CHAPTER VII

SUMMARY AND CONCLUSIONS

Energy has been the sinequonon of economic development and human progress, from the days of Industrial Revolution. Being a universal input and its consumption being considered as an index of economic development, a phenomenal increase in the demand for energy took place in almost all countries, the world over. It was this unprecedented and increasing demand which culminated in the oil shock of 1973, in the wake of which all countries, particularly the developed countries adopted systematic and concerted efforts to economize on the use of energy through changes in the production and consumption, and energy conservation measures, as well as through resort to non-conventional sources.

Till recently when energy crisis became very acute, the approach to energy development adopted by the major countries of the world was that of supply based development paradigm. The persistent demand resulted in four types of crises – a) Capital Crisis, b) Performance Crisis, c) Equity Crisis and d) Environmental Crisis. This necessitated the pursuit of an alternative paradigm known as DEFENDUS. This paradigm gained prominence in the wake of persistent electricity scarcity experienced by developed and developing countries.

Electricity, whose commercial production began in 1878 in New York, became within a few decade, not only the most popular and convenient form of energy, but also an essential tool of development and a symbol of modernity, largely because of its unmatched ability to operate a variety of industrial equipments and household appliances. The possibility of generating electricity from
multiple sources (as different from single source coal in the beginning) propelled electricity production into a gigantic industry in several countries. According to one conservative estimate, the annual revenue from electricity industry is of the order of $800 Billion, twice the size of world's auto industry.

In the developing countries both electricity generating capacity as well as actual production has been increasing during the last two decades, faster than the developed and newly developing countries. Among the developing countries, energy productivity has been lowest in Sri Lanka, Bangladesh and India, while the highest in South Korea, Malaysia and Singapore. In the developing countries electricity demand has been growing much faster than the developed countries, during the last two decades. In these countries electricity demand exceeded GDP growth. With rapidly growing demand per power, drastic changes in the technical process of power generation and the rising prices of power inputs, the power sector of most countries began to face several problems: a) Power Shortage, b) Cost Escalation in Power Generation, c) High T&D Loss, d) Environmental Issues, e) Depleting Fuel Inputs Like Coal Oil and Gas and f) Financial Crunch of the Utilities.

India has been facing almost all problems stated above during the last few decades, although the country had made significant strides in power capacity, generation, per capita consumption and electrification of villages. Available data indicated that during 1995-96 the peak capacity shortage was of the order of 18.3% and energy shortage of 9.2%. The commercial loss incurred by all the 19 SEBs in the country increased by 50%, during the short span of 1992-95. The persistent resource crunch faced by the SEBs have stood in the way of making additional investments in this sector, leading to perpetuation of power shortage in almost all states. The liberalisation policies launched by the govt. of India from 1991 provided
a way out to escape from this predicament, by entering into financial and technical collaboration with foreign firms and agencies.

Among the Indian States, Kerala possesses certain unique features and problems with respect to the power sector. The power system of Kerala is exclusively dependent on hydel projects. Once a surplus state, Kerala has been short of power for the last fifteen years. The unique features and the issues found in the power system of Kerala are:

- Exclusive dependence on hydropower stations,
- Acute and chronic power shortage, despite being a surplus and power exporting State till a few years ago,
- Internal maximum demand of the state power system exceeding the installed power capacity,
- Lowest energy tariff,
- Zero fuel cost for power generation,
- T&D loss higher than the all India average,
- Pattern of energy consumption drastically different from all India,
- Lower per capita energy consumption as compared to the rest of the country.

In spite of such peculiar characteristics and problems, the power sector of Kerala has not been subjected to any systematic and serious study by economists. The only study carried out from an economic perspective pertained to the period, when the state was surplus in power and the nature and dimensions of the problems of the power sector were widely different from what they are today. The present study is a comprehensive analysis of the power system of Kerala from a techno-economic angle.
7.1. Summary of major findings.

During the seventies and the eighties, electricity generating capacity, actual generation, and demand grew faster in developing countries like India, as compared to the developed countries. Growth rate of demand for electricity in these countries by and large exceeded the growth rate of GDP, during this period.

In spite of the great importance of the sector, the power sector outlay in India hovered around 18.5%. Till the sixth five-year plan, the relative share of this sector in the total plan outlay remained below that of the first five-year plan. The low relative share continued even during the post energy crisis period.

Taking the country as a whole, capacity addition in the power sector was found to have moved away from hydel to thermal stations, based on diesel, gas, and naphtha. This had serious implications in the form of environmental problems, (discharge of Co, Co2, So2, and Nox) worsening of balance of payment position due to import of diesel and gas and aggrandisement of peak load shortage, as thermal stations are base load stations in contrast to hydel stations.

Power consumption by the agricultural and domestic sector exceeded that by the commercial and industrial sectors, during 1950-96 at all India level. Power tariff for domestic and agricultural sectors being highly subsided in all the states, the more rapid growth of power demand by the two sectors had a highly adverse effect on the financial position of the state electricity board.

The power shortage faced by India since the turn of the 80s is the outcome of a host of factors like inadequate investment in power sector, insufficient capacity addition, large T&D loss, power system inefficiency (declining energy productivity due to low plant load factor) and poor financial position of the Utilities.
Examining the growth of the power system of Kerala, in terms of power system variables like installed capacity, generation, energy sales, maximum demand (both Internal and the System) number of consumers, connected load, per capita consumption, T&D loss, circuit kilometres of HT and LT lines, and number of distribution transformers, it was found that rate of growth of supply side variables lagged behind that of demand side variables during 1957-95 period. Internal maximum demand has been growing (8.33%) faster than the installed capacity (7.62%) and generation (7.51%). This discrepancy is the cause of power shortage and was partly met through power imports from other states. Import of power began to exceed export from the eighties.

Transmission and Distribution loss (energy loss occurred in the process of transmitting power from the generating point to the consumer end) increased steadily from 90 MU in 1950 to 1950MU in 1996-97. The main reasons for heavy T&D loss is due to insufficient high-tension lines as compared to Low Tension lines in the state. Technically the ideal ratio between HT and LT lines is 1:1. This ratio was never maintained in Kerala, and in recent years it has been declining. The number of transformers per 1000 consumers declined from 11.57 in 1950-51 to 5.10 in 1996-97. The number of transformers per MW of connected load remained almost static during the same period. Due to the insufficient growth of distribution transformers and HT lines, the power system was unable to maintain voltage level at the technically acceptable rate.

The per capita energy consumption (total energy consumption + total population of the state) increased from 13 units in 1950 to 240 units in 1995-96. But energy consumption by actual power consumers (total energy consumption +
total power consumers in the state) steadily declined from 5000 units in 1950 to 1582 units in 1995-96.

The rate of growth of expenditure (19.58%) of the power system exceeded that of revenue (16.79%) during the period under review, leading to financial crisis of the Kerala State Electricity Board. Heavy tariff subsidy to domestic and agricultural consumers and uneconomic method of electricity tariffing are the two reasons for the declining rate of revenue of the state power system.

During 1979-97 period, it was found that installed capacity increased only 49.06%, while internal maximum demand at 171.26% and maximum system demand 44.95%. The tardy growth in installed capacity in relation to internal maximum demand appears to be the major reason for energy shortage. The reasons for slow growth in installed capacity are (1) inordinate delay in the completion of ongoing projects that were started years ago, (2) virtual absence of direct central investment till 1997, (3) inadequate and declining share of state's investment in power sector, (4) and total dependence on hydro projects to the virtual exclusion of other options till 1997. Experts maintained that even if all the available hydel stations are fully utilised, the state might not be able to meet the present demand in the immediate future. The present installed capacity is estimated to be 46% short of the desired capacity level. The desired capacity was estimated by us on the basis of Gompertz model, as it was found to be a better fit. According to this estimation, installed capacity has to be increased to a minimum of 2700 MW in 2000AD and 4006 MW in 2010. Therefore the state power system should install an additional capacity of 2498 MW within a decade to meet the power demand of the people of Kerala, [Without considering the choked demand and T&D loss]
Performance analysis of the ten major hydropower projects was conducted in terms of the parameters, capacity utilisation factor, plant load factor, and energy productivity. The analysis showed that the projects varied among themselves in terms of above criteria. Idukki and Sabarigiri together accounted for as much as 65% of installed capacity as well as design value of generation. But the two projects respectively come in the 9th and 5th positions in terms of plant load factor and 8th and 5th positions in terms of energy productivity. A significant finding from performance analysis is that during 1988-95 period, the actual generation exceeded the design value of generation. One is tempted to conclude from this that water availability was not a constraint for power generation during this period. In addition to this, an attempt has been made to examine the technical and economic efficiency of the state power system as a whole in terms of (1) Load Factor, (2) Demand Factor, (3) T&D Factor, and (4) the rate and structure of tariff.

The load factor, which is an indicator of the extent of demand, was found to be by and large declining. This abnormal behavior of load factor could be explained in terms of the failure of the system to meet peak hour demand, and escapist methods resorted to in the form of load shedding and power cut. The demand factor is the ratio of maximum demand to the total connected load of the system. The value of the demand factor tends to be one, if the efficiency of the power system is good, which implies that the system is capable to meet the demand in tandem with the increase in the connected load. The value of the demand factor in the state has declined from 0.37 in 1960 to 0.29 in 1995. This can be treated as a true reflection of power system inefficiency.

T&D loss in the state occurs in two ways, viz. technical and non-technical (commercial). About 70% of total energy loss are technical in character and 30%
non-technical. Efficiency of transmission network is examined in terms of number of sub-stations, number of transformers and circuit kilometers of various lines. T&D loss in Kerala (23%) is greater than the national average of 21%, the World Bank norm of 15.5%, and the world target rate of 8.25%.

The annual compound rate of growth of T&D loss in Kerala works out to 8.85%, whereas the rate of growth of generation is 7.51%. As per our calculation, one percentage increase in energy generation leads to 1.18% change in the energy loss. If the power system of Kerala could reduce the energy loss at least by 1%, the state could add 19.5 MU of energy to the system. If this much of energy were to be generated, it would require an additional capacity of 3.71 MW, for which the installations cost would be around Rs. 150 million.

Since investment data relating to T&D network as such are not available, we had to resort to indirect methods to examine the trends in T&D investment. The indices used for this purpose were (1) consumers per circuit kilometers of 110kV lines, (2) consumers per transformers; (3) transformer per connected load and (4) transformer per consumption. In terms of growth of these indicators, investment in T&D network appears to have significantly declined over time.

An important determinant of T&D efficiency is the growth of substations of various capacities as they enable the transfer of power at stipulated ratings. For the evacuation of power from the generating point to the various substations located in different parts, 440 kV/ 220 kV sub stations are required. As per the proposal of Kerala State Electricity Board at least three 440 kV substations are required for the state, whereas there exists only one. Similarly eighteen 220 kV substations are required, whereas there are only five. Economic efficiency of Kerala State Electricity
Board, which was already low, further deteriorated in recent years. During the nineties the tariff remained well below the average cost. Cost revenue differences per unit was 10.5 Paise in 1990. It increased to 18 Paise in 1995-96.

The sectoral demand analysis was attempted by grouping power consumers in to the following categories: - domestic, commercial, industrial (LT), industrial (EHT&HT), agriculture, public water works, public lighting and licencees. Sectoral analysis was done with reference to connected load, consumption, and consumers. The rate of growth of connected load in the domestic sector was 10.34%, commercial 7.8%, industry (LT) 7.7%, industry (EHT&HT) 5.9% and agriculture 7.8%, during the period 1970-95.

The relative share of domestic sector in connected load increased from 25% in 1970-71 to 45% in 1995-96, whereas in the industry (HT&EHT) it declined from 29% to 15%. In agriculture there was a marginal increase from 8.8% to 9.76%. Commercial sector remained unchanged. The shares of domestic and commercial sectors together constitute 55% of the total connected load, and this accounted largely for the peak power shortage. The decline in the share of industrial (EHT&HT) connected load is reflective of the stagnating industrial scenario of the state of Kerala. The big increase in the share of the domestic and commercial sector from 35% to 54% is reflective of Kerala pattern of development characterised by high rate of consumption.

Sectoral share in energy consumption shows that the share of domestic sector increased from 4.34% to 37.9%, that of commercial sector from 3.5% to 9.3%, industry (LT) from 5.8% to 7%, Industry (EHT&HT) from 60% to 37% and agricultural from 2.0% to 4.3%, between 1970-95. The observed decline in the share
of the industrial sector was caused partly by the slow growth of industrial units in the EHT&HT categories, and partly by power cuts imposed on such units from 1982 onwards. Nearly 47% total energy sold in the state was consumed by the domestic and commercial sectors.

Even though the relative share of agricultural consumption has increased over time, it remains one of the lowest in India, the reason being, the topographical conditions and the peculiar-cropping pattern. The increase in the percentage share of energy consumption in the agricultural sector could be explained in terms of changing cropping pattern in favour of cash crops and the preferences, priorities and concessions extended to agricultural connections.

In terms of consumers, highest growth rate was registered by the agricultural sector, (11.38%) the next being the domestic sector (9.44%). Lowest rates were recorded by the industrial sectors. Among the three most significant variables of the state power system – viz., total energy consumption, total consumers and total connected load, the rate of growth of total consumers stands out the highest with 9.04% (consumption 4.91%, & connected load 8.52%)

Per capita energy consumption was found to have increased. But analysis of sector wise per capita consumption shows that only in domestic and commercial sectors, per capita consumption increased. Consumption by all other sectors, including agricultural declined. The rate of growth of per capita consumption was 4.93% and 3.67% respectively for the domestic and commercial sectors, during the period 1970-95. For the rest of the sector like industrial (LT) Industrial (EHT&HT), agricultural and the total in the state, the growth rates were, - 0.67%, -3.02%, -4.59%, and - 3.79% respectively.
Consumption per connected load increased in the case of domestic and commercial sector significantly. In the rest of sectors and for the state as whole, it declined. (Sector wise changes in the consumption per connected load have serious policy implications in regard to tariff subsidy and energy conservation policies). The reason for the decline is, non-availability of sufficient power. If system was to maintain 1970-71 level of energy consumption per watt of capacity installed, energy supply had to be raised to 12187 MU in 1995-96 as estimated by us. Actual availability (including import) was 7415 MU, leaving a deficit of 4772 MU. (I e. 39% of the required quantity). The possible economic impact of this deficit was also worked out in terms of energy productivity and output elasticity of energy. Energy productivity was of the order of Rs 10/- during 1990-96, at constant price. The resultant decline in GDP worked out to Rs 4720/- million in 1995-96.

An attempt was also made to forecast energy demand, by assuming observed trends in the sectoral demand for power. For projection we made use of time series analysis technique. For this purpose the statistical software called" RATS" was used. The period considered for the projection purpose was from 1978-79 to 1995-96. Energy demand was forecasted for the terminal years of 2000AD, 2005, and 2010. Our result showed that the annual compounded rate of growth of domestic, commercial, industrial (LT), industrial (EHT&HT), were, 11%, 15%, 2%, and 4.8% respectively. The total energy demand in the state grew at the rate of 10% annually during the same period. Total energy demand forecasted for the year 2010 AD that comes to 29000 MU. This figure doesn't take into consideration the T&D loss and the existing energy shortages. Considering these two factors a 20% increase (15% for T&D and 5% for energy shortage) have to be added to the forecasted figures. Thus total energy requirement as per our calculation would come to 35018 MU. For generating this much of energy additional capacity to be installed
would be of the order of 5158 MW. (On the basis 60% plant load factor). Energy conservation potential of the state needs to be looked into. Assuming an energy conservation rate of 20% the total requirement will be 28015 MU in 2010. The additional capacity for generating this much energy would come to 3825 MW, and the corresponding additional investment to be 1,53,000 Million.

7.2. Policy suggestions.

In view of the fast depleting energy inputs, the present trend in favour of the thermal stations at the all India level is to be discouraged and the installation of hydel stations encouraged instead. Since large hydel projects carry ecological hazards, it would be advisable to install medium range hydel projects (100-150 MW). The ideal balance between thermal and hydel stations may be maintained in the ratio of 60:40 for the country as a whole. As hydro potential is a perennial source of electricity, incentives may be given for setting up of small, mini and micro hydel projects in the country.

The recent tendency to depend on Independent Power Producers (IPPs) to build power plants using Diesel and Naphtha as fuels need to be discouraged in the larger interest of the nation. Power sector investment by the central government in generation, transmission and distribution has to be significantly enhanced with a view to ensuring equity in the distribution of power.

With a view to stabilising the financial position of State Electricity Boards, (SEBs) the power tariff has to be restructured taking into consideration the short run and long run marginal cost principal. The present classification of consumers into domestic and agriculture may be redesigned in such a way that the benefits of subsidy accrue to the really deserving sections. As the cost of electricity is on the
increase in all the states, possibilities of using 'price' as an instrument for energy conservation may be worked out.

In order to ensure reliable and dependable supply of quality power in Kerala, the state has to create an additional capacity of 3350 MW by 2010AD. For achieving this target the state has to accomplish several things immediately. The micro, mini and small hydro-potential, which the state possesses in abundance, may be fully exploited. The enormous scope that exists for non-conventional energy sources like solar and wind also may be tapped to the maximum extends possible. In view of the financial crunch of the state governments, efforts should be made to make use of the resources of IPPs who can raise funds and fuels inputs internationally, and also of the self financing power producers who can raise money and fuel inputs from internal sources. It would be more advisable to bank on the latter as the dependence on the former may give rise to certain negative effects in the long run.

Performance of hydel projects like Pallivasal, Panniar, Sengulam, Idukki, and Sabarigiri was found to be comparatively poor. A study on the technical aspects of low plant load factor of these projects may be carried out soon.

To reduce the T&D loss to 15.5% (the norm stipulated by the World Bank), it is essential that a number of substations, transformers of various capacities and length of HT lines be enhanced. Since huge investments will be required for this, a T&D Corporation may be floated under Kerala State Electricity Board.

The energy demand forecast carried out by different agencies at the state and national level suffer from a serious limitation, as such forecast is exclusively dependent upon secondary data relating to energy consumption, which do not
reflect the real energy demand of consumers, because of power failures, existence of choked demand and non-accommodation of end use service of energy. Hence it is suggested that demand forecasting based on end use analysis be carried out, preferably by Kerala State Electricity Board. For this purpose, it is necessary to develop a techno-economic model to identify energy demand of each consumer based on his connected load, hours of consumption, use of electrical appliances, and possibilities of load staggering during peak hours. Such a model will be helpful in the formulation of energy conservation policies in the state. As the demand for power of domestic and commercial categories of consumers are on the increase in the state, it is highly helpful for the power system to apply the concept of Demand Side Management (DSM). The DSM options include (i) Increase the off peak use of power by the domestic and commercial consumers, (ii) use of high efficiency equipments, (iii) differential tariff based on the time of use, and (iv) encourage the use of captive power during the peak hours. A related point may also be suggested here. Use of power electronic devices such as Compact Fluorescent Lamp (CFL) and electronic regulators would help to significantly conserve energy in the state.

The technological advancements occurred in generation; transmission and distribution areas of electrical engineering have not yet been introduced in Kerala. In advanced countries, for instance electronic meters are used in all types of electrical connections. High quality conductors and under ground cables of high voltage ratings are used to curb T&D loss. Similarly computers net work is extended in all segments of power system, including billing, data compilation, and load forecasting. Such technological innovations may be included in the power system of Kerala, at the earliest, either indigenously, or through technical collaboration. The recently established Kerala Power Finance Corporation is to be converted into nodal agency for investments in power sector of Kerala. A separate economic division may
be created in the Kerala State Electricity Board for taking up works relating to data computation and analysis, cost benefit studies of alternative energy options, determination of environmental costs as well as fixation of economic tariff.