand forecasts echoing the high growth scenario. This strategy also led to depletion of non-renewable energy resources like coal and petroleum and also require huge investment and not even environmentally sustainable. Hence, there may be a serious threat of energy crisis for the future generations.

In these circumstances, it was advocated to design an integrated resource based power planning, as a alternative to the conventional paradigm, which arrives at a mix of all electric supply options including conventional, renewable and end – use efficiency, to meet the total electricity needs of the country.
Thus, in the alternate paradigm, rather than simply building new centralized generation plants, power planners are expected to compare all investment options for both supply side as well as demand side on a common basis and choose the least –cost options to meet the projected power demand.

Thus, the main objective in the present study has been to develop an alternate capacity expansion plan for Haryana State based on integrated resource planning paradigm. The resultant plan would add the same level of capacity which has been given in state’s capacity expansion plan and based on centralized sources only, by incorporating demand-side management, renewable / decentralized sources of electricity supply into it. The comparative economic benefits of the integrated plan over the centralized capacity expansion plan have also been examined. The plan horizon of one decade (2002-2012) from the base year of 2001-02 (2002 in short) up to the terminal year 2011-12 (2012 in short) has been taken.

All the investment options of electricity supply in the state including supply –side as well as demand-side, has been evaluated on the basis of a life cycle cost methodology. The life cycle cost (LCC) may be defined as the total discounted (present value) cash flow from an investment taking into account the future costs during its useful economic life. It is thus equal to the sum of all the present values (PV) of annual costs and initial capital cost.
LCC has also been annualized over the economic life of each plant by multiplying it by the capital recovery factor (refer to appendix -B) to have an equivalent uniform annual worth (cash flow) that remains constant throughout the life of the plant. This is called annualized life cycle cost (ALCC) or levelized cost. Using the ALCC and the net energy generation at busbar, the life cycle cost of energy or capacity in Rs. / unit has been calculated. This is the representative cost of energy or capacity that remains constant over the life of the plant. This cost may be used for comparison even if plants have different generation or capacity levels. Hence, this is a highly versatile decision making tool or commonly used measure to compare alternative investment options or to select the preferred options. This method, however, assumes that the cash flow in all succeeding period will be the same. Though the future disbursements and receipts of a particular alternative may increase because of inflation, in general, these would increase for other alternatives as well. Thus, as long as the method is used for comparison of alternatives, the same conclusions would be reached at any future date as long as all cash flows increase proportionately. However, in the present exercise, all costs have been calculated at 2002-03 price level. To arrive at current prices, we may also use inflation indices for energy and equipment inputs.
Details of life-cycle costing methodology of each option are given in chapter 1; p. 20-32 and worksheets for each option are provided in appendices C, D and G.

The study has used the secondary data, which are compiled by different ministries, agencies, departments, commissions, power utilities etc. However, in the demand-side options, more reliable estimates of potential energy/power savings require additional data on energy consumption disaggregated by end-use equipment/measure in each consumer class. This type of comprehensive information is not available at present in India. Thus, in the study, whenever data were not available, estimates have been used.

The study has been developed in six chapters. The Chapter 1 is introduction. The Chapter 2 is devoted to the Review the existing literature. In Chapter 3, the performance of Haryana power system has been evaluated. In Chapter 4, the centralized and integrated plan for Haryana state has been worked out and results are compared. The Chapter 5 analysis the barriers to DSM within the current system and describe some strategies to achieve the existing DSM potential in the state. The chapter 6 is devoted to the summary and main conclusions of the study.
Main Findings of the Study

The Sixteenth Electric Power Survey of India has estimated an increase in the peak load demand and energy requirement in Haryana state from 3322 MW and 17460 Mkwh in 2001-02 to 7192 MW and 37801 Mkwh (at the bus bar) respectively in the period 2011-12 (Table 4.1). In response to this estimated demand, the state has planned to augment new generation capacity of 4437 MW between 2002-12 through various centralized power projects located within the state and outside, in addition to the available installed capacity of 3211 MW as on 31.3.2002 (Table 4.2). The projections of planned capacity shows that 3888 MW (88 %) would be based on fossil fuels only (coal based thermal, gas based combined cycle gas turbines (CCGT) and gas based open cycle gas turbine (OCGT)). The remaining 12 percent would be based on hydro sources.

Centralized Least-Cost Capacity Addition Plan

We have evaluated the existing and planned centralized power options of the state’s capacity expansion plan on the basis of a life cycle cost analysis to work out a centralized least-cost capacity expansion plans for the state. On the basis of analysis, we have been found that the existing as well as new hydro plants are least expensive electricity supply options, which have lowest life cycle cost of energy i.e. Rs 0.51 / kwh and Rs 0.80 / kwh respectively at 2002-
03 prices level. The existing coal based and gas-based plants also have the lower life cycle cost of energy i.e. Rs 1.84 / kwh and Rs 2.08 / kwh respectively in comparison to the fossil fuels based planned power plants. As the planned coal based, gas based CCGT and OCGT plants has been found, expensive with their life cycle cost of energy of Rs 2.25 / kwh, Rs 2.45 / kwh and Rs 2.90 / kwh respectively.

The average annual capacity cost (fixed cost) of planned options (except the big hydro plants) has been calculated to be Rs. 7317 / KW / yr. at 2002-03 prices. The total cost of new capacity addition is then calculated by multiplying average annual capacity cost to the total planned capacity (except the big hydro plants), which came out to be Rs 2845 crore / yr. at 2002-03 prices. The marginal cost of capacity and marginal cost of energy of the centralized least-cost capacity expansion plan has worked out to be Rs 18273 / KW / yr. and Rs 2.90 / kwh respectively, which is equivalent to the annualized life cycle cost per KW and life cycle cost of energy of the planned gas based OCGT plants (Marginal Plants). The average energy cost of the centralized plan has worked out to be Rs 1.94 / kwh, due to the less expensive existing supply options.

**Integrated Resource Based Least – Cost Capacity Addition Plan**

We have also worked out an alternate plan by considering a much wider array of electricity supply options as an alternative of centralized plan by
adding the same level of capacity in the state by the year 2012. The new options considered include demand-side management (DSM) measures and decentralized/renewable sources apart from the centralized electricity supply options.

On the demand-side, some important energy efficient end-use measures in the agriculture and household sectors in the state have been taken up for analysis. In agriculture sector, the two end-uses i.e. replacing 5-HP existing pump sets by the 3-HP energy efficient (EE) pump sets and replacing of galvanized iron (GI) pipes by high-density polyethylene (HDPE)-low fraction pipes of tube wells has been chosen for demand side management programme. The capacity and savings energy potentials of replacing 5-HP existing pump sets by 3-HP energy efficient (EE) pump sets is estimated to be 82 MW and 481 Mkwh respectively by the year 2012 at the cost of saved energy Rs 0.50 / kwh (2002-03 prices level) at busbar point of centralized power station. Whereas, the respective figures for replacing of (GI) pipes by (HDPE)-low fraction pipes of tube wells has calculated to be 21 MW and 123 Mkwh at the cost of saved energy Rs 0.20 / kwh at busbar point. The total capacity and energy savings potential of these energy efficient end uses in agriculture sector came out to be 103 MW and 604 Mkwh by the year 2012 in the state. Thus,
the above analysis shows that the agriculture sector in Haryana has huge potential for energy saving which may be captured at comparatively low costs.

In household sector also the two energy efficient end-uses i.e. replacing of incandescent bulb (IB, 60 watts, 3 points / household) by compact florescent lamps (CFL, 15 W- (SLS20-RH, Phillips) and replacing of electric water heater (EWH, 25 L) by solar water heater (SWH) with has been considered for analysis. The capacity and energy savings potentials of replacing of incandescent bulb (IB, 60 watts) by compact florescent lamps (CFL, 15 W) has estimated to be 170 MW and 233 Mkwh respectively by the year 2012 at the cost of saved energy Rs 0.11 / kwh (2002-03 price level) at busbar point. Whereas, the respective figures for replacing of electric water heater (EWH, 25 L) by solar water heater (SWH) has calculated to be 223 MW and 59.4 Mkwh at the cost of saved energy Rs. 2.11 / kwh at busbar point.

The total capacity and energy savings potentials of these measures in household sector came out to be 393 MW and 292 Mkwh by the year 2012. Thus, the analysis indicates that the domestic sector has a large potential for capacity saving at end use point that may result in at a relatively very low cost in the state (Table 4.4).

On the supply -side, apart from the centralized options, three decentralised / renewable electricity supply options i.e. sugar co-genration,
small hydro and biomass combustion, having large potential in the state, have also been evaluated. (Table 4.9). The life cycle cost of energy of sugar co-generation (power potential of 92 MW) has worked out to be Rs.1.08 / kwh (2002-03 price level) at busbar. Whereas, the life cycle cost of energy of small hydro (power potential of 45 MW) and of biomass combustion (power potential of 900 MW) have been calculated as Rs. 0.99 / kwh and Rs. 1.94 / kwh (2002-03 price level) respectively at busbar. The total power potential of these renewable sources came out to be 1037 MW by the year 2012 (Table 4.9).

Thus, after having analyzed and estimated the costs and potentials of all the new and existing power options, they have been ranked according to the ascending order of their life cycle costs of energy. Then, the least expensive sources have been selected up to the point that their total capacity is equivalent to the total of existing and planned capacity considered in the state’ conventional plan by 2012 (7648 MW) to work out the “integrated” resource based least-cost electricity plan for the state (Table 4.11).

On the basis of the above analysis, the demand-side management measures, the existing power plants, renewable sources have been found comparatively economical and less expansive. Hence, all these options have been included in the integrated resource plan (IRP). The whole capacity of the
coal-based plants (i.e. 3096 MW), given in state’s capacity expansion plan, has not required being included in the integrated plan. Out of this, only 2355 MW capacity is included, because when more capacity is added to the list, the total capacity exceeded the specified goal (i.e., 7648 MW by the year 2012). Similarly, new gas plants have also not required to be added in IRP.

The average annual capacity cost (fixed cost) of the new / planned options of the IRP (except the planned big hydro sources) has estimated to be Rs. 5987.7 / KW / yr. at 2002-03 prices. The total cost of the capacity addition is then calculated by multiplying average annual capacity cost to the total planned capacity (except the planned big hydro sources), which came out to be Rs 2328 crore / yr. The marginal cost of capacity and marginal cost of energy of IRP has worked out to be Rs 14166 / KW / yr. and Rs 2.15 / kwh respectively, which is equivalent to the annualized life cycle cost per KW and life cycle cost of energy of the planned coal based plants (Marginal Plants). The average energy cost of the IRP has worked out to be Rs 1.76 / kwh, due to the less expensive DSM and renewable energy supply options.

Comparison of the Integrated Plan and Centralized Plan

The comparison of centralized and integrated plan shows that the centralized plan simply adds more coal and gas based capacity in the state. In this plan, about 64 percent of the incremental energy demand would be met by
coal–based thermal plants, while 20 percent would be met by gas-based thermal power plants by 2012. The rest, i.e. 16 percent would be met by hydro sources. Hence, this plan uses more fossil fuel and is not environmentally sound. It is not even capable of complying with the provision the Electricity Act, 2003, which envisages 10 percent of electricity to be generated in the state by the renewables by the year 2012.

On the other hand, integrated plan also add the same level of capacity in the state, but having incorporating the DSM options and renewable / decentralized sources in it. In this plan, about 2 percent of the incremental power demand would be met by DSM options, while 16 percent would be met by renewable / decentralized sources by 2012. The rest, i.e. 82 percent would be met by traditional centralized sources comprising of 56 %, 8 % and 18 % from coal, gas and hydro respectively. The marginal and average cost of energy of the integrated plan is about 29 percent and 10 percent less than the centralized plan. The average annual capacity cost of the new options of the integrated plan is estimated to be 23.6 percent less in comparison to the centralized plan.

In effect, the study shows that the integrated plan would capable of financial saving of about 23 percent while adding the same level of capacity in the state by the year 2012, which is planned to be added by the state
considering centralized projects only. In addition, integrated plan will be environmentally sound and reduce the fossil fuel requirements as well.

Policy Suggestions

Based on the results, main policy recommendations has emerged that it should be made obligatory on the part of all the state governments as well as central government to prepare integrated resource based power plans for their respective regions. These plans may act as a preference model. To operative these plans, the following actions / measures are recommended.

- Awareness building at the top management level
- Awareness building at the level of working engineers
- In order to increase technical expertise to carry out energy studies, manpower training in integrated resource planning may be encouraged.
- Centres of excellence for research in the power sector should be set up with funding from state / utilities.
- Energy audit to be made mandatory.
- In order to render it viable for the distribution companies to investment in energy efficiency programmes, serious consideration will have to be given to the establishment of financing and / or other regulatory mechanism that allow utilities to cover costs and / or make a profit from DSM investment.
• For effective implementation of energy efficiency measures, role of Energy Service Companies (ESCO’s) has to be enlarged to enter in this area through the creation of tax incentives and attractive power purchased agreements.

• For increasing rate of diffusion of end-use efficient measures, it is necessary on the part of government / utility to have controlled and well-monitored demonstration programmes for each of the DSM options, which clearly brings out the benefits and costs.

• DSM programmes need to have institutional mechanism for implementation, monitoring and support the process. It is recommended that the responsibility for co-coordinating DSM programmes should be clearly entrusted to a specific agency, be it the utility or energy service companies (ESCOs) or a consortium consisting of representatives from utility, financial institutions, equipment manufactures and consumers. It is important that this nodal agency is formed to function on a self-sufficient or a commercial basis, deriving its financial sustenance from savings through DSM options. This agency should focus on policy implementation.

• Equipment manufacturers need to be involved in DSM programmes, as they are the immediate gainers from such an investment. However,
discussions on this aspect are necessary. A competent group should be formed to define institutional mechanisms for this purpose and evaluate them.

- While fiscal sops are necessary to foster conservation, the institution of energy conservation awards would go a long way to encourage such initiatives

- The utility should improve its grid conditions and allow smooth evacuation of surplus power from decentralized / renewable power supply sources.

From the above, it is clear that at the heart of recommendations is the application of integrated resource based least - cost planning to electricity sector in the state. But more data and analysis as well as institution building are needed before large- scale implementation is undertaken. However, the electric power utilities must begin gaining experience in exploiting end use energy - efficiency through small-scale projects. Analysis and capacity building may take place simultaneously. Thus, the electric utilities may certainly play an important role in adopting integrated resource planning, but there are other players, such as government agencies, regulators, industry, environmental organizations, and customer organizations, that may be part of IRP in a broader sense. In other words, these stakeholders may play an important role in
optimizing the social benefits from renewable energy sources and demand-side managements.

We conclude that the study justifies implementations of specific programmes and political actions for adopting the integrated resource planning for power sector in the state. However, there are many issues, which still call for further studies. Among the areas requiring further attention are the following.

- Further research and survey, to fully assess the impact of demand side management programmes on peak demand at different levels of aggregation: transformer, feeder, substation, distribution, transmission and generation system.

- A review of the transaction and administrative costs for implementing the demand side management programmes in the state.