CHAPTER 1

INTRODUCTION

Energy is a vital input in all fields of economic activity. Growth in energy consumption is often used as a physical indicator of economic growth and availability of energy is considered as the most important prerequisite for economic development. While the importance of energy as a crucial input has always been recognized, energy sector as such did not receive much attention till the end of the sixties. The awareness that natural resources are exhaustible and they become a limiting factor in growth is of relatively recent origin. The Club of Rome study[1] has highlighted the limited availability of non-renewable natural resources. The study estimates that Global Coal reserves are expected to last for 111 to 2300 years and Petroleum and Natural gas reserves for 20 to 50 years depending on the assumptions made. This awareness of exhaustibility of resources together with the sharp hike in Petroleum prices in 1973, resulted in a spurt of studies on the energy sector. A large number of studies, that have come out, pertain to demand forecasts of energy and a few deal with the substitution possibilities amongst various fuels.

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1 Donella H. Meadows et al, The Limits to Growth, New American Library, 1972.

1.1 Energy Studies in India

In India also in the seventies a number of studies have come out mainly dealing with demand forecasts. Before the seventies, the one significant study[2] on energy is by the National Council of Applied Economic Research where demand forecasts for different types of energy are given for the years 1965-66, 1970-71 and 1975-76. Demand was estimated for different regions and for the broad sectors of economic activity. 'Second India Studies - Energy'[3] deals with the present use pattern of energy and provides estimates of demand and availability for various types of energy for 2000 A.D. The study estimates that the energy required in 2000 A.D. is ten times that of the energy used in 1970-71 in the Indian Economy. It also shows that the need to find a substitute for Oil is inescapable. Tyner[4] in his study traces the relationship between energy consumption and national income in India for the period 1953-54 to 1970-71 and finds that an increase of one million TCR of energy would result in the increase of nearly Rs. 6 crore of national income in 1960-61 prices. After reviewing the progress of the power sector over the four plan periods, he observes, that the heavy shortfalls in the planned power target, have constrained both agriculture and industrial

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2 Demand for Energy in India. NCAER, New Delhi, 1966.

3 Parikh, Kirit. Second India Studies: Energy. Macmillan and Co., Delhi, 1976.

4 Tyner, Wallace E. Energy Resources and Economic Development in India. Allied Publishers, Delhi, 1978.

growth. He argues that heavy emphasis should be put on the power sector and specially on Coal-based thermal power. He recommends that India should pursue a strategy of increasing domestic Oil production by leasing the off-shore areas to foreign Oil companies to minimize the investment liability. Pachauri[5] in his study brings together the demand estimates and resource potentials, pertaining to various agencies and examines the new technologies and alternatives that India faces in the Energy sector. Henderson,[6] in his study, undertaken for the World Bank, reviews the energy resources of India and the trends in the supply of energy in the decade of the sixties. He also deals, in detail, the policy and prospects for the Fifth Plan period. He finds that the energy intensity has increased from 0.57 to 0.80 from 1960-61 to 1970-71 when energy is measured in MTCR and output is measured in billion rupees (10^8 Rs.). He further analyses the change in terms of changes due to composition of output and energy coefficients. Out of the total increase of 81.4 MTCR over the decade, output changes account for 55.4 MTCR. Ashok Desai[7] analysing the source of growth of energy consumption from 1955 to 1970 finds that 58 per cent of the increase in energy consumption during the period can be

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5 Pachauri, R.K. Energy and Economic Development in India. Praeger Publishers, New York, 1977.

6 Henderson, P.D. India: The Energy Sector. Oxford University Press, Delhi, 1975.

7 Desai, Ashok V., "India's Energy Consumption and Trends," Energy Policy, Vol. 6, No. 3, 1978, pp. 217-230.

attributed to net domestic product (NDP), while 42 per cent is due to change in energy intensity.

Chitale and Roy in their study, 'Energy Crisis in India'[8], besides providing forecast of energy consumption and comparing it with other forecasts, dwell at some length on the behaviour of energy consumption per unit of output intertemporally and across countries. One surprising outcome of their analysis is that Indian industries by and large, consume more fuel per unit of output than their counterparts in the U.S.A., though the level of mechanization and automation is extremely high in U.S.A. as compared to India, thereby indicating that there is considerable scope for conservation of energy in India. They are of the view that energy input in the industry can be reduced by as much as 20 per cent. They also give the energy coefficients for some important industries for the period 1965-66 to 1971-72. With the high price for Oil and its consequent impact on the balance of payments situation, the study also examines the interfuel substitution prospects. The interfuel substitution programmes based on what they call technical guesstimates, would reduce the demand for Oil from 48 million tonnes to 42 million tonnes in 1985-86.

The major focus of the above studies is largely on the commercial energy use and the fuel policy pertaining to commercial energy.

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8 Chitale, V.P. and Roy, M. Energy Crisis in India. Economic and Scientific Research Foundation, New Delhi, 1975.

1.2 Non-commercial Energy Studies

In the Indian context, where majority of population lives in rural areas, the non-commercial energy has a dominant role. Non-commercial energy while did not receive as much attention as commercial one, is not altogether neglected. The estimates of consumption and supply of non-commercial energy were made first by National Council of Applied Economic Research[9] and later by the National Sample Survey.[10] There are number of studies,[11] which have made a closer scrutiny of the various forms of non-commercial energy, dealing with the cost-benefit

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9 Domestic Fuel Consumption in Rural India. NCAER, New Delhi, 1965.

10 National Sample Survey No. 141, Tables with Notes on Household Consumption of Fuel and Light. Delhi, 1969.

11 Vide for instance the following:

(a) Baran, C. Energy, Employment and Basic Needs: Discussion Paper No. 53. Centre for Development Planning, Erasmus University, Rotterdam, 1980.

(b) Bhatia, Ramesh. Energy and Rural Development in India: Some Issues. Institute of Growth, Delhi, 1975 (Mimeo.).

(c) Bhatia, Ramesh, "Economic Appraisal of Bio-gas Units in India," Economic and Political Weekly, Special Number, August 1977, pp. 1503-1518.

(d) Desai, Ashok V. India's Energy Economy: Facts and Their Interpretation. Centre for Monitoring Indian Economy, Bombay, 1980.

(e) Domestic Fuel Consumption in Rural India. NCAER, New Delhi, 1965.

(f) Reddy, Amulya Kumar N. and Prasad K. Krishna. "Technological Alternatives and the India Energy Crisis," Economic and Political Weekly, Special Number, August 1977, pp. 1485-1502.

aspect, the employment potential, the basic needs and the standard of living of the rural population.

1.3 Energy Studies by the Government of India

The energy problem, naturally received attention from the Government of India. Long before the fuel crisis, in 1963, the Government of India appointed a Committee[12] to provide basic material for development planning in the field of energy. The report of the Committee provides estimates of demand and supply of energy, both total and in respect of all the constituents of energy on a national, regional and sectoral basis for the years 1970-71, 1975-76 and 1980-81. It also considered the development of the power resources and the question of fuels for thermal power stations, the location and sizes of the power plants. Even with the relatively low prices of Oil, then prevailing, the Committee felt that the increased Oil use is certain to cause the balance of payments problem and recommended that measures be taken "to produce and popularize the use of, for domestic purposes, of commercial fuels based on indigenous Coal supplies".[13] The Committee further examined the replacement and the conversion factors of various types of fuels taking into consideration the Indian experience and provided these estimates.

The Government of India subsequently appointed a Fuel

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12 India (1965). Report of the Energy Survey of India Committee, New Delhi.

13 Ibid., pp. 164-165.

Policy Committee[14] in 1970 to provide estimates of demand and supply and to study the efficiency in the use of fuels. This Committee submitted its report in 1974. The report takes into account the multifold price hike in Oil in 1973 and provides energy perspectives upto 1990-91. The Committee report highlights the necessity for a regional energy policy as a part of a well-conceived regional development policy.

The National Committee on Science and Technology[15] also appointed a team to look into the energy question and the team submitted, to the Committee, a report on the Fuel and Power Sector. The report goes into the technical aspects of fuel efficiency and suggests how fuel can be economised by recycling energy from one subsystem to another within a unit, where heat is required at different temperatures for different subsystems.

In December 1977 the Government of India set up a Working Group on energy policy.[16] The major thrust of the Working Group was directed towards curbing the consumption of Oil to the minimum possible level by increasing the efficiency of its utilization and by substituting it by renewable sources of energy. The Working Group also recognized that there is a need for reappraisal of the economic development strategies so that

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14 India (1974). Report of the Fuel Policy Committee, New Delhi.

15 National Committee on Science and Technology. Report of the Fuel and Power Sector. Technology Bhavan, New Delhi, 1974.

16 India (1979). Energy Policy Report of the Working Group. Planning Commission, New Delhi.

energy can be conserved by appropriate choices of technological and locational policies.

1.4 Importance of Regional Aspect

India is not only a large country, but it has a variety of climatic zones as well as soil, water and geological conditions. As the availability of natural resources is different from region to region, the use of different energy forms are observed in various parts of India. Not only the forms of energy used are different, but the intensity in which it is used also vary from region to region. Such a variation can no longer be neglected as energy is becoming increasingly scarce. Hence the analysis of the energy problem for India, needs to be done at the regional level as well.

A brief survey of the major studies on energy sector in India, presented earlier, deals with the demand forecasting and energy policy for the country as a whole. Except in the field of demand forecasting, there are no studies in India on the problems pertaining to energy, at the regional level, though the Fuel Policy Committee and the Working Group of the Planning Commission have recognized the importance of the regional dimension in analysing the energy problem. As Miernyk et al[17] have observed, "Energy has not been thought of as an important locational determinant in the past, except in a few capital intensive electrolytic processes. But it is likely to be one

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17 Miernyk, W.H., Giarratani, F. and Socher, C.F. Regional Impacts of Rising Energy Prices. Ballinger Publishing Company, Cambridge, 1978, p. 3.

of the important locational determinants for a fairly wide range of manufacturing activities in the future."

The present study therefore sets out to examine the interregional variations in fuel consumption and the efficiency of the existing technologies in the regions from the energy point of view. Before elaborating the objectives of the study, a brief review of the literature on the regional energy analysis is given below.

Miernyk and others[18] have studied the impacts of the rising energy prices at regional level for the U.S. economy. Their study has been carried out with the basic hypothesis that the new structure of energy prices will have differential regional impacts due to regional variation in energy production, consumption, industry-mix, etc. They argue that the focus of regional growth is likely to shift from demand oriented approach to supply oriented one. Making use of an interesting modification in Leontief's model by A. Ghosh, they formulate a model in input-output frame to relate output to supply factors.

The article by Lesuis, P., Muller, F., and Nijkamp, P.[19] outlines an input-output model for energy management, though empirical results are not provided. For a given sector it considers the input vectors of different regions separately

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18 Ibid.

19 Lesuis, P., Muller, F. and Nijkamp, P., "An Interregional Policy Model for Energy-Environmental Management," in T.R. Lakshmanan and P. Nijkamp (ed.), Systems and Models for Energy and Environmental Analysis, 1983, pp. 59-69.

instead of one average technique for the nation as a whole whereby import substitution between regions can be considered. Hafkamp, W. and Nijkamp, P.[20] develop a simulation model, incorporating regional input-output tables wherein some preset goals like regional income and environmental quality are optimized by an appropriate choice of the energy source available in different regions.

Walton[21] in his article, studies the substitutability between energy and non-energy inputs for the Middle Atlantic Region of the U.S. economy and finds it smaller than that of the U.S.A. as a whole and argues that the results based on aggregation of regions may result in non-optimal investment policies. Harper and Field[22] tried to obtain elasticity of substitution between energy and non-energy inputs for various regions in the U.S.A. and find that the elasticity of substitution between capital and energy is very small for most sectors and regions. The results of Harper and Field do not confirm the hypothesis of Walton that the older regions are characterized by greater capital-energy substitutability than the newer ones.

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20 Hafkamp, W. and Nijkamp, P., "National-Regional Interdependencies in Integrated Economic-Environmental Energy Models," in T.R. Lakshmanan and P. Nijkamp (ed.). Systems and Models for Energy and Environmental Analysis, 1983, pp. 70-79.

21 Walton, A.L. "Variations in the Substitutability of Energy and Non-Energy: The Case of the Middle Atlantic Region," Journal of Regional Science, August 1981, pp. 411-420.

22 Harper, C. and Field, B.C. "Energy Substitution in U.S. Manufacturing: A Regional Approach," Southern Economic Journal, Vol. 50, No. 2, October 1983, pp. 385-395.

As the foregoing shows, the growing literature on regional energy problem largely focuses on a particular region rather than comparisons across regions.

1.5 Purpose of the Study

The main objective of this study is to analyse the interregional variations in the fuel consumption, (fuelwise), of the manufacturing industries at the aggregate level as well as the individual industry level. It attempts to study the efficiency of the existing technologies of different manufacturing industries, and also to indicate the location for newly coming up industries such that the cost of fuel consumption is reduced. The study mainly focuses on the following questions:

(1) What are the variables on which the regional fuel consumption of the industrial sector depends?

(2) What is the elasticity of substitution for various fuels across regions for the industrial sector?

(3) What is the energy efficiency of regions on physical and cost basis?

(4) To what extent the differences in energy/income ratios between the regions and the nation are due to industrial structure and to what extent they are due to higher energy intensity?

(5) Which are the energy efficient regions for Heavy Fuel Using industries?

(6) What is the optimal allocation of industrial output with the minimum energy cost at the country level?

(7) What is the differential impact of the energy price hike on industries of the various regions?

The study is based on the information on the large scale manufacturing industries in India for 1970. The data are compiled from the reports of the Annual Survey of Industries (A.S.I.). The detailed data for eleven fuels for each of the industries classified according to the highest level of disaggregation (i.e. coded in 7 digits) and for each region are available from A.S.I. reports. The latest year for which such detailed data are available is 1971. There are 24 regions (i.e. States including the Union Territories) for the year under study. The analysis is carried out for the industrial sector both at aggregate level and at the individual industry level for some important industries. The analysis is carried out in value terms as well as in energy units. The particular energy unit chosen for the present study is Tonne Coal Replacement (TCR).

1.6 Scheme of the Analysis

Chapter two deals with the data sources, the data adjustments and the considerations, governing the choice of energy unit.

The third chapter presents a broad picture of fuel consumption at the All India and at regional level. An attempt is made to assess the factors that have an influence on the regional fuel consumption at the aggregate as well as individual fuel levels. The nature of the elasticity of substitution between

fuels is also examined.

In chapter four the intensities of energy consumption and the efficiencies of energy use in different regions both at the aggregate and at the individual industry level are studied. The differences in the energy/income ratios between the States and the nation are examined by isolating the structure effect from the energy intensity effect.

The fifth chapter contains the analysis of the energy efficiency for the single industries across regions. A mathematical method is developed to compare the costs of energy to produce the same level of output between different regions. It compares the costs; one as the actual one and another as the hypothetical cost which is the cost evaluated with one region's fuel technology and another region's prices. This helps in identifying the low fuel cost technology for the industry as well as the regions with price advantages.

The sixth chapter deals with the optimal allocation of industrial output across regions for the object of the minimum energy cost at the country level. This has been carried out with the help of a Linear Programming Model. The regional economies are divided into eighteen sectors and the same technologies, except for energy sector, are assumed for all the regions, while developing the Linear Programming Model.

In the seventh chapter, we propose to develop the energy specific regional input-output tables of order eight, which have four energy sectors and four non-energy sectors. The purpose of constructing such input-output tables is to study

the impact of change in prices of one energy sectors on the other economic activities. As these impacts are studied across regions, an assessment about the differential effects of energy price rise on the regional sectoral prices has been attempted. The study carries out such comparisons over the period 1970 to 1981.

The overall results and the conclusions are summarized in the last chapter of the study.