CHAPTER 3

ON THE DEVELOPMENT OF AN ENERGY MODEL FOR INDIA

The energy crisis of the seventies radically changed the common belief that simple extrapolation of past consumption is sufficient to reliably predict the future energy requirement. It forced Governments to re-examine their policies and the economists to review their analytical tools. The traditional approaches have been found inadequate to predict the future energy requirements in a meaningful manner.

The vital role played by energy resource utilization in national economics indicates that the identification of energy issues, energy policies and their implementation are vital areas which deserve a careful investigation. Energy analysts and policy makers have realized the importance of an integrated approach to energy analysis. The integrated approach involves not just prediction of the energy demand but also allocation and utilization of the same in an optimum manner considering such factors as energy price, national income, technological improvements and environmental quality. Analytical and modelling tools became more sophisticated particularly in their treatment of uncertainty, reliability and supply quality. A broad framework that should underline all national level planning and policy making has become a necessity to ensure the best use of the scarce resources which would definitely improve the socio-economic standards and raise the quality of life of the people. Some of the concepts involved in the evolution of a viable energy model, the prominent parameters that should find a place in the analysis and the rationale for choosing them are presented and discussed in the following sections.
3.1 ENERGY POLICIES IN INDIA

In India, devaluation of rupee has been carried out in 1960 and again in 1991 in order to make exports beneficial and imports costlier. With regard to energy resources, this policy decision has helped to reduce the import of oil and has helped in the increased utilization of available resources, like coal, nuclear and renewable sources. Such policies have forced consumers to restrict the quantity of oil consumption to a certain extent.

Several committees have been set up in India for recommending energy policies to suit Indian economic conditions since the late fifties. The Energy Survey Committee (Report 1965), 1963-'65 has been the first of its kind to take a comprehensive view of India’s energy problems and make projections of energy demand and supply for the period 1965-'89. The committee recommended development of clean coal technology and increased utilization of coal and reduction in the consumption of mineral oil, since a bulk of this commodity was being imported. It also recommended that electricity should be generated using hydropower. In spite of these recommendations it is found that during 1965-'69 coal consumption stagnated while oil consumption increased by about 50%.

As consumption proceeded in a manner inconsistent with the endowment of resources, a Fuel Policy Committee (FPC) has been set up in 1970, (Pande 1980). Considering the resource endowments and the costs at which these resources could be exploited, the committee recommends that coal should be the principal commercial source of energy in India. It emphasized the need for the substitution of oil by coal and identified the methodology to be adopted for carrying out the conversion.

While the ESC concentrated on realistically forecasting the future energy demand, the FPC concerned itself with the development of alternate strategies and pattern of future fuel resource requirements. Neither committee did determine an optimal fuel resource utilization pattern taking into account a well chalked out
energy plan coupled with an economic development plan. The above two committees accepted the theory that energy plan has to be derived from the economic plan. Also, though both committees strongly recommended the setting up of hydropower plants, in each of the Five Year Plans it has been observed that the share of the thermal power witnessed a notable increase. This is attributed to long delays in the execution of hydro plants within the Plan periods and also to cost escalation.

To overcome these shortcomings, a Working Group on Energy Policy (Report 1979), has been set up during 1977-'79. The major recommendations of this group among other things pertain to the larger and increased use of renewable sources, to improve the efficiency of energy conversion systems, to reduce total oil consumption and to reduce energy intensity in the industrial sector. Later the Committee on Power 1978-'80 brought out similar recommendations. The Advisory Board on Energy has been set up in 1983 and since then it has been presenting recommendations for evolving energy policies to the Government of India (ABE 1987). The Board advises the Government strongly to encourage people to practise energy conservation in a concerted manner, to review critically high energy intensive areas, to improve the working of thermal and hydel power system, to opt for the increased usage of non-conventional energy sources and to develop methodologies for effective utilization of agro residues.

Major environmental issues linked with energy resource utilization have in the meantime, started demanding the attention of energy and environmental analysts. It has been found that the energy policies in India have been drafted without giving due consideration to environmental consequences. Energy cannot be dealt in isolation. Energy is linked and interlinked with several factors. Energy is linked with economy through supply, demand and prices. It is linked with environment through pollution. Economy in turn is linked with environment through environment control measures. Political factors also interfere with the economy through taxes and policies. Hence, while framing energy utilization policies, these factors should also be borne in mind.
It is found that conventional time series and econometric models have not been developed taking into account these factors. It has become very necessary to involve environmental factors in energy models. Similarly improvement in technological efficiency may have far reaching consequences in reducing energy consumption. There is an urgent need for the development of an econometric model involving environmental aspects taking into account technological efficiency parameters.

3.2 AN OVERVIEW OF MODEL DEVELOPMENT

Energy is growing in its importance day by day. Proper planning is vital to meet the future needs. Uncontrolled exploitation of the available commercial energy resources will lead to a bleak future since a bulk of these is non-renewable in nature. Indiscriminate and thoughtless use of fossil fuels starting from early seventies and the havoc it played on the world economy and environment forced the analysts to rethink and the consumers to react. During the period from 1953 to 1970, models have been developed with energy demand as a function of national income. But after the 1973 oil crisis, price is also being included in the energy demand model along with national income. The second energy disruption of 1978 resulted in removing energy wastages and making the consumers and the analysts energy conscious. Technological efficiency is found to be a factor of great importance. Several energy conservation, energy audit measures have been carried out in all energy consuming fields. Technological explosions and innovations are witnessed in almost every field. A model without considering them would become a void.

An attempt has been made to fill this void by including factors, which have not been considered so far, in the energy forecasting model developed in the present work. The depiction of the effect of efficiency changes on the widest spectrum possible, by adopting innovative technologies within the limits of second law of thermodynamic conditions need to be considered. Price and national income are found to be necessary variables but they alone are not sufficient to
describe the consumption pattern. The model is expected to achieve a certain degree of acceptance by introducing a technological factor, but its sophistication could still be refined.

Several variables like import and export earnings, price of substitute fuels, capital formation and expenditure are used in energy models by different researchers. But none of them is found to be significant. The late eighties brought into its wake the consequences resulting from energy consumption. The issues like global warming, acid rain, photochemical smog are being debated over by academicians, politicians, energy analysts and environmentalists. It has been realized that energy should be utilized in an environmentally optimum way. The major concern of all the countries has been the process of global warming which has been caused mostly by carbon dioxide (CO$_2$) emission and accumulation and hence it has been decided to find its effect on the energy consumption. The inclusion of environmental factor is likely to enhance the credibility of future energy models.

Over 95% of the energy demand of the industrial world is met by burning fossil fuels. India’s commercial sources meet nearly 70% of the country’s energy requirement. Large scale fossil fuel utilization coupled with massive deforestation has accelerated the environmental degradation. Along with CO$_2$, oxides of sulphur and nitrogen, particulates, carbon monoxide and volatile organic compounds are emitted into the atmosphere. To control the emission level in the atmosphere resulting from fossil fuel burning, an optimization technique can be adopted. An optimization model, used in conjunction with prediction models will enable the planners to ensure suitable policies, perhaps to strike a compromise between two conflicting issues - to meet the increased energy requirement on the one hand and to limit the emissions on the other.

Global energy consumption increases exponentially as does population. The essential and desirable aspects for the day to day existence are obtained using the natural resources. Usage of the natural resources most of the time results in
the outcome of unwanted wastes - causing pollution of air and water. Air pollutants resulting from fossil fuel utilization and allocation of resources for minimum pollution are the thrust areas in energy environment sector. Hence energy, economy and environment have been given prime importance in the optimization model. The optimization model will give the amount of coal, oil and electricity that need to be utilized for maintaining acceptable levels of ecology. The balance will have to be supplied by non-conventional energy sources which are environmentally friendly.

3.3 SCHEMATA OF THE PROPOSED MODEL

The traditional approach to energy planning is to determine the energy demand and then plan supply accordingly. However the current situation calls for a methodical approach where economic growth, environmental degradation and technological efficiency are considered simultaneously. The exercise might involve the development of a Modified model and an Optimization model. A Delphi study for evolving scenarios of future energy utilization pattern might also be useful. The present work has attempted to carry out the above tasks in the process of evolving an energy model for the prediction of commercial energy requirement in India. The schematic representation of the overall energy forecasting model envisaged in the present work is given in Fig.3.1.

The commercial energy demand could be predicted using a Modified model, developed using two stage least square principle. The model links commercial energy consumption to price, national income, technology and environment. The commercial energy requirements obtained from Modified model are then used as input in the MPEEE model, which maximizes the GNP-energy ratio based on environmental constraints. The model is analysed at different percentage reduction of emissions upto the planned electricity generation capacity in 2000-01 for India. The difference between the predicted requirement of the commercial energy from the Modified model and optimum from MPEEE model may have to be obtained from the non-conventional energy sources. The Delphi
FIG. 3.1 SCHEMATIC REPRESENTATION OF THE ENERGY FORECASTING MODEL
study has been conducted to determine the possible percentage utilization of non-conventional sources, keeping in view, the state of the art of technology, economics of new devices and social acceptance. The arrival at consensus and stability are checked by statistical tests.

The complete details of the energy forecasting model which links energy, economy and environment with technological factors and the validation of the model are dealt in detail in the following chapters.