CHAPTER II

REVIEW OF LITERATURE

Energy Economics is a relatively recent area of research, a development of the post-1950s. The growth of this branch remained quite slow till the beginning of the seventies, the bulk of the studies in the area being confined to fossil fuels, the basic and the most important source of commercial energy. Studies began to proliferate in this area, in the wake of the energy crises sparked off by the oil price hike of 1973. The energy crisis provoked the advanced countries to institute research centers, whose immediate concern was to develop energy alternatives to costly oil and to invent energy conservation techniques. It was in this background that electricity as a form of energy received priority treatment at the hands of policy planners and researchers, mainly because it is a cheap and clean energy. The notion that electricity is a clean energy has gradually changed as generation of electricity from thermal plants (the dominant method of electricity generation in the West) gave rise to serious problems of pollution in several western countries. Therefore studies in this area in initial years turned to environmental issues from generation. Such studies often lacked economic content.

In the ensuing years, particularly after the eighties the concern of the developed countries turned to technological innovation aimed at improving efficiencies at generation, transmission and distribution points of electricity. Simultaneously economic issues associated with the three segments were also taken up by energy experts in these countries. The developing countries were, on the other hand occupied with the problem of meeting the demand supply gap in energy, issues relating to technological improvements seldom figuring in their
priorities. However the rising imput costs, persisting power shortage and burgeoning revenue deficit of the utilities compelled developing countries to study economic issues of electricity sector.

The pioneering study in the realm of energy economics is usually attributed to Scarlotte and Eugene (1952)\(^1\) This Study mainly focussed on the reserve potential of major forms of commercial and non-commercial energy, their rate of utilisation, as well past and future trends. Though the scope of the study covered the world as a whole, the authors' examination was largely confined to the developed countries, due to severe data constraints in the underdeveloped world. This work generated considerable interest on the part of economists in examining the contribution of energy to economic growth. Darmstadter's\(^2\) study merits special mention in this context. He found that as GNP increased, energy consumption rose in close conformity. A subsequent enquiry by Fremont Felix\(^3\) using 1961 data pertaining to 153 countries proved the positive correlation between percapita national income and energy consumption.

With continuing economic growth and development, dimensions were added to energy related studies. Ford Foundation Energy Policy Project\(^4\) examined at length, aspects related to the interchangeability of energy with other production factors. According to the Project, the rapid increase in energy consumption since the Second World War was mainly caused by systematic substitution of energy for labour, capital, and raw materials. It was in this context, Tanzer\(^5\) referred to energy as the 14\(^{th}\) factor of production. As rightly observed by him, just as capital without labour is useless, so too sophisticated labour without energy.
The circumstances mentioned just before also led to proliferation of studies on energy related issues. The growth of studies in demand related issues was so tremendous that, during its formative years, energy economics meant studies in energy demand, as rightly observed by Ramesh Batia\textsuperscript{6}.

A celebrated pioneering study pertaining to energy demand was that of Hill et al\textsuperscript{7}. The importance of this work is that it related to an early period when energy economics had not emerged as distinct branch. In this historico statistical work, the authors give a graphic description of the changing energy scenario of the United Kingdom. The authors have attempted to estimate energy requirement for different time points using simple conventional techniques. As per their calculation per capita energy consumption per day was 88.2 Mega Joule in 1500 AD, 378 Mega Joule at the time of industrial revolution and one Giga Joule in recent years. The chief drawback of this work is that the authors were not able to make use of the modern sophisticated techniques of demand forecasting.

The unprecedented increase in energy consumption across the countries in the wake of the realization that energy consumption is a symbol of development and a virtual factor of production called for studies on energy efficiency. The energy demand analysis carried out from the turn of seventies falls under two categories: at the macro level and at the sectoral level. A convenient method of macro level energy demand analysis is to compute energy GDP ratios over time or across countries or regions for comparison. The conceptual issues in using energy GDP ratios, the problem of measuring energy consumption and GDP, and the problems with cross-country comparisons in this context have been examined at length by Desai \textsuperscript{8} Smolik \textsuperscript{9} Choe, et al \textsuperscript{10} and IBRD \textsuperscript{11}. 
The early works at the macro level category were done within the framework of single equation model. Works of these genera are those of Wolf, Siddayao and ESCAP. Later researchers pointed out the limitations in the use of single equation model since it does not consider possible changes in the energy mix over time.

To overcome this deficiency many authors subsequently made use of double log formulation, incorporating variables like population, urbanization, agricultural growth, structure of GDP, relative prices of energy and non energy inputs etc. Such works included in those of Pindyck, Berndt et al, Bohi, Dunkerley et al, Munasinghe and Sehramm and others. In this connection special mention should be made of a study by Rehman using Indian data. His is a thorough analysis of various factors affecting energy consumption and economic growth in a simultaneous framework using macro econometric and computable general equilibrium models.

An easy method that was followed for energy demand analysis at the macro level was to compare the growth rates of energy and GDP. It is a convenient method to see the relation between energy consumption and the level of economic activity. Because the calculation of the two growth rates are very easy, many authors have used this technique in the early years, and have evinced great temptation to use this measure without going to the factors that might have affected superficial interpretation of the growth rates, often led to wrong conclusions. Bhatia found no stable relation between energy consumption and GDP in the context of India. This method is also very sensitive to the selection of the base and terminal years for estimating growth rates.
The limitations of macro level studies and the problems associated with identifying demand determinants at the macro level have been pointed out by Bhatia. In view of inter-regional differences in socio-economic development, Bhatia suggested that demand studies at the sectoral level could be more tractable. Accordingly he estimated energy demand for the four major sectors: Industrial, Agricultural, Transport, and Households— in Indian context.

Regarding energy consumption in the agricultural sector, one of the early important studies is that of FAO (1972). According to this study, the average use per hectare of commercial energy in developing countries was only one tenth of that in developed market economies. However during 1972-80, the estimated consumption of commercial energy in agriculture in developing countries increased by 117%, the bulk of the increase being in fertiliser consumption.

Energy use in the industrial sector has been studied at the aggregate, sub-sector industry, or enterprise level, by various researchers. Jankowsky has examined aggregate consumption of energy in the industrial sector for four countries—Brazil, India, Korea and Kenya—taking industrial demand for energy as a function of the absolute size of the industrial sector, the structure of output, and the energy intensity of production. The finding is that in Kenya Industrial demand grew faster than industries; while in Brazil, rapid industrial growth had been accompanied by comparable increases in energy demand despite the greater role of heavy industries in the total. In India, the structure of fuel sources, namely, the high dependence on coal appears more significant in explaining industrial energy demand than does the structure of its output mix.
Available energy studies have analysed aggregate demand for transportation services, energy demand by type of transport service and demand for various transport fuels. (The studies of Divan\textsuperscript{25} Pindyck\textsuperscript{26} Parikh\textsuperscript{27} etc). A review of some of these studies shows that the price elasticity is limited for petroleum products in the short term, especially for gasoline. The demand for these products is income elastic, especially in the long run.

Available studies on the energy demand of the household sector, use both macro level data and data obtained from surveys of household expenditures on energy uses to workout elasticities with respect income, price, and demographic variables. Studies of Cecelski et al\textsuperscript{28} Havrylyshym & Munasinghe\textsuperscript{29} Amarullah\textsuperscript{30} and others are worth mentioning. The level of detail as well as sophistication of analysis varies from one study to the other. Some studies give bivarite tables, while some others attempt econometric analysis to estimate income and price elasticities.\textsuperscript{31}

Raily\textsuperscript{32} studied the demand aspects of energy and pointed out that the date on energy consumption do not reflect the demand as such, but rather demand is constrained by the supply factors. Raily suggested to include supply variables in the regression equation to overcome this problem.

Thus far our review covered major economic studies pertaining to energy at large. From now on the review will be confined to economic studies relating to electricity, as the primary concern of the present study is with power.

The study on electricity demand in Costa Rica by Dias-Bandaranaike and Munasinghe\textsuperscript{33} explicitly considers the quality of power supply by distinguishing three levels of voltage variation. The results indicated that the quality of supply has a significant impact on demand and thus should be recognized in planned electricity
consumption. The residential consumers whose supply of electricity was poor or very poor in Costa Rica consumed only 85% and 70% respectively of the electricity they would have consumed if the supply quality had been medium. A study like this would be highly useful to determine power investment planning to achieve optimal power system reliability. There is relevance for such a study in Indian context.

Goldemburg et al.\textsuperscript{34} have suggested DEFENDUS \textit{[DE}velopment \textit{Focussed END Use oriented Service directed.]} model to determine electricity demand in a state based on the end use of services of electricity rather than the volume of electricity consumption. Though the model appears to be a better method of electricity demand projection, the state Electricity Boards in the country are interested in applying this model. Thus a national level electricity demand analysis based on this model needs to be carried out in the Indian context, so that the actual energy requirements in the economy, the potential for energy conservation, and the thrust area of energy conservation can be identified.

Reddy\textsuperscript{35} analysed the pattern of energy carrier consumption in residential sector. The dependence of income on the energy carrier utilized has been established by using a Carrier Dependence index. Using regression analysis, the index verified the impact of different explanatory variables on consumption. The study showed that income played a very important role not only in the selection of energy carrier, but also on the quantity of consumption per household.

In an another research work on the end use pattern of power consumption of the people of the metropolis of Bangalore, Reddy\textsuperscript{36} found out that the share of traditional fuels, household energy consumption has been declining rapidly from 67%, in 1953-54 to 25% in 1989-90. In contrast to this, there is a sharp increase
in the demand for LPG & electricity. The major finding of this study is that with increase in income, household energy carrier consumption increased in favour of electricity.

Ranganathan\textsuperscript{37}, in his research work on the application of cost benefit analysis of rural electrification has developed an econometric model for demand forecasting for electrical power sector, to determine high load growth area. He suggested that the high load growth area, which should be electrified first, so that the benefits of electrification are maximized.

The largest electricity demand forecasting model on Indian economy, which was designed for the 6\textsuperscript{th} five-year plan, with an aim to augment input–output model was developed by Parikh\textsuperscript{38}. This was one of the major models developed for India to determine energy policies at the national level. In an another study on policy alternatives for Western and Southern power system in India, Parikh\textsuperscript{39} developed a model called “INGRID2”- a non-linear optimisation model used to simulate interconnections of two regional grids. The model minimises the total variable costs for the total power system with physical constrains on demand and supply side. This model was basically aimed as an aid to the planners for the 8\textsuperscript{th} five-year plan.

In several countries, it is observed that electricity consumption doesn’t reflect the real demand. There are constraints on supplies. Also the Utilities curtail energy demand through load shedding, blackout, power cut, quota allocation etc. Monasinghe\textsuperscript{40}, Monasinghe and Schramme\textsuperscript{41} and Sanghvi\textsuperscript{42} have attempted to study the adverse effects of energy constraints on economic activity. It is proved that apart from general inconvenience, power breakdown may result in shutdown of industrial activities. Since shortages may result in undesirable consequences and its
impact would differ from one sector to the other, it is necessary to assess where the shortages (or unfulfilled demand) are occurring.

Batia\textsuperscript{43} carried out a study on the impact of power shortage on the industrial sector, and observed that power shortages in the industrial sector may lead to captive power generation. Such back up systems involve higher unit investment costs, because they lack economies of scale, and use costlier fuel inputs other than coal. In India, there is greater increase in the number of captive power plants yet the economic aspects of captive power, both at the national and the state level are to be researched.

Sectoral demand analysis of power was carried out by scholars like Pindyck\textsuperscript{44} and Uri\textsuperscript{45}. In their model of study they took industrial output as independent variable. The parameter of these models were determined from time series data for a number of industries and worked out the responsiveness of electrical energy demand to these independent variables.

Nayar\textsuperscript{46} attempted to study the problems of power availability in the rural areas. He suggested hybrid energy system, which integrates renewable energy technologies with diesel generators, batteries and inverters to provide highly reliable twenty-four hours grid quality AC power in remote areas. This hybrid system has been applied in Australia for electrification of remote communities. A microprocessor based control system optimises the performance of the system as it meets the site load requirements for any given application. One limitation of this study, we have observed is that, it doesn't mention anything about the cost / kWh generated by renewable and an inter price comparison of hybrid energy system.
Raiky and Singh\textsuperscript{47} studied the determinants of energy consumption pattern in sectors like household, agricultural and industry. This study was based on the primary data collected from 120 farmers, 74 industrial units and 128 household families. The determinants of energy consumption in the three sectors have been studied through statistical and econometric techniques.

The research work on the demand for energy in Indian industries has been carried out by Joyashree\textsuperscript{48} using quantitative techniques. This work contributes to the general trend by estimating elasticity of substitution and price elasticity for three conventional fuel types: coal, oil and electricity for the “energy intensive” manufacturing industries in India with the help of three input translog model. They observed that in the wake of the supply constraints especially in the oil sector, dependence of oil could be reduced by influencing the demand responsiveness of the industrial consumers through price mechanism.

Now let us turn to some of the review of literature available on the pricing aspect of electricity. Munasinghe et al\textsuperscript{49} have studied the significance of marginal cost principle in electricity price determination. They do not find any reason to follow average cost pricing, since it used historic data, which proved inadequate for price fixation.

Hill et al\textsuperscript{50}, in their study on the pricing aspect of electricity stressed the significance of adding the environmental cost as one of the components of electricity pricing. This attempt would help to depend heavily on environmentally benign renewable.

Wee and Li’s\textsuperscript{51} work on the pricing aspect of electricity supply in China made it clear that in the wake of globalization, tariff restructuring becomes inevitable.
They even suggest that power sector reforms in the economy is highly useful to introduce optional pricing policy in this sector. They have appreciated the role of foreign capital in electricity sector.

Pachauri, while analysing the role of inputs on production has asserted that like labour and capital, energy shall be considered as one of the inputs of factors of production. Though this point is well known to the manufacturers and producers, due to its lowest percentage share on the total cost of production, energy cost is still included in the miscellaneous items. In his explanation, there is an indirect indication to apply partial productivity analysis of energy.

Partial productivity analysis of electricity has been worked out in the research study of Sumanth. In his book on partial productivity, he referred to a study assisted by Du Boff (1966) on the relationship between price of electric power and changes in productivity in American manufacturing industry. He also builds a theoretical framework for measuring the effects of electrical technology on factor costs, i.e. labour, capital and raw materials.

Deshmukh et al studied the pricing aspect of electricity consumption by the H.T industrial units of Maharashtra. It was a techno-economic study to find out how and how much of load can be staggered from the peak load to peak load period, through pricing mechanism.

Scholars in electricity pricing like Reddy, Little child and Vaidya have worked on the determination of optimal price for electricity. They do not find any reason to follow average cost pricing, since it used historic data, which proved inadequate for price fixation. They preferred to apply long run and short run marginal cost principle for determining unit cost. For long
term planning application, long run marginal cost finds more appropriate than the short run marginal costs.

Korean Electric Power Corporation which is responsible for generation, transmission and distribution of electricity in Korea, has implemented one of the sophisticated tariff structures incorporating long run marginal cost and the time of the Day tariff. The tariff levels are fixed on the bases of the anticipated rate of return on investment. KEPCO’S experience in tariff policy led SEBS of developing countries to follow Korean example.

Faruqui and Malko have analysed the sources of time of use Tariff (TOUT) this rate has been tested for the residential and small commercial energy users in the USA, and a review of 12 such experiments found that TOU rates can reduce peak period electricity consumption by up to 30%.

Pont et al has examined the validity of least cost utility planning process in different planning process in different nations. They reviewed that countries like US, Canada, Australia, Sweden, Jamaica, Thailand and Malaysia have implemented least cost utility planning process in determining the best sources of electricity generation on a priority basis, which takes into account, besides the direct cost, the cost of externalities as well.

Rao Govind et al examined at length the nature, characteristics and the issues found in the power tariff in India. They observed that actual tariffs levied by SEBS are at variance with the broad principles of rational pricing policy, which is incentive compatible and is required to generate resources for reinvestment. SEBS have failed to recover cost even when measured in accounting terms, with interest payable on State govt. loans being highly subsidized and depreciation calculated by
historical costs. They have also pointed out that economic consideration do not seem to have dictated the determination of tariff. The tariff on different categories of consumers bears no relationship to marginal cost of supplying electricity to them. In fact, in some case the tariff is inversely related to the average costs under lining the importance of political factors.

Munasinghe\textsuperscript{63} examined the significance of demand management and conservation in electricity sector, and has pointed out that the power system should follow the principles of integrated energy planning, which would help to conserve energy. Hastopoulos\textsuperscript{64} used various models to identify the cost effectiveness of energy use. A number of technical, economic and financial factors combined to determine the cost effectiveness of investment in energy conservation technologies. Widely used in analysis of engineering economics of projects are the Net Present Value (NPV) the Internal Rate of Return (IRR) and the Gross Pay Back Period (GPBP).

Bose and Anandalingam\textsuperscript{65} have studied the different engineering solutions to overcome electricity crisis. They pointed out that there was a lack of general ability to diagnose, design and implement engineering solutions to energy problems. They summarized that lack of technical know-how was the greatest non-economic barriers to energy conservation.

Bhattacharya\textsuperscript{66} examined the functioning of public sector utilities in developing countries and argued that the problems being faced by the power sector were diverse and privatization and deregulation cannot solve all of them, though the financial burden of the utilities may be cased. He further argued that privatization may lead to neglect of long term planning of electricity sector.
The studies of Schramm67 World Bank68 Bernelt69 Sanghvi70 Tenenbaum et al71 were mainly concentrated on the current issues of power sector in developing countries. They analysed that all the SEBS in developing countries are characterised by factors like structure of the system, growth rate, technical performance, debt crisis, heavy T&D losses, and capital scarcity.

Nadal72 has examined the scope for and the methods of energy conservation in Indian context. He further suggested that there are 27 ways of efficiency improvement. Through the application of these efficiency measures in industrial, agricultural, commercial and domestic sector, on an average 20-25% electricity consumption could be saved. Cost effectiveness of energy saved per kW and cost of generation per kW by various sources has been elaborated. He recommended that whenever a measure costs less per kW than a new power plant, a measure is likely to be cost effective in Indian context.

Morris73 critically examined the recent policy changes, especially as regards the Independent Power Producers (IPPs) and revealed that there are many disfunctionalities in this policy, particularly the enormous and quite unnecessary burden it places on the balance of payments. He has also pointed out several constraints to the healthy growth of the power sector. These constraints include the inability of the state sector to discipline its management and work force, large-scale corruption and leakages, load and system imbalances, brought about by inadequate investments in distribution system, and in hydel capacities etc. Recently the bulk of industrial consumers being increasingly left to fend themselves through captive power generation as also the political inability to raise tariff and thus contributed to the structural weakness of State Electricity Boards.
Reddy and Sumithra analysed Karnataka's power sector—the present situation, and the trends of electricity demand and supply, the financial problems, the import ant policy and technical milestones in the development of power sector.

A number of realistic and small measures are suggested, both on the demand side and the supply side to overcome present power shortages. These measures include:

1. Demand side measures like (a) efficient lighting, (b) use of solar water heaters (c) efficient irrigation pump sets, (d) efficient motors,

2. Supply side measures like (a) environmentally sound hydro electric power projects (b) reducing T& D losses (c) captive power generation, (d) cogeneration (e) small hydel, wind, and solar and

3. a new energy paradigm- the solution for the long term like the shift to the new energy paradigm, giving thrust up on energy services, rather than energy consumption.

Besides the above short and long term measures to make the power system efficient, viable, and dependable, the authors stressed the need to develop a sustainable energy future. However one of the limitations of this research work is that the economic contents of power shortages have not been properly looked into.

The review attempted in the foregoing section covers the major works in the power sector carried out within the country and abroad. In this review, studies directly concerning the performance of State Electricity Boards have figured but rarely, for the simple reason that such studies are few and far between in India.

The present study is concerned with an exhaustive analysis of the power system of Kerala, from technical and economic angle. Therefore a brief look at the works already done in the context of Kerala would be in order.

The first and perhaps the only comprehensive economic study about the power system of Kerala is that of Pillai. The author examined supply and demand aspects of the Kerala Power System during 1957-58 to 1976-77, using econometric
techniques. The major findings of the study include 1) Aggregate demand for electricity consumption grew at an annual compounded rate of 10.4% during the period 1957-76. 2) The income elasticity of demand in the short and long run are 1.63 and 1.363 respectively and estimated price elasticities-0.633 and -0.813 respectively. The income elasticity of demand for electricity in Kerala has been much higher than those prevailing in other developed countries like USA, USSR, UK, France or West Germany, but less than that at the all India level.

Many of the findings of the study have however become irrelevant as the work was carried out in the seventies when the State was surplus in electricity production. The continuing deficit occurred since 1982 have thrown out several issues in the power sector of the State, which the author could not foresee. Inspite of such visible limitations found in his work, the methodology followed, the observations derived, the major suggestions put foreword have valuable relevance even today.

Parameswaran76 examined the reasons for severe power and energy shortages in Kerala since 1979 and strongly recommended introducing super power thermal station in the central part of Kerala to meet power demand for the next few decades. But it is observed that the Kerala Power System did not install thermal alternative till 1997. In another work he77 observed that the power potential of the state was limited due to inter-state disputes over hydro sites, and the serious environmental objections raised against hydro projects. Menon78 studied the attractiveness of the unexploited hydel projects, in comparison with thermal power projects based on coal to be transported from eastern coalfields of Orissa.
Pavithran, G. Examined the demand and supply gap in energy and pointed out that the gap has been growing at an exponential rate. The situation took a worse turn beyond 1986 when "Blackout" and "Brown outs" became regular phenomena in the state.

The causes and the characteristics of power crisis in the context of Kerala have been examined by Pavithran, K. and observed that the internal peak demand and the system peak supply has been widening over the years, particularly from 1990 onwards. Some of the causes of power shortages mentioned are- 1) insufficient installed capacity, 2) neglect of hydel alternatives, 3) unexploitation of mini, micro, and small hydel projects, 4) poor energy conservation program, 5) relatively low tariff structure, and 5) lack of measures to reduce heavy T&D loss in the state.

Unnikrishnan examined the reasons for power shortages in Kerala and observed that 1) the energy policy of the Central govt. 2) the stand of environmental fundamentalists, 3) the cost over run and time over run of hydel projects, 4) corruption in the project construction and 5) lack of central investment in the power sector in Kerala, have been responsible for the present power crisis. However such issues have not been examined in analytically rigorous manner by the above authors.

KSSP studied the problems of power sector confined to the district of Kannur and pointed out that the most of the power problems in the district are just the continuation of the State level problems. However some of the problems peculiar to the districts of north malabar are- a) abysmally low voltage during the peak hours, b) insufficient transmission lines leading to high level of voltage drop,
c) over loaded connections per transformer, d) inadequate sub stations, e) lack of 220 kV lines, f) centralized store purchase, and lack of energy conservation awareness. This study recommended to use renewable like mini/micro/small hydel potential to meet energy demand during the peak hours. It also suggested using solar water heaters, and automatic lighting. One of the important suggestions of this study is to install atleast 100 MW thermal power project in the district of Kannur.

Menon[83] studied at length the merits and demerits of a nuclear power project in Kerala in the wake of acute power shortage. He stressed that nuclear power projects in the state were not to be encouraged due to health and environmental considerations. He was of the view that the present energy crisis was the direct result of the heavy appetite for energy by the EHT and HT industrial units. Most of the large-scale industrial units in Kerala are highly energy intensive. To reduce the energy demand and supply gap, industrial restructuring giving importance to energy light, and employment-oriented industries is suggested.

ECS[84] prepared a draft report on the alternative energy strategy for Kerala and the main proposals are - to introduce renewables in the energy sector, adopt an environmentally and economically sustainable energy policy, and involve of voluntary agencies and peoples movements in energy conservation and other energy related issues.

Jyothi[85] carried out a study on the economic aspects of environment friendly technology in the power sector of Kerala. Alternative energy option available in the state has been verified and observed that even if the existing cost per unit of solar energy is relatively higher, by harnessing technological
advancements, the cost per unit can be significantly reduced, and solar photovoltaic system may complement the existing hydel generation, particularly during summer. It is observed from the analysis of this study that sufficient attention has not been given to cover up the technical aspects of environment friendly technology.

Devi's Study on the energy perspective of Kerala economy examined the reasons for present power shortage in Kerala. The main findings of her study included: a) internal energy resources of Kerala are inadequate to meet energy requirements of the state in future, b) The T&D losses are quite high by comparable standards, c) energy policies of the state have not considered properly the possibilities for energy conservation. To meet power requirement for the next decade, two pronged approaches have been suggested, (1) to develop non-conventional energy on a significant scale, and (2) enhance technical efficiency in both generation and consumption of energy, together with ceaseless efforts to conserve energy.

Isac et al studied the pattern of power consumption at the micro level. This study merits special significance due to the obvious reason that a similar study of this kind was not conducted in the state. This study covers major aspects like 1) Pattern of energy consumption 2) Energy demand for the panchayat 3) End use analysis of power consumption 4) Power line mapping to determine load concentration 5) Levels of voltage to the consumer end during peak hours 6) Scope for integrated energy planning at the micro level. This pioneering study has now become the base for energy studies at the local level.

IRTC conducted a detailed study on the electricity demand in seven major sub divisions in the State. These seven areas belong to seven districts chosen on
the basis of the voltage problem and similar other considerations. The demand analysis was held using end use analysis (DEFENDUS Model). One of the major findings of this study was that the power consumption of higher income group is much higher due to the use of various types of domestic electrical appliances. The impact of gulf boom on the demand for power in the domestic sector has also been observed. It followed two methods of end use analysis called 1) Appliances approach and 2) Engineering approach. Based on this analysis, it recommended following energy conservation techniques like the use of CFL (Compact Fluorescent Lamp) in the State liberally which would help to bring down energy demand by 400 MW.

Pavithran, G. examinated the different aspects of T&D set up in the state and recommended introducing drastic measures to curb energy loss and also to improve the voltage level during the peak hours. The major findings of this study are – 1) Poor ratings of power lines and transformers, 2) Insufficient reactive compensation 3) Value of power factor below the expected minimum (0.90) 4) Over loaded transformers and 5) Over extended HT&LT lines. His recommendations included 1) Load staggering 2) Installation of additional transformers 3) Setting up of additional substations of various ratings and 4) Replacement of old and weak transformers.

Krishanan and Pavithran analysed the problems and remedies of huge T&D loss in Kerala. They observed that the poor T&D in the State is due to the low priority in the allocation of financial and managerial resources required for the power system. The technological advancements in the electrical engineering in West countries helped them to curb energy loss below 15%. Such technological developments including equipments and software packages are rarely used in the
context of Kerala. The measures suggested to curb energy loss are 1) Energy auditing 2) Load survey 3) Network reconductoring and reconfiguration 4) Reactive compensation 5) Use of more shunt capacitors and 6) Underground cables. The investment on T&D improvement will be paid back within a few years.

Mohanan\textsuperscript{91} worked on the technical and non-technical aspects of energy conservation potential in the State, particularly in the industrial sector. The motor drives used in most of the industrial units are induction type and if it could be replaced by variable speed motors, about 20% of energy consumption could be saved. However in the context of Kerala such a move is yet to take place.

Hydari\textsuperscript{92} conducted a Delphi study on energy efficiency and energy conservation in the context of Kerala. Non availability of sufficient data on different aspects of energy conservation prompted him to make an expert opinion study namely Delphi. Energy auditing is recommended as a policy measure to promote energy conservation in the State. Another point suggested by him is to promote less energy intensive industries like electronics to conserve much energy. Experts have a convergent opinion that increased energy consumption leads to environmental problems and hence each should be accounted in the assessment of energy efficiency. This study though covers many aspects of Kerala Power System, excluded major areas like the causes of power shortage, demand projections and sectoral demand for energy.

Late eighties witnessed a phenomenal increase in the research work on the power system – both at the National and State levels, due to persistent power shortage and power system unreliability. However one of the limitations observed in many of such studies is that the economic content of power crisis has not been
exposed much. When individual researchers find hard time to work on the economic aspects of electricity, institutions like IISc, IGIDR, IIT Delhi, and TERI and similar other pioneering energy research institutions have carried out extensive research work on the power system, giving special attention to both technical and economical aspects. Some of the area in which special attention has been given are: 1) Power demand and supply gap 2) Causes of system unreliability 3) Production and value loss due to power shortage and system unreliability 4) Impact of power deficit on value addition and employment, 5) The economics of inter-fuel substitutions 6) Marginal cost pricing 7) Cost benefit analysis of power alternatives like capital power, generators, inverters etc. 8) Integrated energy planning 9) Economic cost of renewable and 10) The energy demand and price modeling. But none of such institutions have taken up for enquiry problems faced by the power system of Kerala.

The forgoing review of major works done on the Kerala power system indicates that most studies are technical in nature and content, economic studies being rather scanty. By virtue of its nature, a meaningful study of power system would dictate a techno- economic approach, which is totally lacking in Kerala context. The present exercise is a techno- economic study of Kerala power system covering such aspects like installed capacity, power generation, maximum demand, pattern of energy consumption, sectoral demands for electricity, and revenue and tariff structure.
2.1. Notes and References


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