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Power Scenario of Punjab with special reference to Forecasting and Management

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Abstract

Electricity demand and supply forecasts assume special significance vis-à-vis ever-increasing demand. Different agencies and authors, to forecast demand, have used various methodologies but on the other hand, no concerted effort is visible in predicting the supply. Moreover none of the methodologies used can be considered perfect. The present study attempts to forecast the two and tends to reach the conclusion that in not too distant a future, there is likely to be a comfortable balance between them. A shift in policy has been observed as earlier, trends of demand growth were observed and it was assumed that they will continue to behave in the same manner and no effort was made to manage demand. However, demand has assumed a relatively significant role of late whereas supply was emphasised upon earlier. As a sequel to the above, it may be mentioned that demand measures are more effective than supply measures as they benefit not only the consumers and power utilities but also the environment by reducing generation requirements. This is especially beneficial in the state of Punjab where conventional sources of generating electricity have already been exhausted and capacity can be increased only by resorting to non-conventional and renewable sources.

SECTION-I

INTRODUCTION

Different agencies and research institutions undertake forecasting as a routine exercise. Forecasting means making estimates about the future behaviour of a variable on the basis of its past trend. Forecasting demand and supply of electricity assumes special significance on account of its ever-growing demand. The forecasts can be made on the basis of relations between electricity demand-supply and their determining variables. A variety of methodologies have been used for this purpose. The World Energy Outlook (2000), projects electricity demand in India to increase by 5.4 per cent per year from 1997 to 2020, faster than the assumed GDP growth rate of 4.9 per cent. Generally a high positive correlation has been observed between the growth of GDP of a country and its electricity consumption. It is a good sign that with improving efficiency of electricity use; this correlation has come down in India. This is indicated by the elasticity of electricity consumption with respect to GDP, which has declined over the years. While consumption of electricity went up by 3.14 per cent for every one per cent growth in GDP in the first five-year plan period, it went up by only 0.97 per cent in the eighth plan period.

LITERATURE REVIEWED

NCAER (1960) made demand forecasts for energy for various years both at all-India level and regional level. The total energy as well as electricity consumption was projected by relating them to the hypothesis of economic development. Coefficients for elasticity of demand for energy were obtained at the aggregate level and used for forecasting demand for future periods.

The Energy Survey Committee (1965) made demand forecasts at macro level, by using relation between national income and consumption and at sector level by estimating energy demand by various types e.g. coal, oil and electricity by assuming them to grow at given rates. Dhar and Sastri (1967) related observed input output coefficients with the desired level of production in different sectors for forecasting demand.

The Report of the Fuel Policy Committee (1974) considered three methods for forecasting energy demand and found that trend method provided a reliable means of forecasting energy demand only in developed market economies. The committee preferred regression model to trend method. Parikh (1976) modified slightly the approach used by the Fuel Policy Committee and projected demand for energy under two scenarios- one optimistic and the other pessimistic - for the period 1991-2001. He also developed a simulation model based on Cross-country regression for energy demand to forecast commercial, non-commercial and electrical energy demand in developing countries. Pachauri (1977) too developed a simulation model for projecting the demand for electricity in the state of Andhra Pradesh.

Reddy and Prasad (1977) selected a number of countries, both developed and underdeveloped to find out the relationship between consumption of energy and economic growth and they found a strong correlation between the two.

The Central Electricity Authority[1] (CEA) uses three methods for long-term projections of demand for electricity. These are trend method, the end use method and Scheer's formula. The Task Force Report on Electricity (Rao 2004) suggests that demand forecasts made by CEA must take into account the elasticities of demand since the next few years are likely to see rebalancing of tariffs and reduction of thefts, resulting in variations in demand therefore demand forecasts will require much better information base on T&D losses and other matters than is presently available. Prayas (2004) also points out a drawback in CEA's methodology of forecasting. The authority does not make any attempt to influence power consumption and reduce power requirement. Trends are studied and it is assumed that they will continue. It has been found that the peak load projections have always been very high in many states. A review of demand forecasts and actual demand on an all-India level, from 1995-2002 shows that the demand projections have been 15-20 per cent higher than actual demand. There is a valid reason for inflated demand projections. The state budgets are allocated on the basis of demand projections therefore the state electricity boards find it profitable to exaggerate demand projections. For example, the Eighth Five-Year Plan document estimated 20 per cent shortage of electricity at the end of plan period despite an additional generating capacity of 30,500 mw during the period. However, in reality, only 16,500 mw was added. The actual shortage still remained at 18 per cent. Ranganathan (2004) also supports this fact when he says that until recently, there was multi- level forecasting, done by the state electricity boards, by regional electricity boards, by CEA and finally by Planning Commission and the demand forecasts were invariably exaggerated. Another example from MSEB shows that demand estimates made by the board at the time of Enron agreement in 1992 were inflated by about 2000 mw, which is almost exactly equal to the total capacity of the project. Thus, sometimes over projections are made in order to justify the mega power projects like Enron which further results in high costs, high subsidies, inefficient use, high demand and again high demand forecasts, thus creating a vicious circle of exaggerated forecasts. Over projections are also made due to the fact that optimum plant generation is not estimated and price elasticities are not taken into consideration. Projections generally ignore the scope of supply side efficiency enhancement. An unrealistically high demand forecast results in shortage psychosis. It might be argued that it is safe to have excess generating capacity in view of the fast growing demand for electricity but the need for excess capacity is fast becoming redundant because of the possibility of inter-regional exchanges of power. However, this is not true for Punjab where it has been observed that despite high forecasts, adequate capacity additions were not made and this has led to far reaching economic, political and social consequences in the state.

The electricity demand forecasts are made at macro level whereas regional forecasts are very few. Moreover, energy demand forecasts are more abundantly available as compared to electricity demand and supply forecasts. Therefore, it is felt that state level forecasting exercises are required to have a realistic picture at the micro level. Keeping this fact in view, the state of Punjab was selected for the present study. Due to numerous factors, forecasting demand for electricity in the state has remained a problem. As previously mentioned, a variety of methodologies have been used for this purpose. However, none of them can be considered perfect due to the reasons outlined below :

- Various policy changes continue to be introduced not only in Punjab but also in the neighbouring states and at central level which influences shifting and growth of industry. For example, incentives announced by Himachal Pradesh have attracted industry from Punjab and the shift of pharmaceutical industry from Jalandhar is particularly notable. On the other hand, free power has been reintroduced in Punjab, which is likely to increase demand for tubewells. Again, the decreasing water table in the state is already causing demand for electricity to increase. It is also possible that the number of tubewells reach a saturation point after some time. Moreover, if crop diversification takes place and the state comes out of wheat paddy rotation, agricultural power demand may decline.
- With the constitution of Punjab State Electricity Regulatory Commission and enactment of Electricity Act (2003), consumers now have the option to set up their own captive power plants and will be able to obtain power through open access to the grid system. This has also caused industrial demand for electricity in the state to come down.
- If the efficiency of power distribution system is enhanced through installation of capacitors, the demand for power will certainly decrease.
- The extent of power cuts varies from time to time and the annual data is only an average of demand during different periods. Therefore this data may not depict the actual demand.

The major objectives of this study are :

- To review the present status of demand and supply of electricity in the state of Punjab,
- To forecast demand and supply of electricity in the state,

- To suggest some Demand Side Management (DSM) and Supply Side Management (SSM) measures to regulate demand.

DATABASE AND METHODOLOGY

Annual data for the period 1989-2004 (i.e. for a period of fifteen years) is used for the study. The advantage of using annual data is that they are available at a much more detailed level and they sidestep the problem of seasonality. The data for electricity consumption and its price was collected from various issues of the Energy Statistics of Punjab. Data regarding Net State Domestic Product was obtained from various issues of the Statistical Abstract of Punjab. Dividing the net state domestic product at current price by the wholesale price index of respective years deflated the net state domestic product. For this purpose, the year 1993-94 was taken as base Year.

The extent, to which demand will respond to price variations, is generally modelled using own price elasticity demand coefficients. It helps us in measuring and forecasting the demand for electricity, which occurs due to changes in its price. In the present study, projections are made using four techniques:(a) multiple regression technique, (b) Box-Jenkins method, (c) Trend method, (d) on the basis of consumption-income relationship as a high correlation has been observed between the two in the past though recently this relationship has weakened.

Econometric analyses of electricity are normally based on log-linear specifications (Pesaran and Smith, 1995). In this model, economy-wise electricity consumption is assumed to be a function of various variables such as average price of electricity, real income of the state and electricity Consumption during the previous time period. Such a model is also called autoregressive model because the independent variable is expressed as a function of its own lagged values. The electricity demand equation takes the following form :

$$\text{Log } q_t = a_1 + a_2 \log P_t + a_3 \log Y_t + a_4 \log q_{t-1} + e_t \qquad \text{....... (1)}$$

q_t = desired demand for electricity in period t,

P_t = Average price of electricity in period t,

Y_t = Net domestic product of the state at constant prices in period t,

q_{t-1} = Consumption of electricity (in mw) during period t–1,

e_t = Error term,

a_1 = intercept

a_2, a_3 and a_4 = parameters.

The electricity supply equation takes the following form :

$$\text{Log } q_t = a_1 + a_2 \log P_t + a_3 \log C_t + a_4 \log G_t + a_5 \log IC_t + e_t \qquad \text{......(2)}$$

q_t = supply of electricity in period t,

P_t = Average price of electricity in period t,

C_t = Average cost of producing per unit of electricity in period t,

G_t = Generation of electricity in period t,

IC_t = Installed capacity of electricity in period t,

e_t = Error term,

a_1 = intercept

a_2, a_3, a_4 and a_5 = parameters.

In multiple regression method, we estimate the relationship between independent and dependent variables for the period for which data are available. Then we forecast the values of independent variables for future time periods. When such an exercise is carried out, one has to make future projections for each of the independent variables separately. Though numerous functional relationships exist, the following three equations were used to make projections for independent variables as they are most widely used in statistical analysis :

$$Y = a + bt \quad \text{...... (Linear function) (3)}$$

$$\log y = \log a + (\log b)\, t \quad \text{...... (Log linear function) (4)}$$

$$\log y = \log k + (\log a)\, b^t \quad \text{...... (Growth curve) (5)}$$

After making projections for independent variables with the help of these equations, Karl Pearson's coefficient of correlation between each group of the projected and actual values was calculated. This was done in order to find out the best fit. The values obtained by the best fitting equation in each case were used to obtain final forecasts with the help of multiple regression equations.

In Box-Jenkins method, we regress the dependent variable on its own past values :

$$C_t = \alpha + \beta C_{t-1} \quad \text{...... (6)}$$

Where :

C_t = Consumption of electricity in period t,

C_{t-1} = consumption of electricity in period t-1

α, β = Constants.

This auto regressive formulation assumes that a variable will continue to behave in the same way as in the past unless some major upheavals occur. Another form of the auto regressive equation was also used for making forecasts:

$$\log C_t = \log\alpha + \log\beta C_{t-1} \quad \text{...... (7)}$$

Here we have taken the log values of consumption instead of actual values.

Various studies have revealed a strong relationship between national income and consumption of electricity. Therefore, this relationship was explored for the Punjab economy through the following equation:

$$\log C_t = \log a + \log b Y_t \qquad \ldots\ldots (8)$$

Where :

C_t = consumption of electricity during period t,

y_t = net state domestic product of Punjab at constant prices during period t.

a, b = constants

Forecasting was also done using the growth rate equation of the following form :

$$\log Y_t = \log a + (\log b)\, t + u \qquad \ldots\ldots (9)$$

Where :

Y_t denotes : consumption of electricity in period t,

t = time,

U = error term,

a, b = constants.

Further, in order to find out which forecast gave the best results, Karl Pearson's coefficient of correlation was again calculated between actual values and forecasts obtained with the help of various equations and the highest coefficient of correlation was found for the forecasts made by multiple regression equations. Thus it was inferred that multiple regression gave the best demand forecasts.

SECTION-II

PRESENT POWER SCENARIO IN PUNJAB

As far as the sources of energy are concerned, coalmines, natural gas, tidal power and oil are not available in Punjab. The scope for wind energy and tidal energy is also limited due to low velocity of winds and the distant location of the state from the sea. Despite wide scope of solar energy, the commercial exploitation of this source is negligible as yet. For many years there has been a demand for nuclear power station in the state but it has not yet materialised. The main source of power in the state is hydro and thermal electricity. Three perennial rivers -Ravi, Beas and Sutlej flow through the state and are exploited to produce hydroelectric power. Besides hydropower, there are three thermal power stations, which contribute the major share of total power supply. Marginal generation of electricity is through vegetable waste. Recently, there has been a problem in hydroelectric power generation due to the fall in water levels in the rivers of Punjab. As a result of this, our dependence on costlier thermal power has increased. Coal has to be transported from far off places to Punjab to generate thermal power; it causes pollution and increases cost of generation. Keeping in view these developments, due consideration is being given to the development of non-conventional energy sources. Recently, the Lehra Mohabbat thermal plant and Ranjit Sagar dam projects have been completed and various projects are in pipeline. Investment in supply is lopsided and is biased towards generation. At present the state has achieved cent per cent rural electrification and the per capita consumption of electricity in Punjab is the highest among the states.[2]

A special feature of demand for electricity in Punjab is that weather plays

Table 1

Consumption of Electricity, Installed Capacity, Generation, T&D Losses and Power Purchased in Punjab During Various Years

Year	Consumption of Electricity (MU)	Installed Capacity (MW)	Generation (Million KWH)	T&D Loss (%)	Power Purchase (MU)
1990-91	11907	3049	14618	19	2515
1991-92	12652.6	3289	14677	18.7	3115
1992-93	13896.2	3499	15718	19.24	3491
1993-94	14607	3509	16322	18.46	4027
1994-95	15507	3509	17175	16.7	4080
1995-96	15778.6	3509	16898	18.3	4904
1996-97	17162.5	3509	18455	18	5045
1997-98	17490.7	3719	17900	17.9	6647
1998-99	19264.2	3929	20880	16.83	6190
1999-00	20930.3	3929	22563	18.4	5834
2000-01	19346	5683	21528	27	4519
2001-02	19851	5700	22188	26.25	4220
2002-03	20964	5702	21760	25.07	81.3
2003-04	22310	5701	29654	25.33	108.87
2004-05	22414	5964	30080	24.27	34.2
2005-06	24192	5919	32658	25.07	221.3

Source : 1. Central Electricity Authority, Delhi.
2. Punjab State Electricity Board, Patiala.

a significant role in determining demand. During extreme summer and winter, the demand for electricity shoots up due to heating and cooling requirements. The pattern of demand is undergoing a significant change. In the nineteen eighties, the share of domestic consumption to total consumption was 11-12 per cent whereas today (2006-07) it is 20 per cent and the share of agriculture that was 40 per cent, has come down to 37 per cent now.

The demand for electricity in Punjab is actually suppressed and not effective demand as supply is less than demand. The peak load in the year 2004-05 was 5574 mw and installed capacity during the year was 5948 mw (4456 mw own capacity and 1492 mw share in central sector). Many a time expensive electricity has to be bought from outside and this purchase of electricity is depicted in Table 1. Earlier, a major part of total power required was purchased from outside but recently these purchases have come down mainly because of poor finances of PSEB and also due to the reason that the states and agencies, which earlier gave their surplus power to Punjab, don't have extra power any more due to increased electricity demand everywhere. For many years now, the PSEB has been facing numerous problems. An important segment of electricity supply in Punjab is the rural supply to irrigation pump sets. Around one third of total electricity supply goes to agriculture in Punjab. In fact, one of the main factors responsible for green revolution in Punjab has been the extension of electricity supply to agriculture at subsidised rates. It is believed that The Punjab State Electricity Board and the Government of Punjab have worked together to usher in green revolution in the state. But besides this, supply to agricultural sector has a dark side also. In the late nineteen sixties and seventies, when extensive rural electrification programme was started in the state and Punjab was one of the first few states to electrify all of its villages, there were only a small number of irrigation pump sets in the state and agricultural electricity supply formed only a small fraction of total supply and it did not adversely affect the finances of the board. But with the passage of time the number of irrigation pump sets continued to grow and subsidised supply of electricity to them ultimately became free supply, thanks to the election sops announced by the successive state governments. As of today, there are about 9.1 lakh pump sets in the state and free electricity supply has eaten into the vitals of power sector. So bad is the condition of finanoes of PSEB that there is no money even to repay the loans taken, what to say of capacity additions and renovation of existing plants. The share of agriculture in total sales of electricity was 35.53 per cent in the year 2001-02 and the share of revenue from agricultural sales was zero per cent due to free of cost supply. To compensate for this loss, a high price was charged from industrial and commercial consumers. The subsidy to agriculture increased, from Rs. 687 crores in 1992-93 to Rs. 2339 crores in 2001-02. During this decade, the govt. granted subvention to the PSEB only once i.e. in the year 1999-2000 and this is one of the primary reasons of continuously deteriorating rate of return on capital. On the other hand, since electricity is available free of cost, its wastage is inevitable. Due to excessive withdrawal of groundwater, water level is going down at an alarming rate in the state of Punjab and at some places there is the problem of water logging. During the summer season, when demand for electricity is at its peak, the board imposes heavy cuts on those consumes, who pay the highest price for electricity (i.e. the industrial and commercial consumers) so that electricity can be supplied to agriculture free of cost. Also, expensive electricity is purchased from outside to fulfil the requirements of agriculture. Despite the progress of reforms in power sector, there has been no turnaround in the policy of free power supply. In case of rural electrification too, promotional aspect seems to have overlooked all other factors. The recovery of cost is also dismal. It was only 67.24 per cent during the year 2001-02. A major part of electricity supplied is lost in transmission and distribution. These losses were as high as 27 per cent in 2000-01. They include technical losses (17.25 per cent), which are due to faulty equipment and commercial losses (9.25 per cent), which are due to theft of electricity. Theft of power has assumed serious proportions and many cases of theft occur due to the connivance of PSEB employees. Even large industrial houses are involved in stealing electricity. The auxiliary power consumption is also high due to increased share of thermal generation in total generation. Auxiliary consumption is 1-2 per cent in hydro stations whereas it is 8-10 per cent in thermal stations. Moreover, thermal stations have another problem. Their heat rate (per unit fuel consumption), which is the inverse of efficiency and an important parameter for all generating stations, is also high and this also causes low efficiency. There are some other problems such as poor quality of coal, over-employment and lack of accountability like any other administrative department.

Delay in construction of projects further creates problems due to escalated costs and delayed benefits. For example, the estimated original cost of Ranjit Sagar Dam was Rs. 242.32 crores whereas its revised cost was Rs. 4800 crores. Similarly, the original estimated cost of the S.Y.L. canal was Rs. 103.64 crores and its revised cost was Rs. 163.74 crores.[3] Due to this reason, capacity additions were delayed indefinitely though the demand has consistently increased as is evident from Table 1. It is clear that the growth of installed capacity and generation has not been very impressive. Generation shows an increase because it includes power purchased from out of the state. The hydrothermal generation ratio has continued to decline from 97.11 per cent in 1971-72 to 46.4 per cent in 1999.[4] Table 1 also shows that despite power sector reforms, T & D losses are not coming down. In fact after the introduction of reforms, these losses suddenly shot up. It is a well-known fact now that earlier the losses were clubbed together with agricultural consumption and an impression was there that agriculture consumed around forty per cent of total electricity supplied. But the actual agricultural consumption is much less and the Board has started confessing that T&D losses (including theft) constitute a major part of the total power produced and theft of power causes a revenue loss of Rs. four hundred crores per annum. Thus the power scenario in Punjab is not so promising. In fact it is mired in a deep-rooted crisis.

SECTION-III

PROJECTING DEMAND AND SUPPLY OF ELECTRICITY

Having analysed the present power scenario of Punjab, we now make an effort to project the demand and supply of electricity. The projections are made for the period 2004-05 to 2013-14 and they are shown in Table 2.

The forecasts made by using multiple regression show that demand for electricity is likely to be 31376 mw in the year 2013-14. The forecasts made by auto regression equation, assuming a linear function give slightly lower values of forecasts at 28511 mw for the same year and the auto regression equation assuming a log-linear relation gives slightly higher values. The equation based on the income-consumption relationship gives the lowest forecast values at 22547 mw. This is an understandable result keeping in view the fact that income elasticity of demand has come down or probably this is due to shortages of power. The trend equation gives the highest forecast value at 36962 mw during the year 2013-14. As already mentioned, multiple regression is expected to give the best results since it is based on the observed behaviour of causal factors. However, it can be seen from Table 2 that demand forecasts made by trend method give results which are amazingly close to supply forecasts made by multiple regression. Therefore we can say that forecasts made by trend method can also be relied upon. It is more so because existing literature in the field tells us that trend method is also considered to be an ideal method for forecasting.

The last column of the table shows the electricity supply forecasts for the period 2004-05 to 2013-14. The supply forecasts could be made only with the help of multiple regression as demand and supply of electricity is simultaneous, data for both is the same[5] and other equations will generate forecasts identical to demand forecast. A perusal of the various supply forecast values shows that demand supply gap is likely to shrink and supply position is likely to be comfortable. A comparison of supply forecasts with demand forecasts shows that supply is likely to increase more than demand if we take into consideration the demand forecasts made by multiple regression method, Box-Jenkins method and income-consumption relationship method. However, supply is likely to be very close to demand if we consider demand forecasts made by the trend method. The Karl Pearson's coefficient of correlation between various forecasts and actual values shows that multiple regression gives the best forecasts. Thus it may be concluded that trend method and multiple regression both give reliable forecasts and we can safely say that demand-supply situation is likely to be comfortable in the near future.

Table 2

Forecasting Electricity Demand & Supply (MW)

Year	Demand					Supply
	(1)	(2)		(3)	(4)	(5)
	Multiple Regression	Box-Jenkins		Income-Consumption Relationship	Trend Method	Multiple Regression
		Actual	Log			
2004-05	23153	22580	22667	20356	24128	24221
2005-06	24003	22675	22215	20641	25299	25414
2006-07	24868	23390	23396	20912	26527	26659
2007-08	25751	24122	24640	21174	27814	27958
2008-09	26647	24854	25951	21424	29164	29308
2009-10	27559	25585	27339	21667	30579	30716
2010-11	28489	26316	28783	21898	32064	32185
2011-12	29433	27048	30313	22121	33620	33705
2012-13	30393	27780	31933	22341	35252	35303
2013-14	31376	28511	33623	22547	36962	36963

Functional Form

$$\text{Log } q_t = a_1 + a_2 \log P_t + a_3 \log Y_t + a_4 \log q_{t-1} + e_t \qquad \text{....... (1)}$$

q_t = desired demand for electricity in period t,

P_t = Average price of electricity in period t,

Y_t = Net domestic product of the state at constant prices in period t,

q_{t-1} = Consumption of electricity (in mw) during period t–1,

e_t = Error term

a_1 = intercept

a_2, a_3 and a_4 = parameters

$$C_t = \alpha + \beta C_{t-1}$$

and

$$\log C_t = \log\alpha + \log\beta C_{t-1} \qquad \text{...... (2)}$$

Where :

C_t = Consumption of electricity in period t,

C_{t-1} = consumption of electricity in period t-1

α, β = Constants

$$\log C_t = \log a + \log b Y_t \qquad \text{...... (3)}$$

Where :

C_t = consumption of electricity during period t,

y_t = net state domestic product of Punjab at constant prices during period t.

a, b = constants

$$\log Y_t = \log a + (\log b)\, t + u \qquad \text{...... (4)}$$

Where Y_t denotes : consumption of electricity in period t,

t = time,

U = error term,

a, b = constants

$$\text{Log } q_t = a_1 + a_2 \log P_t + a_3 \log C_t + a_4 \log G_t + a_5 \log IC_t + e_t \qquad \text{...... (5)}$$

q_t = Supply of electricity in period t,

P_t = Average price of electricity in period t,

C_t = Average cost of producing per unit of electricity in period t,

G_t = Generation of electricity in period t,

IC_t = Installed capacity of electricity in period t,

e_t = Error term,

a_1 = intercept

a_2, a_3, a_4 and a_5 = parameters.

SECTION-IV

MANAGEMENT OF ELECTRICITY DEMAND AND SUPPLY

In the past there has been more emphasis on enhancing supply to meet the increasing requirements of electricity and no effort has been made to reduce or manage demand and conserve electricity. Recently, this trend has changed and now demand side measures are gaining ground because by reducing demand, huge investment requirements can be avoided. Demand side measures include demand-side management (DSM) and economising the electricity use by improving the efficiency of electricity using equipment. Some supply side measures (SSM) may also be needed like increasing efficiency of electricity supply by improving the performance of electricity generation, transmission and distribution system through renovation and modernisation of generating plants, improving the transmission and distribution network and by developing renewable energy options. These measures are discussed at length here.

DEMAND SIDE MANAGEMENT

Demand Side Management (DSM) is any action that influences the consumer's side of supply- demand equation in order to change the level or pattern of demand for electricity. According to the definition adopted by California Public Utilities Commission, DSM is "Planning, implementation and evaluation of utility sponsored programmes to influence the amount or timing of customers' energy use." Indian Electricity Regulatory Commissions use the term DSM in contrast to SSM (Supply Side Management) implying reduction or alteration of demand. It covers activities, which will help the state electricity board, or other power utilities in reducing peak demand, shifting demand from peak to off peak hours and reducing overall electricity demand. It includes: (a) Controlling the time of service required by introducing time of use metering and by introducing seasonal tariff during summer months, (b) Using efficient end-use devices like chloroflourescent lamps (CFLs), (c) Replacing old machinery in industries by efficient equipment and using efficient pump sets in agriculture, (d) Using renewable energy sources such as solar energy for lighting, cooking, heating and cooling of buildings with underground thermal energy storage and thermo-chemical reactions, (e) Displaying labels on electric appliances informing the consumer about their efficiency, (f) By switching off lights when not required and (g) By designing buildings, those are airy and allow enough light so that minimum electricity is used for lighting during daytime.

There is an urgent need to adopt DSM measures due to environmental concerns because if demand for electricity falls, environmental pollution will also fall. Increasing electricity prices also call for such measures. The history of DSM is not new to India. In the beginning days of electrification, the State electricity boards introduced DSM measures to boost electricity demand by leasing electric equipment but now the opposite is required and the utilities have to subsidise energy efficient equipment. To make DSM effective, all the interest groups concerned with consumption, generation and distribution of power i.e. consumers, government, public utilities and the IPPs need to be involved. DSM experiences in various countries have shown impressive electricity savings e.g. U.S.A. (11-14 per cent of peak load), Thailand (25 DSM programmes), Brazil (recent legislation mandates utilities to invest one per cent of their revenue in energy efficiency projects and R&D. A government campaign in California state helped manufacture of efficient refrigerators, which played a significant role in DSM. The Global Environmental Facility (GEF) has promoted lighting and refrigerator efficiency projects in some countries e.g. Argentina, China, Vietnam, Poland, Mexico and Philippines.

A study by Sant & Dixit (2000) developed a least cost plan for Maharashtra state and showed that DSM and decentralised generation can reduce demand and conserve electricity to a significant extent. It has been observed that tube lights and CFLs are much more efficient than incandescent bulbs. If we use CFLs, which are 3-4 times more efficient than ordinary lamps, we can save about 70 per cent power in lighting. Not only electricity is saved but our electricity bill also will be much less. A study by Prayas (2005) shows that one unit of electricity saved at consumer end avoids 1.4 units of electricity generation which implies saving of one kg. coal. In other words, a reduction of just 50w at consumer end for about 6 hours a day, avoids coal usage of 110 kg. per year. Thus it is far cheaper to save electricity in many situations, than to build new generating plants. There is large DSM potential in India ranging between 20-30 per cent. If only the domestic consumers try to save electricity, they can save about ten per cent of peak demand. The potential for saving in offices is much more i.e. 15-25 per cent. Similarly, 30 per cent electricity saving is possible by installing efficient pump sets using low friction pipes and foot valves. There is wide scope of energy saving in agriculture because two thirds of our population depends on it. The promotion of solar power, biomass power and animal power can go a long way in saving electricity in rural areas.

A study by IEA (2002) suggests that removal of electricity subsidy would lead to significant reductions in electricity consumption particularly in agricultural sector and total electricity consumption will be 40 per cent less in the absence of all subsidies. This would mean much less environmental degradation also. In the long run, this reduction in subsidy will increase consumption by properly serving the consumers who cannot get enough power due to shortages and blackouts.

Another study by IEA (2003) finds that in developed countries, the concept of demand response is gaining ground. Demand response is a set of strategies, which aim to bring the demand side of electricity market back into price setting process. Price peaks can be clipped by demand response and markets can become more efficient. When the consumers are offered differential prices at different times, they may shift the time of the day at which they demand power from a peak hour to an off peak hour. They may also be trained to reduce their demand through efficiency measures or by resorting to self power generation because all consumers don't need electricity at all times and they may be willing to curtail their demand for limited periods if so motivated. Time of the day metering is likely to get some demand response from consumers. It will benefit the utility because need for capacity additions will be less. It will also benefit the consumers in the form of reduced electricity bills. This method has proved to be effective in advanced countries.

Yet another study by IEA (2005) suggests an alternative approach to quickly save electricity based on the measures to improve energy efficiency and change consumer behaviour. In this manner, electricity saving of 3-20 per cent is possible. The methods suggested include making equipment more efficient, replacing incandescent bulbs with CFLs and change in consumer behaviour by encouraging them to shift demand to low-load periods through media campaigns and enhancing consumer awareness. Installation of capacitors reduces demand and simultaneously increases the capacity of generators to generate more mws (real power). Thus DSM measures and energy conservation can go a long way in managing demand for electricity.

SUPPLY SIDE MANAGEMENT

Supply side management (SSM) means measures, which can be adopted by the power utility to increase efficiency of power supply system. Up to now, the main emphasis of power utilities used to be on such measures only. Though demand side measures are gaining ground, supply measures are also required to solve the present power crisis. They include : (a) Adoption of renewable energy technologies, modern equipment and latest construction techniques, (b) Improving the efficiency of providing service and reducing losses and rationalisation of energy prices, (c) Setting up pithead thermal plants on a larger scale to avoid expensive transportation of coal, which becomes costlier than the cost of coal itself, (d) To reduce human error in meter reading and installing recording meters (if possible) which can send information directly to a central recording station, (e) To take advantage of the different climates in different regions, electricity can be obtained from other states through regional/ national grid. As electricity cannot be stored, it is better to use it elsewhere if it is available in excess. It will also reduce capacity addition needs, as it is costly to create generating capacity according to peak demand because then, full capacity will be used only for a few hours, (f) Renovation and modernisation (R&M) of existing hydro and thermal Plants to increase their generating capacity and operational efficiency through automation and computerisation as the cost of R&M is much less than the cost of setting up a new plant, (g) Introducing distribution reforms covering all aspects of distribution of electricity e.g. Organisation, structure, engineering, financial planning, construction, operation and maintenance (O&M) and development and use of superconductors in transmission and distribution cables as they have excellent efficiency and reduce T&D losses to a significant extent, (h) To Use better quality fuels to generate electricity keeping in view the efficiency and environmental norms and reduction in auxiliary power consumption in thermal power units.

To improve electricity supply, access to electricity has also to be increased. Though extensive electrification programmes are going on in India, yet a number of studies point out that a majority of poor people have no access to electricity. Reddy (2002), Sankar (2002), World Energy Outlook (2002), Pachauri and Spreng (2004) and Rejikumar (2005) have suggested measures to increase accessibility of power.

EFFICIENCY OF ELECTRICITY GENERATION ARID ELECTRICITY USE

By efficiency we mean, efficiency of electricity generation as well as of electricity use. The efficiency of power system is not high. Measured as the PLF of the power plants; this indicator has not improved much in post-reform period. In transmission part of the system, several large failures of grid occurred in recent years. Carbon dioxide emissions from power sector represent half of the total Indian emissions. Steam power plants, using high ash content and low calorific value have been recognised as major contributors of airborne pollution. There are numerous studies, which highlight the adverse environmental impact of electricity generation. Every technology for generating electricity has some kind of adverse environmental impact. Hedley (1986), and Sagar (2002) analysed the environmental impact of various power generating technologies. The efficiency of electricity generation can be increased by reducing losses and by following environmentally benign generation technologies.

To increase the efficiency of electricity use, labelling of electricity consumption of electrical and electronic appliances should be made compulsory. The Electricity appliances made by different manufacturers, use different amounts of electricity. Further, the information on electricity consumption is not easily available or easy to understand. The electric appliances thus manufactured are inefficient. The labelling programme, if introduced, will surely lead to increased efficiency and reduce electricity consumption by enabling consumers to make a comparative study of electricity consumption of various appliances and choose the one with minimum electricity consumption.

SECTION-V

SUMMING UP

The above analysis shows that the demand-supply equation is likely to be balanced in near future. Though efforts are on to enhance generating capacity, yet actual capacity additions take a long time to materialise. Therefore to solve the power crisis in the state of Punjab, Inter-regional exchanges of power should be encouraged. It is expected that with improved supply and reduction in transmission and distribution losses, demand and supply projections are likely to become more reliable. The demand and supply management measures need to be given more consideration than is presently the case. Such measures benefit the consumers in the form of reduced electricity bills and also the power utilities and environment by reducing generation requirements. The power sector is in a precarious situation today precisely due to the fact that earlier demand and efficiency measures were neglected and the main emphasis was on increasing supply. But such a policy resulted in inefficient management of power sector, high T&D losses, and exaggerated forecasts. The commercial viability was totally ignored and socio-political considerations led to irreparable damage of power sector. But now these long standing mistakes must be rectified and DSM should become an integral component of power planning. These options along with a rational and scientific forecasting of future electricity demand are likely to go a long way in eliminating the ills of power sector. The fact is that efficiency measures and DSM measures cost money and don't show results immediately and there is a limit to such improvements but our power system has lots of inefficiencies and the scope for improvement is substantial.

Notes :

1. The Central Electricity Authority, Delhi.
2. Govt. of Punjab (2002), "*Energy Statistics of Punjab*" Economic Advisor to Govt. Punjab, Chandigarh.
3. Govt. of Punjab (1998), "*Energy Statistics of Punjab,*" Economic Advisor to Govt. Punjab, Chandigarh.

4. Jain, Varinder (2004), "Punjab : Reviving Power Sector- Need for A Rethink," *Economic and Political Weekly*, March 27.
5. Since units supplied are equal to the units billed as well as units consumed, the data for electricity consumption and supply is the same and the explanatory variables only determine the demand and supply equations.

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