

**ANALYSIS OF REGIONAL VARIATION
IN FUEL CONSUMPTION OF
INDIAN INDUSTRIES**

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CERTIFICATE

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"Analysis of Regional Variation in Fuel Consumption of
Indian Industries" submitted by Mrs. Latika Argade was
carried out by the candidate under my supervision. Such
material as has been obtained from other sources has been
duly acknowledged in the thesis.

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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 study¹ 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.

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 study² 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. Tyner⁴ 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

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. Pachauri⁵ 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 Desai⁷ 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

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.

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 Research⁹ 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

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 Committee¹² 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

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

13 Ibid., pp. 164-165.

Policy Committee¹⁴ 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 Technology¹⁵ 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

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 al¹⁷ 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

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 others¹⁸ 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

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 pre-set goals like regional income and environmental quality are optimized by an appropriate choice of the energy source available in different regions.

Walton²¹ 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 Field²² 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.

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 the 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.

CHAPTER 2

DATA : SCOPE, COVERAGE AND ADJUSTMENTS

The analysis of regional variation in fuel consumption is dependent on the composition of four major sectors of the regional economies, viz. agriculture, manufacturing industry, transport and the household sector besides the availability of energy in the region. In the agriculture sector, the fuel consumption depends on the level of irrigation, cropping pattern, and the level of mechanization. In the transport sector, it mainly depends on the mode of transport. The regional variations of consumption in the household sector depend among others on the level of incomes, the density of population, etc. In the manufacturing industry sector it mostly depends on the level of industrialization and the composition of industries.

It would be instructive to study each of the above sectors to assess the magnitude of the differentials and the causes of such variation in fuel consumption across the regions. An in-depth analysis of each sector goes outside the scope of one single study. The present study is limited in scope and confines itself to the regional variation in fuel consumption in the organized large scale industrial sector in the economy of the country.

2.1 Definition of Region

A region can be defined in a number of ways, depending on the nature and purpose of the problem. Broadly speaking there are three approaches in defining a region and are based on the concept of homogeneity, hierarchy of centres and administrative units. These approaches often yield different divisions of the same geographical space.

But, for the purpose of analysing the regional variation in fuel consumption the basis for defining the regions should be the fuel resource endowments and similar other infrastructural facilities. But unfortunately the data for delimiting the country into regions on this basis is not available in the requisite format. Secondly, in view of the policy implications of the present study, it is necessary that the economic region howsoever defined must have matching political and administrative authority. That is, for any policy decision it is always helpful to have the economic region congruent with the administrative region. Therefore, in this study we have taken all the 16 States and the 8 Union Territories as constituting the regions. A list of them is presented in the Table A₂.1.

2.2 Scope and Coverage of the Data

2.2.1 Nature of Industrial Sector

The industrial sector is not a homogeneous sector as the size of industrial units has significantly a wide range of variation. On the basis of the size of an industrial unit, the industrial sector is divided into two segments in the statistical reporting system of the country. One part is the registered

or factory sector and the other is the unregistered or household sector. The registered sector is defined to consist of the industrial establishments registered under the Indian Factories Act, 1948. The said Act divides the registered sector into two groups. The first group covers the establishments employing 50 or more workers with power and 100 or more workers with or without power. This group is called the Census sector as data on all units is collected on an annual basis. The establishments with 10 or more but less than 50 workers with power and employing more than 50 but less than 100 workers without power, comprise the second group, termed as Sample sector as data are collected by sampling the units. All the remaining unregistered establishments belong to the household sector.

The difference in these three industry sectors is not only in their employment size, but also in many other vital economic parameters. The capital output ratios, the level of mechanization, the utilization of capacity are different between these three sectors. And these obviously are the important factors which affect the level of fuel consumption in an industrial unit. Hence it is not appropriate to study either

national or industrial variation in fuel consumption for the total sector aggregatively. It is useful to study these factors separately.

Availability

Data relating to the Census or large scale sector by the Annual Survey of Industries (A.S.I.). The

or factory sector and the other is the unregistered or household sector. The registered sector is defined to consist of the industrial establishments registered under the Indian Factories Act, 1948. The said Act divides the registered sector into two groups. The first group covers the establishments employing 50 or more workers with power and 100 or more workers with or without power. This group is called the Census sector as data on all units is collected on an annual basis. The establishments with 10 or more but less than 50 workers with power and employing more than 50 but less than 100 workers without power, comprise the second group, termed as Sample sector as data are collected by sampling the units. All the remaining unregistered establishments belong to the household sector.

The difference in these three industry sectors is not only in their employment size, but also in many other vital economic parameters. The capital output ratios, the level of mechanization, the utilization of capacity are different between these three sectors. And these obviously are the important factors which affect the level of fuel consumption in an industrial unit. Hence it is not appropriate to study either regional or industrial variation in fuel consumption for the industrial sector aggregatively. It is useful to study these three sectors separately.

2.2.2 Data Availability

The data relating to the Census or large scale sector is published by the Annual Survey of Industries (A.S.I.). The

classification of industries is based on the NCST basis and data are given upto the seven digit disaggregation level of the said industry classification. The entire economy is divided into 200 seven digit industries. The data reported are tabulated in seven tables, which provide exhaustive information for the industry. In Table 4 of these reports, the data regarding fuel consumption for each type of fuel both in quantity and value terms are given. The fuels distinguished are: (1) Coal, (2) Coke, (3) Coal-gas, (4) Firewood, (5) Charcoal, (6) Aviation and Motor Spirit, (7) Diesel oil, (8) Other Fuel Oils, (9) Lubricating Oil, (10) Industrial and Power Alcohol, (11) Electricity, (12) Water, and (13) Others. These data are reported at the State level, which is useful for studying the regional variation in fuel consumption.

The Sample sector data are published for the three digit level of industries. The collection of data is based on the sample basis. The results are not given in as many details as for the Census sector at both regional and fuel level. The detailed information regarding consumption is given for Coal, Electricity and Oil products, mainly Diesel Oil, and is available only for regions and not for individual industries at regional level. At the regional level the data for fuel consumption is supplied at aggregate level and only in value terms.

For the household industry sector, data are not available in any prescribed form. But those that are available in adhoc surveys and reports are scanty and insufficient for any worthwhile use.

In view of the above it is clear that only the registered large scale sector is found to have somewhat adequate data base, for an analysis of the regional variation in fuel consumption at both the macro and micro levels. The latest A.S.I. report at the summary level is available for the year 1979-80. The fuel data, reported therein, give aggregate information for all fuels together at the regional level. Further no physical data on energy are available in the report. Hence not even macro level study at the regional level is possible for the year 1979-80. The latest year for which the detailed A.S.I. data, which could be used for both micro and macro level studies, was for 1970 when this work was initiated. Subsequently the 1971 data were released. Therefore, for the purpose of the analysis in this study we have used the 1970 A.S.I. energy data for large scale industrial sector.

2.3 Data Adjustments

The analysis of regional variation in energy consumption can be carried out in two ways. The first is on the value basis and the other one is on the physical requirement basis. Each type of analysis has its own importance. The study made in physical units is useful as it is free from the price effect and the estimates based on them refer to real or physical requirements. But at the same time, the analysis in value terms has its importance, especially in the analysis of cost efficiency as the various fuels are substitutes to each other in many instances, especially when used for the generation of heat energy. In view of the above, the energy studies are normally

carried out in both value and energy units. In the present study also the analysis is done in both the units.

For the purposes of analysis it is necessary to make two types of data adjustments. The first one concerns the nature of the data reported in A.S.I. and the other relates to the conversion of all fuels to a uniform energy unit.

2.3.1 A.S.I. Data Adjustment

The A.S.I. data needs the following adjustments: (1) Adjustment for coverage, (2) Splitting of States, clubbed at the industry level, and (3) Adjustment for Electricity.

(1) Coverage Adjustment : In the A.S.I. Census data returns of 13,542 factories out of 14,083 are received. This means 96 per cent of the units are covered. In terms of output, the coverage would be even larger as it is only relatively the smaller units that might not have reported. Though adjustment for 4 per cent under coverage is necessary, we could not make it as there is no way of knowing the output for the non-reporting industrial units, output being the relevant variable. This non-adjustment we feel is unlikely to affect our analysis as a large part of the analysis is carried out in terms of ratios or shares where the absolute levels do not matter and these ratios or shares are based on as large a sample as 96 per cent of the universe.

(2) Clubbed Data Adjustment: On account of the operation of the secrecy clause in reporting the A.S.I. data, in a situation where one or two identifiable industrial units exist

in a region, the data pertaining to such units are either clubbed with a region of similar nature or the region is not disclosed, reporting the data under the heading 'other states'. On account of this form of reporting there is some loss of information for the regional analysis. To estimate the individual state data at each required industry level is not only tedious but the estimates obtained are also not satisfactory. However, the present study does not require this elaborate adjustment for the following reasons. For comparing the regions at the aggregate industry level, the data for variables such as fuel consumption, gross output are directly given and hence individual industry estimates at regional level are not required. At the individual industry level, the main interest is to study the fuel consumption patterns. Adjusting the clubbed data prorata on any reasonable basis does not serve the above purpose. However, the lack of this adjustment does not become a major shortcoming as the industry, wherever, it is important, is normally reported separately and when an industry is left out its share in output is generally small.

(3) Electricity Adjustment: Electricity, being a non-basic source of energy, is either purchased from outside or produced within the production unit. The Electricity produced in the factory uses the fuel as well as non-fuel inputs which are otherwise used for the industrial production by the factory unit. Therefore a simple addition of the Electricity generated in the unit and the Electricity purchased results in the double

counting of various fuels. Therefore to get an accurate estimate of energy consumption, the Electricity produced in the unit should be added to the Electricity purchased and a part of the other fuels used for generation of Electricity should be subtracted. However for the purposes of analysis in value terms this adjustment turns out to be small and negligible. But, for the analysis in physical terms, we have made the above adjustment as follows. In the absence of the knowledge about the technology of the captive power plant of the unit, on the basis of all India technology, the factor of net addition in energy due to Electricity generated within the unit is estimated as 0.5286 in energy units and is added to the amount of energy purchased. This implies that thousand KWH of Electricity produced within the unit is equivalent to 0.5286 TCR energy units of addition to Electricity consumption.

2.4 Different Energy Units

An important consideration for any energy study relates to the selection of a uniform energy unit of measurement. There is a variety of measurement units for energy, such as kilocalories (KCal), Kilo-Watt-Hours (KWH), Joules (J), Ergs and British Thermal Units (BTU), etc. But the problem of selecting a particular unit out of them becomes trivial, as there exist conversion factors to express one unit in terms of the other. However, conversion from one energy unit to another with the help of the conversion factors does not obviously imply one form of measurement of energy is replaced with the same

efficiency in its alternative form. So the problem of selecting a unit which apparently looks trivial, does not actually remain so simple. While converting energy from one form of measurement to its equivalent energy in the alternative form, the efficiency factor has to be taken care of. Further, the said efficiency factor varies over time with improvements in technology.

Second important consideration in the choice of the unit relates to the different sources of energy, such as chemical energy which is generated from Coal and Oil or mechanical energy obtained from Water and Wind power and heat energy created by sun. In expressing energy by a single unit, there is a loss of information about its source. These are some of the important considerations for choosing the energy units.

2.5 Choice of Energy Unit

Excluding Ergs and Joules which are not usually found used in energy studies, the choice needs to be made from amongst BTU, KCal, TCE (Tonne Coal Equivalent), KWH and TCR (Tonne Coal Replacement) units. KCal and BTU units give the calorific values of a fuel, which do not give any idea about the physical requirement of energy. A BTU of one fuel is not equivalent to the same of another fuel. The liquid fuels have the same conversion factor in calorific units, while separate conversion factors for almost each liquid fuel are established in terms of physical conversion ratios such as TCR, etc. In addition, the calorific unit has the disadvantage that it is a very small unit. For the purpose of the India Energy studies, a million

million kilo calories (1000 TCal or 10^{12} KCal) will have to be used¹ and this hinders the arithmetic side of the study.

Since 1 KWH was taken as equivalent to 1 TCR unit in India till 1960-61 and Coal is the largest available fuel, the choice between KWH and TCR leads to TCR only. The TCE unit does not reckon with the conversion efficiencies when energy is consumed through devices, appliances and plants. Therefore Indian reports about fuel studies use the TCR rather than the TCE units. The TCR measure takes note not only of the quantity of the heat value available in different fuels, but also the varying efficiency in the appliances. Thus, we conclude that TCR (Tonne Coal Replacement) is the suitable energy unit for the present study. The fuelwise conversion factors in terms of TCR used in the present study are based on the average efficiencies of the different fuels.

2.6 Conversion Ratios

The differences in the purposes of fuel use, the qualities of fuels and the levels of fuel efficiencies are some of the difficulties in deriving uniform conversion ratios for individual fuels. The major source, for the estimates of such ratios, for India, is the Sachdev Committee Report.² It provides a detailed estimation procedure of obtaining the conversion ratio for each fuel from its original physical unit to the

¹ India (1965). Report of the Energy Survey of India Committee. New Delhi, p. 390.

² Ibid.

chosen energy unit viz. TCR. The conversion ratios of some important fuels are noted below.

(i) Coal: Indian Coal has a special problem as its heat content varies from one type of Coal to another. But the conversion between Coal types is avoided to retain the major advantage of Coal replacement unit; namely, to keep the reported data for the major energy source as it is. Also it is not possible to distinguish between the qualities of Coal used on the basis of the data reported. Therefore we have assumed all Coal reported as a homogeneous fuel.

(ii) Electricity: A detailed study has been carried out by the Sachadev Committee for determining the efficiencies of the thermal electric plants. By considering different efficiencies and conversion ratios of the required fuel inputs for Electricity, the ratio of requirement of Coal per unit of Electricity is evaluated for 1960-61. Further, taking into account the factors such as average efficiency of the plant and the reduction in Coal consumption, the future estimates of the conversion ratios for Electricity are made upto the period 1980-81. The TCR equivalent of Electricity for the period 1953-54 to 1965-66 is taken as unity (1 TCR = 1000 KWH) per thousand KWH and for the later period upto 1980-81 it has been worked out as 0.7 TCR. We have adopted this TCR equivalent of Electricity for our purpose.

(iii) Liquid Fuels: Since the conversion ratios for the liquid fuels, viz. Motor Spirit, Diesel Oil, Lubricating Oil, Other Fuel Oils and Power Alcohol, are worked out in terms of

Tonnes and the ASI report their consumption data in terms of litres, an equivalence between litres and tonnes is necessary to derive the conversion ratios of the liquid fuels. Using the NCAER study³ and Sachadev Committee Report, we have obtained the required conversion ratios of various liquid fuels. The Table 2.1 lists the conversion ratios for different fuels, used in the manufacturing sector.

Table 2.1 : Fuelwise Conversion Ratios between the Original Unit of Reporting and the TCR Equivalent

Fuel	Original unit	TCR Equivalent
Coal	Tonne	1.00
Coke	Tonne	1.13
Coke and coal-gas	000 Cubic metres	0.83
Diesel oil	000 litres	7.4380
Aviation and motor spirit	000 litres	5.2558
Other fuel oils	000 litres	1.7212
Lubricating oils	000 litres	1.7953
Charcoal	Tonne	1.146
Firewood	Tonne	0.95
Power Alcohol	000 litres	0.5116
Electricity	000 KWH	0.70

A comparison of the ratios given in Table 2.1 with the NCST (National Committee on Science and Technology)⁴ indicates a difference only in the case of Oil Products which is mainly

³ Consumption Pattern of Selected Petroleum Products. NCAER, New Delhi, 1971.

⁴ Report of the Fuel and Power Sector. NCST, Technology Bhavan, New Delhi, 1974.

due to the difference in their assumed consumption compositions within the group of Oil Products. In any case this difference in the aggregate conversion ratio is not of any consequence to us as our study uses each Oil Product at its individual level.

It is also important to note here that though TCR and TCE ratios are different due to efficiency considerations, it is surprising that no such difference is seen in the conversion ratios as given in the above reports in respect of most of the fuels used in the manufacturing sector.

Table A₂.1 : Regions Covered in the Study

Sr. No.	Region	Sr. No.	Region
1.	Andhra Pradesh	13.	Rajasthan
2.	Assam	14.	Uttar Pradesh
3.	Bihar	15.	West Bengal
4.	Gujarat	16.	Haryana
5.	Jammu and Kashmir	17.	Andaman and Nicobar Islands
6.	Kerala	18.	Delhi
7.	Madhya Pradesh	19.	Himachal Pradesh
8.	Tamil Nadu	20.	Tripura
9.	Maharashtra	21.	Pondicherry
10.	Karnataka	22.	Goa, Daman and Diu
11.	Orissa	23.	Manipur
12.	Punjab	24.	Chandigarh

CHAPTER 3

DETERMINANTS OF AGGREGATE FUEL USE AT THE REGIONAL LEVEL

Fuel consumption in the industrial sector varies from region to region. This variation in fuel consumption of the industrial sector between regions depends among others, on the factors like development level of a region, availability of fuels and the industry-mix. A broad picture of fuel consumption at the All India level and Regionwise is presented below. 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.

3.1 Pattern of Fuel Consumption

3.1.1 Consumption at All-India

The energy sources are divided into two categories viz. commercial and non-commercial fuels. Though India has a significant share of non-commercial energy consumption (46.6 per cent in 1970), it is found to be declining over the period.¹ As the sectoral break-up for the non-commercial energy is not available, we present the consumption of commercial fuels alone in Table 3.1 for 1970-71 and 1978-79 in million tonnes of coal

¹ Report of the Working Group on Energy Policy. Government of India, Planning Commission, New Delhi, 1979, Table 2.8, p. 6.

Table 3.1 : Fuelwise Consumption in Different Sectors of the Indian Economy for 1970-71 and 1978-79

		(In million tonnes of coal replacement)	
Sector	Fuel	1970-71	1978-79
Household	Coal	4.1	4.0
	Oil	27.6	28.6
	Electricity	3.9	7.7
Agriculture	Coal	-	-
	Oil	4.5	19.3
	Electricity	4.5	12.0
Industry	Coal	31.1	50.5
	Oil	10.9	9.0
	Electricity	34.4	53.8
Transport	Coal	15.9	12.4
	Oil	47.2	78.2
	Electricity	1.4	2.6
Others	Coal	0.3	1.9
	Oil	7.0	6.0
	Electricity	4.5	8.3
Total	Coal	51.4	68.8
	Oil	97.2	141.1
	Electricity	48.7	84.4

Source: Report of the Working Group on Energy Policy.
Government of India, Planning Commission.

replacement. The economy is divided into five broad sectors and the commercial energy is divided into three fuels viz., Coal, Oil and Electricity. It is obvious from the Table 3.1 that the Industry sector consumes the largest amount of Coal

and Electricity than any of the other sectors. In the case of Oil, its major consuming sectors are Agriculture and Transport. The Industry sector is found to have consumed 76.4 mter (million TCR) energy in 1970-71, which has subsequently increased to 113.4 mter in 1978-79, maintaining its highest energy consuming position in the economy. The Transport sector is the second in rank in respect of energy consumption, consuming 64.5 and 93.2 mter in 1970-71 and 1978-79 respectively. The Agriculture sector is found to have tripled its energy consumption in 1978-79 than 1970-71.

3.1.2 Fuelwise Consumption of Industrial Sector at All-India

The fuelwise consumption data for both commercial as well as non-commercial fuels are available for the large scale industrial sector alone. The consumption composition of these fuels for all India large scale manufacturing sector for 1970, is presented in Table 3.2. The consumption compositions are calculated on physical and value basis.

It is seen that Coal is the most important fuel accounting for more than half of (53.91 per cent) the total energy in physical units. Next in order of importance is Electricity accounting for about 25 per cent followed by Other Fuel Oils.

In terms of value, however, the picture significantly differs on account of the differential prices of the fuels. While Coal contributes twice that of Electricity in physical terms, valuewise the shares of these are nearly equal; in fact the share of Electricity (37.85 per cent) is marginally higher

Table 3.2 : Fuelwise Percentage Share of Consumption (in Total Industrial Energy Use at All-India)

Fuel	Percentage share on energy basis	Percentage share on value basis
Coal	53.91	36.23
Coke	1.77	2.52
Coal gas	5.67	0.34
Firewood	1.33	0.90
Charcoal	0.08	0.15
Aviation and Motor Spirit	0.67	1.66
Diesel Oil	3.16	2.85
Other Fuel Oils	8.37	13.52
Lubricating Oil	0.33	3.95
Industrial and Power Alcohol	neg.	0.03
Electricity	24.71	37.85
Total	100.00	100.00

than that of Coal (36.23 per cent). The share of Other Fuel Oils in value terms is 13.52 per cent compared to 8.37 per cent which is its share on the physical basis.

Thus for the industrial sector, while Coal can be considered as the major fuel in terms of physical energy, from cost point of view Electricity is equally important.

3.2 Regional Fuel Consumption

3.2.1 Aggregate Fuel Consumption

Regionwise fuel consumption data are not available, as to our knowledge, either for all the sectors together or for the individual sectors. For the large scale manufacturing sector alone they are available from the A.S.I. reports. Therefore,

Table 3.3 : Statewise Percentage Shares of Fuel Consumption for the Industrial Sector for 1970 (All Fuels Combined)

State	Percentage share on energy basis	Percentage share on value basis
Andhra Pradesh	4.70	4.20
Assam	6.52	1.22
Bihar	10.15	9.81
Gujarat	8.03	11.18
Jammu and Kashmir	0.17	0.23
Kerala	1.44	1.80
Madhya Pradesh	6.76	5.49
Tamil Nadu	9.48	8.63
Maharashtra	11.91	17.62
Karnataka	3.15	3.57
Orissa	6.77	5.90
Punjab	1.58	1.25
Rajasthan	1.81	2.03
Uttar Pradesh	10.69	10.70
West Bengal	13.48	12.11
Haryana	1.26	1.72
Andaman and Nicobar Islands	0.01	0.02
Delhi	1.80	2.12
Himachal Pradesh	0.11	0.15
Tripura	0.05	0.05
Pondicherry	0.08	0.10
Goa, Daman and Diu	0.05	0.05
Manipur	neg.	neg.
Chandigarh	neg.	0.05
Total	100.00	100.00

we present the regional shares of fuel consumption, aggregated over all fuels, for the year 1970, in both value and physical terms in Table 3.3. It is found that the states which are industrially advanced show higher shares of energy consumption on value basis such as Bihar 9.81 per cent, Gujarat 11.18 per cent, Tamil Nadu 8.63 per cent, Maharashtra 17.62 per cent, Uttar Pradesh 10.70 per cent and West Bengal 12.11 per cent and amongst the above listed States, Maharashtra stands first sharing the highest share. On the other hand, namely the consumption shares on the physical basis, West Bengal shows the highest share (13.48 per cent). The other important energy consuming States are Bihar (10.15 per cent), Gujarat (8.03 per cent), Tamil Nadu (9.48 per cent), Maharashtra (11.91 per cent) and Uttar Pradesh (10.69 per cent). This set of States alone consumes 70.05 per cent energy of the total industrial sector in terms of value which is equivalent to 63.74 per cent when evaluated on physical basis.

3.2.2 Use of Each Fuel Across Regions

The fuelwise consumption compositions across regions for the industrial sector are evaluated on both value and physical basis in Tables 3.4 and 3.5 respectively.

As noted earlier Bihar, Gujarat, Tamil Nadu, Maharashtra, Uttar Pradesh and West Bengal are the major fuel consuming States. Considering individual fuels, by and large, the above States turn out to be the major users of commercial fuels, though the ranking of these States differs in the use of individual fuels.

From the industrially advanced group, barring Maharashtra, the remaining States account for a significant share of Coal consumption. The State of Orissa also has a high Coal consumption share (10.60 per cent). Maharashtra consumes one-fifth of the Electricity consumed in the Industrial sector of the country. Except Bihar, the remaining States of the major fuel consuming group, account for a significant share of Electricity consumption. In case of Coke, Bihar has the highest consumption share (36.53 per cent) followed by West Bengal (14.57 per cent). In case of Coal-gas, in addition to Bihar and West Bengal, Assam is also a significant consumer. While two industrially most advanced States, viz. Maharashtra and West Bengal, consume more than half of the Aviation and Motor Spirit, in case of Diesel Oil, the major consumption of it is made by Bihar in addition to Maharashtra and West Bengal. Because of the high level of industrialization, Maharashtra, Gujarat and West Bengal are the major consumers of the Lubricating Oils.

In the non-commercial fuels, Uttar Pradesh accounts for the highest share (31.04 per cent) in Firewood consumption, followed by Kerala (15.11 per cent) and Karnataka (14.93 per cent). Charcoal consumption is more concentrated than that of Firewood in Karnataka, which consumes two-thirds of the total Charcoal consumption in the industrial sector of India. Maharashtra, Tamil Nadu and West Bengal are the other three States consuming sizable Charcoal with equal shares around 7 per cent.

Table 3.6 : Statewise Groups on the Differential Consumption Shares For Each Fuel (Industrial Sector, 1970)

Fuel	States with fuel consumption share on		
	Value basis > Quantity basis	Value basis = Quantity basis	Value basis < quantity basis
Coal	Gujarat, Jammu and Kashmir, Kerala, Karnataka, Orissa, Punjab, Rajasthan, Uttar Pradesh, Delhi, Haryana	Andhra Pradesh, Assam, Bihar, Maharashtra, Himachal Pradesh, Tripura, Pondicherry, Chandigarh.	Madhya Pradesh, Tamil Nadu, West Bengal
Coke	Gujarat, Madhya Pradesh, Tamil Nadu, Maharashtra Karnataka, Punjab, Delhi.	Assam, Bihar, Jammu and Kashmir, Kerala, Rajasthan, Uttar Pradesh, Himachal Pradesh, Haryana Chandigarh.	Andhra Pradesh, Orissa, West Bengal
Coal-gas	Andhra Pradesh, Bihar, Gujarat, Maharashtra, Orissa, West Bengal, Haryana.	Uttar Pradesh, Delhi.	Assam.
Firewood	Gujarat, Jammu and Kashmir, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, Andaman and Nicobar Islands, Delhi.	Andhra Pradesh, Bihar, Madhya Pradesh, Tamil Nadu, Orissa, Himachal Pradesh, Pondicherry, Goa, Haryana.	Assam, Kerala, Karnataka, West Bengal.
Charcoal	Andhra Pradesh, Assam, Bihar, Gujarat, Madhya Pradesh, Tamil Nadu, Maharashtra, Punjab, Rajasthan, West Bengal, Delhi, Himachal Pradesh, Haryana.	Jammu and Kashmir, Kerala, Uttar Pradesh, Andaman and Nicobar Islands, Chandigarh.	Karnataka, Orissa, Goa.
Aviation and Motor Spirit	Punjab, Uttar Pradesh, Rajasthan.	Andhra Pradesh, Assam, Bihar, Gujarat, Jammu and Kashmir, Kerala, Madhya Pradesh, Tamil Nadu, Maharashtra, Orissa, Karnataka, Andaman and Nicobar Islands, Delhi, Goa, Chandigarh.	West Bengal, Himachal Pradesh, Haryana
Diesel Oil	Andhra Pradesh, Bihar, Madhya Pradesh, Karnataka, Uttar Pradesh, Andaman and Nicobar Islands, Himachal Pradesh, Tripura.	Gujarat, Jammu and Kashmir, Kerala, Tamil Nadu, Punjab, Rajasthan, Pondicherry, Manipur, Chandigarh.	Assam, Maharashtra, Orissa, West Bengal, Delhi, Goa, Haryana.
Other Fuel Oils	Bihar, Madhya Pradesh, Karnataka, Orissa, Punjab, Rajasthan, Uttar Pradesh, Delhi, Haryana.	Andhra Pradesh, Assam, Kerala, Tamil Nadu, West Bengal, Himachal Pradesh, Tripura, Goa, Chandigarh.	Gujarat, Maharashtra.
Lubricating Oils	Andhra Pradesh, Assam, Jammu and Kashmir, Tamil Nadu, Maharashtra, Karnataka, Orissa, Punjab, Goa.	Bihar, Kerala, Madhya Pradesh, Rajasthan, Uttar Pradesh, Andaman and Nicobar Islands, Delhi, Himachal Pradesh, Tripura, Pondicherry, Haryana, Chandigarh.	Gujarat, West Bengal.
Electricity	Assam, Gujarat, Madhya Pradesh, Tamil Nadu, Rajasthan, West Bengal, Delhi, Haryana.	Bihar, Jammu and Kashmir, Maharashtra, Himachal Pradesh, Pondicherry, Goa, Chandigarh.	Andhra Pradesh, Kerala, Karnataka, Orissa, Punjab, Uttar Pradesh.
All Fuels (Combined)	Gujarat, Jammu and Kashmir, Kerala, Maharashtra, Rajasthan, Delhi, Haryana, Chandigarh.	Karnataka, Punjab, Uttar Pradesh, Andaman and Nicobar Islands, Himachal Pradesh, Tripura, Pondicherry, Goa.	Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Tamil Nadu, Orissa, West Bengal.

Because of regional price differences, share of consumption in physical terms would differ from that in value terms. To understand these divergencies, States are classified into three groups: (1) States with fuel consumption share on value basis higher than that on quantity basis. (2) States with consumption share on value basis equals that on quantity basis. (3) States where the fuel consumption share on the value basis less than that on quantity basis.

The above classification of States for each fuel is presented in Table 3.6. The three categories represent the role of price differentials across the regions. The category, where consumption share on value basis is greater than that on quantity basis, the fuel prices are generally higher. On the other hand, the category where the said share on value basis is smaller than that on quantity basis, the fuel prices are relatively lower.

Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Tamil Nadu, Orissa and West Bengal are the States, constituting a group where energy, at the aggregate fuel level, is relatively cheap. On the other hand, Gujarat, Kerala, Maharashtra, Rajasthan, Delhi, Haryana, Jammu and Kashmir constitute a disadvantageous group where energy at the aggregate fuel level is relatively costly.

3.2.3 Composition of Fuel Consumption at Regional Level

The percentage shares of different fuels consumed, in each region, are presented in Table 3.7 on the value basis and

Table 3.7 : Percentage Share of Fuel Consumption for Industrial Sector in Each Region (in Value Terms)

State/Union Territory	Coal	Coke	Coal gas	Firewood	Charcoal	Aviation and Motor Spirit	Diesel Oil	Other Fuel Oils	Lubricating Oils	Industrial and Power Alcohol	Electricity	Total
Andhra Pradesh	43.35	2.75	neg.	1.04	0.05	1.91	1.40	8.74	2.88	-	37.88	100.00
Assam	8.61	0.23	1.51	1.65	0.02	2.28	19.88	38.98	6.06	-	20.78	100.00
Bihar	47.62	9.41	0.74	0.38	0.01	0.43	4.54	12.53	2.66	0.01	21.66	100.00
Gujarat	33.34	1.74	0.25	0.33	0.01	0.81	1.23	19.76	4.94	0.01	37.58	100.00
Jammu and Kashmir	63.35	0.17	-	6.22	0.11	15.30	2.82	0.01	5.79	-	6.23	100.00
Kerala	1.57	0.26	-	7.37	0.27	0.51	1.36	41.30	1.80	neg.	45.56	100.00
Madhya Pradesh	48.43	1.57	-	0.35	0.01	0.45	2.46	2.38	3.87	-	40.48	100.00
Tamil Nadu	34.44	1.21	neg.	0.47	0.12	1.18	1.67	15.44	2.71	0.06	42.70	100.00
Maharashtra	12.23	1.34	0.23	0.38	0.07	3.84	2.71	26.22	4.73	0.01	48.25	100.00
Karnataka	25.15	4.14	-	3.66	2.70	1.12	5.19	11.52	3.74	0.01	42.77	100.00
Orissa	62.07	0.82	0.05	0.11	neg.	0.41	1.66	4.52	2.68	0.01	27.67	100.00
Punjab	21.20	3.97	-	0.54	0.06	3.08	2.67	6.42	6.42	-	55.64	100.00
Rajasthan	53.91	1.22	-	0.48	0.04	0.56	2.89	5.82	4.38	-	30.70	100.00
Uttar Pradesh	44.97	1.47	neg.	2.50	0.02	1.09	1.46	5.82	2.94	0.12	39.61	100.00
West Bengal	37.39	2.95	1.40	0.27	0.09	2.52	3.46	7.58	5.56	0.02	38.76	100.00
Haryana	46.05	2.16	0.11	0.44	0.02	1.91	2.21	9.35	6.29	0.30	31.16	100.00
Andaman and Nicobar Islands	0.43	0.32	-	7.20	1.73	1.93	48.18	8.49	10.54	-	21.18	100.00
Delhi	60.08	1.26	neg.	0.24	0.04	1.13	4.48	6.32	1.84	-	24.61	100.00
Himachal Pradesh	41.90	2.62	-	0.21	0.48	8.01	14.61	2.76	5.33	-	24.08	100.00
Tripura	4.38	-	-	4.04	-	0.17	78.42	3.21	8.69	-	1.09	100.00
Pondicherry	34.51	-	-	1.89	-	0.31	0.28	0.51	5.15	-	57.35	100.00
Goa, Daman and Diu	-	-	-	1.31	1.27	4.60	46.08	3.43	15.88	-	27.43	100.00
Manipur	-	-	-	-	-	-	30.95	1.19	17.86	-	50.00	100.00
Chandigarh	10.20	0.73	-	0.03	0.07	6.25	2.75	30.77	13.89	-	35.31	100.00
India	36.23	2.52	0.34	0.90	0.15	1.66	2.85	13.52	3.95	0.03	37.85	100.00

Table 3.8 : Percentage Share of Fuel Consumption for Industrial Sector in Each Region (in Energy Units)

State	Coal	Coke	Coal gas	Firewood	Charcoal	Aviation and Motor Spirit	Diesel Oil	Other Fuel Oils	Lubricating Oils	Industrial and Power Alcohol	Electricity	Total
Andhra Pradesh	65.05	2.09	neg.	1.29	0.02	0.68	1.23	4.57	0.20	-	24.87	100.00
Assam	2.74	0.03	84.98	1.25	neg.	0.16	4.67	4.24	0.08	-	1.85	100.00
Bihar	66.93	6.43	0.58	0.63	neg.	0.17	4.58	6.72	0.21	neg.	13.75	100.00
Gujarat	48.91	1.28	0.03	0.46	0.01	0.43	1.67	19.47	0.58	neg.	27.16	100.00
Jammu and Kashmir	75.21	0.07	-	5.05	0.10	9.20	4.58	neg.	0.45	-	5.34	100.00
Kerala	1.62	0.15	-	19.18	0.18	0.25	1.89	33.55	0.20	neg.	42.98	100.00
Madhya Pradesh	77.44	0.77	-	0.44	neg.	0.14	1.65	1.07	0.25	-	18.24	100.00
Tamil Nadu	61.55	0.55	neg.	0.61	0.05	0.45	1.71	9.08	0.19	neg.	25.81	100.00
Maharashtra	27.09	0.93	0.08	0.50	0.03	2.06	4.30	22.65	0.52	neg.	41.84	100.00
Karnataka	30.40	2.77	-	8.36	1.88	0.50	5.62	7.35	0.32	neg.	42.80	100.00
Orissa	72.77	1.36	0.01	0.18	neg.	0.15	1.82	1.95	0.19	neg.	21.57	100.00
Punjab	16.24	1.86	-	0.33	0.01	0.90	2.65	2.27	0.39	-	75.35	100.00
Rajasthan	74.03	1.00	-	0.64	0.01	0.24	4.39	3.82	0.43	-	15.44	100.00
Uttar Pradesh	61.41	1.00	neg.	2.68	0.01	0.44	1.40	3.12	0.25	0.02	29.67	100.00
West Bengal	68.09	2.40	0.41	0.41	0.04	0.98	4.08	4.23	0.50	neg.	18.86	100.00
Haryana	62.98	1.93	0.01	0.65	0.01	1.14	4.07	5.91	0.63	0.07	22.60	100.00
Andaman and Nicobar Islands	0.50	0.40	-	11.36	1.53	2.38	68.51	2.93	1.85	-	10.54	100.00
Delhi	77.00	0.81	neg.	0.18	0.01	0.51	6.31	3.60	0.18	-	11.40	100.00
Himachal Pradesh	57.41	2.15	-	0.39	0.22	4.76	16.25	1.50	0.57	-	16.75	100.00
Tripura	3.93	-	-	12.37	-	0.07	81.41	1.15	0.66	-	0.41	100.00
Pondicherry	45.14	-	-	2.48	-	0.17	0.30	0.17	0.48	-	51.26	100.00
Goa, Daman and Diu	-	-	-	2.96	1.30	1.91	76.58	2.25	1.07	-	13.93	100.00
Manipur	-	-	-	-	-	-	36.48	0.82	4.51	-	58.19	100.00
Chandigarh	17.77	0.72	-	0.04	0.02	4.24	4.53	31.24	1.94	-	39.50	100.00
India	53.91	1.77	5.67	1.33	0.08	0.67	3.16	8.37	0.33	neg.	24.71	100.00

in Table 3.8 on the quantity basis in TCR units. At the All-India level as also in most of the States Coal and Electricity figure as the dominant fuels. However, Assam is found to use little of Coal and relatively less of Electricity and is found to use Oil and Coal-gas predominantly from the point of view of value and quantity respectively. Jammu and Kashmir uses very little of Electricity and Oil, while Coal, Aviation and Motor Spirit and Firewood are the dominant fuels in the industrial sector of its economy. Kerala also uses very little of Coal, while its major energy demands are met with Electricity and Other Fuel Oils. Firewood also plays a significant role in Kerala's industrial activity. The share of Firewood is 7.37 per cent in Kerala while that at all India level is only 0.9 per cent. The industries of Maharashtra are based mainly on Electricity, but Other Fuel Oils also play a significant role. Coal consumption in Maharashtra is quite low (12.23 per cent) in comparison with all India (36.23 per cent). Though Karnataka has Electricity as its major source of energy, the use of non-commercial fuels is also of a significant order in comparison with that at the all India level. In Punjab also, Electricity is the most dominating fuel constituting 55.64 per cent share on the value basis, which is equivalent to 75.35 per cent on the physical basis. Rajasthan has a coal-based industrial sector, even though it is not a coal-producing State.

3.3 A Statistical Analysis of Variation

While Coal and Electricity are the dominant fuels, as noted above and the pattern of fuel consumption as a whole, is

broadly similar across regions, with the specific peculiarities illustratively noted, the use of individual fuel across regions show a significant variation in their consumption shares. We now try to analyse this variation statistically by the Analysis of Variance technique.

The consumption shares of each fuel at regional level are affected by the size of the region and to adjust for the same, we use the State Domestic Product (SDP) as a proxy for size. In fact, the fuel consumption considered here, relates to the industrial sector alone. Therefore, one may think of income from the industrial sector as a better proxy to adjust for the size of the region. However, the industrial income is not only related to the size of a region but is also related to the level of industrialization in it. Hence the use of industrial income as a proxy for adjustment for the varying size of the region leads also to controlling the level of industrialization which should not be adjusted for.

The Analysis of Variance is carried out as follows.

We have 21 regions and 11 fuels and the basic data C_{ij} represents the consumption of j^{th} fuel in i^{th} region per Rs.1,000 of its SDP. The analysis is carried out for C_{ij} expressed both in value and quantity terms respectively and helps to test the following two hypotheses. They are:

1. There is no variation in the consumption of different fuels within regions.
2. There is no variation in the consumption of a single fuel across regions.

The first null hypothesis indicates that the industries within a region are not fuel specific. The second null hypothesis indicates that the use of a given fuel is not region-specific in the locational sense for the industries across the regions. But the two hypotheses above are not exclusive in nature; they are interlinked.

The results of the ANOVA are presented below both in value and quantity terms in Tables 3.9 and 3.10 respectively.

Table 3.9 : ANOVA for Fuel Consumption

(in Rs./000 Rs. of SDP)				
Source of Variation	S.S.	D.F.	Mean S.S.	F Ratios *
Fuels	7.43	10	0.743	21.32**
Regions	1.49	20	0.075	2.14**
Error	6.97	200	0.035	
Total	15.89	230	-	

*F ratio for $n_1=10$ and $n_2=200$ is 2.345 at 1% level and for $n_1=20$ and $n_2=200$ is 1.92 at 1% level.

** indicates significance at one per cent level.

Table 3.10 : ANOVA for Fuel Consumption

(in TCR/Lakh Rs. of SDP)				
Source of Variation	S.S.	D.F.	Mean S.S.	F Ratios *
Fuels	4250448.45	10	425044.85	1.95 *
Regions	8490918.96	20	424545.97	1.95 *
Error	43594342.26	200	217971.71	-
Total	56335709.67	230	-	

* F ratio for $n_1=10$, $n_2=200$ is 1.845 at 5% level and for $n_1=20$, $n_2=200$ is 1.60 at 5% level.

The ANOVA shows that the F ratios in both tables are highly significant indicating sharp variation in the fuel consumption between regions and between different fuels in the industrial sector.

The implication of the rejection of both the null hypotheses is that the industry-mix as well as the location of a region are the most important factors that cause the variation in the fuel consumption at the regional level. The higher value of F for the main effect of fuel in the ANOVA on value basis, indicates that the prices of fuels also play a significant role in causing the regional variation in fuel consumption.

3.4 Causes for Regional Variation in Fuel Consumption

Having established statistically, the existence of variation in the fuel consumption patterns at regional level, which arises mainly because of the differential pattern of availability and requirement, we now consider the impact of the following variables on regional fuel consumption.

- 1) Production of fuels
- 2) Prices of fuels
- 3) Relative prices of different fuels
- 4) Level of industrialization at regional level
- 5) Industry-mix of a region
- 6) Level of mechanization of a region.

Before we set up our analysis, we elaborately examine the nature of the above variables in the rest of this section.

1) Production and Prices of Fuels

Since Coal and Electricity are the two dominant fuels and the Oil based fuels are not as region-specific as the

earlier two, we continue below to consider the production and price data simultaneously about Coal and Electricity.

Coal: Statewise production, consumption shares* and also the producer prices of Coal are given in Table 3.11. It also provides the purchaser prices of Coal for the industrial sector of the state economy for immediate comparison between producer and purchaser prices. It is observed that while Coal is consumed in large quantities throughout the country, the production of it is concentrated in certain regions only. Bihar produces the largest share of Coal contributing 46.59 per cent. Next in the importance is West Bengal (26.06 per cent), followed by Madhya Pradesh (17.04 per cent). All the Coal producing States, and Tamil Nadu, consume more than 70 per cent of Coal and Lignite, consumed in the entire large scale manufacturing sector of the country. This indicates the direct relation between production and consumption of Coal.

The producer prices of Coal in different regions do not differ significantly from each other. The average producer price at the all-India level is 35.68 Rs. per tonne in 1970. The minimum producer price of Rs.34.08/Tonne was recorded by Bihar against the maximum of Rs.39.36/Tonne recorded by Andhra Pradesh.**

* As the A.S.I. Reports do not differentiate between Coal and Lignite, the consumption figures relate to both the fuels, where production data relates to Coal alone.

** Jammu and Kashmir is the exceptional case where the producer price of Coal is Rs.90.71 per Tonne. This abnormal case can be neglected because of its negligible share (0.03 per cent) in the production.

Table 3.11 : Statewise Production and Consumption Shares, Producer Prices and Purchaser Prices of Industrial Sector for Coal, 1970

State	Production share	Producer price Rs./tonne	Consumption** share	Purchaser price Rs./tonne
Andhra Pradesh	5.16	39.36	5.67	53.90
Assam	0.71	38.22	0.33	53.49
Bihar	46.59	34.08	12.61	60.78
Gujarat	-	-	7.28	82.03
Jammu and Kashmir	0.03	90.71	0.24	107.57
Kerala	-	-	0.04	110.73
Madhya Pradesh	17.04	36.50	9.71	45.80
Tamil Nadu *	-	-	10.82	46.50
Maharashtra	2.41	35.37	5.98	53.23
Karnataka	-	-	1.78	85.20
Orissa	2.00	37.80	9.13	68.97
Punjab	-	-	0.48	95.94
Rajasthan	-	-	2.49	75.77
Uttar Pradesh	-	-	12.18	67.91
West Bengal	26.06	37.02	17.02	44.92
Haryana	-	-	1.48	91.37
Andaman and Nicobar Islands	-	-	neg.	200.00
Delhi	-	-	2.57	78.05
Himachal Pradesh	-	-	0.11	90.69
Tripura	-	-	neg.	115.00
Pondicherry	-	-	0.07	88.26
Goa, Daman and Diu	-	-	-	-
Manipur	-	-	-	-
Chandigarh	-	-	0.01	99.68
India	100.00	35.68	100.00	59.44

* It has Lignite's 100% production, but cannot be added here. The producer's price for Lignite is 25.35 Rs./tonne.

** Based on physical units of consumption (Lignite included).

The purchasers prices vary widely among the Indian regions. The minimum price is recorded by West Bengal (Rs.44.92 per tonne) against the maximum price (Rs. 110.73 per Tonne) observed in Kerala. Amongst the Union Territories, Andaman and Nicobar Islands has recorded the largest purchaser price viz. Rs.200 per tonne. The difference between the purchasers and producers prices is largely due to transport costs. Since Coal producing States are expected to have the advantage of a lower purchaser price, it is surprising that the largest coal producing State of Bihar shows the purchaser price as high as Rs.60.78/Tonne. An inverse relation is seen to exist between the consumption of Coal and its purchaser price and the rank correlation coefficient between consumption and purchaser price (0.8442) turns out to be highly significant.

Electricity: Statewise production and consumption shares for Electricity, as also its producer price and purchaser price for the industrial sector of the state economy are presented in Table 3.12. The production data in the Table does not include the Electricity, produced within the manufacturing units. However, such production in each State is found to be less than 10 per cent, and the coverage adjustment does not affect the production shares of States.

Unlike Coal, Electricity production is well diversified across the country. Maharashtra is the largest power producer State, producing nearly one-fifth of total Electricity production in the country. Next in importance are Tamil Nadu and Uttar Pradesh. From the point of Electricity consumption Maharashtra

Table 3.12 : Statewise Production and Consumption Shares,
 Producer Prices and Purchaser Prices of Industrial
 Sector for Electricity, 1970

State	Production share	Producer price Rs./KWH	Consumption share	Purchaser price Rs./KWH
Andhra Pradesh	6.06	0.16	4.30	0.09
Assam	0.68	0.16	0.69	0.13
Bihar	2.58	0.16	5.62	0.09
Gujarat	5.56	0.13	10.85	0.12
Jammu and Kashmir	0.32	-	0.04	0.10
Kerala	3.99	0.10	2.23	0.08
Madhya Pradesh	6.72	0.14	5.99	0.11
Tamil Nadu	10.54	0.11	10.05	0.10
Maharashtra	19.33	0.10	20.25	0.10
Karnataka	8.78	0.06	4.15	0.07
Orissa	2.86	0.05	4.53	0.07
Punjab	8.36	0.08	1.93	0.04
Rajasthan	3.10	0.16	1.73	0.14
Uttar Pradesh	10.70	0.13	11.74	0.09
West Bengal	7.58	0.10	12.77	0.12
Haryana	0.13	-	1.46	0.12
Andaman and Nicobar Islands	0.01	-	0.01	0.33
Delhi	2.53	-	1.32	0.15
Himachal Pradesh	0.13	0.06	0.10	0.13
Tripura	0.02	0.41	neg.	0.19
Pondicherry	0.00	-	0.15	0.09
Goa, Daman and Diu	0.01	-	0.04	0.14
Manipur	0.01	-	neg.	0.21
Chandigarh	0.00	-	0.05	0.11
India	100.00	0.10	100.00	0.10

stands first accounting for 20 per cent share of the total Electricity consumption of the industrial sector of the country. Tamil Nadu and Uttar Pradesh do not show any significant divergence between production as well as consumption shares of Electricity. Gujarat and West Bengal are the two States whose consumption shares are significantly higher than their production shares.

An important factor that contributes to the regional variation of producer prices is the different mix of production technologies of Electricity such as Hydro and Thermal. The above data show that the producer prices of Electricity for different States lie in the range Rs.0.05/KWH to Rs.0.16/KWH in Indian regions for 1970. The range for its purchaser price is, however, wider. It is minimum at Rs.0.04/KWH in Punjab against the maximum at Rs.0.33/KWH in Andaman and Nicobar Islands. It is surprising that in many of the States the purchaser price is less than that of the producer price. It is well known that many of the Electricity Boards run under losses. Even then this order of negative difference in so many States is surprising and it is difficult to explain. More than the purchasers prices the producer prices figures are suspected. The producer price figures have not been used in the subsequent analysis. The inverse relation in case of Electricity also is found to exist between purchaser prices and consumption shares with a rank correlation coefficient 0.6713, which is lower than that of Coal, noted above.

The variation in purchaser prices for different fuels

across regions is obtained by calculating the coefficient of variation presented in Table 3.13. It is found that the price variation is smaller in case of Oil based fuels than that of the other resource based fuels. Since Electricity cannot be transported easily, the price differentials for it are noticed to be higher than Coal.

Table 3.13 : Fuelwise Coefficient of Variation (for Purchaser Prices)

Fuel	Coefficient of Variation (in %)	
Coal	38.79	
Coke	33.80	
Coal gas	80.34	
Firewood	50.11	
Charcoal	41.03	
Aviation and Motor Spirit	6.68	
Diesel Oil	46.67	(17.51)*
Other Fuel Oils	65.81	(28.48)**
Lubricating Oil	13.49	
Alcohol	100.45	
Electricity	50.06	

N.B.: * Excluding the two extreme observations, the coefficient of variation reduces to 17.51 per cent.

** Excluding the three extreme observations, the coefficient of variation reduces to 28.48 per cent.

2) Relative Prices

It is quite possible that the absolute difference in the price of a given fuel in two regions may not be significant, but in comparison with other fuels, the fuel under consideration may be cheaper in one region than that in the other. Hence

it is necessary to assess the role of relative prices.

However, assessing the relative price of a given fuel with reference to each of the other fuels renders the analysis rather clumsy. To do away with this, we propose to assess the relative price of a given fuel by standardizing the reference fuel, the price of which is taken as the weighted average price of the other fuels, the weight being the industrial fuel consumption in the region. The relative price index is worked out as follows -

$$I_f = \frac{P_f}{\frac{\sum_{i=1}^k W_i P_i}{i/f}}, \quad i = 1, 2, \dots, k,$$

where k is the number of different fuels, P_i is the price of i^{th} fuel per TCR unit and W_i is the weight.

Thus defined and calculated the relative price index compares the price of a given fuel in relation to a standardized fuel price. The relative price index, when less than unity, indicates that the price of the given fuel is cheaper than others and when greater than unity the price of it is dearer than the others. Table 3.14 gives the estimates of the relative price indices for Coal, Electricity, Other Fuel Oils and the important fuel, if any, for the region.

At the all-India level, it is seen that Coal is the cheapest source of energy pricewise. Electricity, on the other hand, turns out to be the costliest though consumptionwise it stands only next to Coal. It is further found from the Table 3.14 that Coal has relative price index less than unity in all

Table 3.14 : Relative Prices of Coal, Electricity, Other Fuel Oils and Any Other Important Fuel of a Region

State	Coal	Elec- tricity	Other Fuel Oils	Any Other Fuel	Name of the Fuel *
Andhra Pradesh	0.3989	1.9198	1.9928	-	
Assam	0.0353	13.8419	15.0933	Very low	Coal gas
Bihar	0.4594	1.6612	1.9803	1.5329	Coke
Gujarat	0.5145	1.1291	1.6647	-	
Jammu and Kashmir	0.5734	1.1289	(Not used)	1.5422	Aviation and Motor Spirit
Kerala	0.9991	1.4469	1.0560	0.3444	Firewood
Madhya Pradesh	0.2816	2.9535	2.2854	-	
Tamil Nadu	0.3211	2.2345	1.7697	-	
Maharashtra	0.3627	1.3477	1.2006	0.5985	Diesel Oil
Karnataka	0.7808	0.9687	1.6767	0.4219 0.9337	Firewood Diesel Oil
Orissa	0.6291	1.3413	2.3855	-	
Punjab	1.3366	0.4314	2.8808	-	
Rajasthan	0.4200	2.3465	1.5562	0.6562	Diesel Oil
Uttar Pradesh	0.4988	1.6120	1.9016	-	
West Bengal	0.2769	2.7809	1.8254	0.8435	Diesel Oil
Haryana	0.5031	1.5423	1.6434	0.5284	Diesel Oil
Andaman and Nicobar Islands	0.8558	2.2943	3.0603	0.6034 0.4263	Firewood Diesel Oil
Delhi	0.4519	2.5183	1.7962	0.7003	Diesel Oil
Himachal Pradesh	0.5264	1.6389	1.8288	1.7261	Aviation and Motor Spirit
Tripura	1.1188	2.6462	2.8737	0.2975 0.8304	Firewood Diesel Oil
Pondicherry	0.6432	1.2734	2.9878	-	
Goa, Daman and Diu	-	2.3663	1.5190	0.2611	Diesel Oil
Manipur	-	1.6038	2.2369	0.0765	Diesel Oil
Chandigarh	0.5254	0.8515	0.9567	0.5925 1.5100	Diesel Oil Aviation Spirit
India	0.4859	2.0556	1.7113	-	

* The fuel considered in this category has a significant share in the regional fuel consumption, other than the major fuels, viz. Coal, Electricity, Other Fuel Oils.

the States with the exception of Punjab and Tripura. In Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Maharashtra and West Bengal it is relatively cheaper than in other States. Surprisingly Bihar being the highest Coal producing State, does not show a lower relative price index in comparison with all India. In the case of Maharashtra, Coal is found to be relatively cheap because the prices of all its other energy sources are equally high. Electricity is noticed to be relatively cheaper in Punjab, Chandigarh and Karnataka with relative price index less than unity. On the other hand, Assam, Madhya Pradesh, Tamil Nadu, Rajasthan, West Bengal and Delhi, the relative price index shows values higher than all India average. No large divergencies are found in the relative price index of Other Fuel Oils. It is observed from the last column of the Table 3.14 that Diesel Oil and Aviation and Motor Spirit are the two oil based fuels found cheap in quite a number of regions. This is mainly true of those regions which do not have any natural energy resources. The other region-specific fuels are Coal-gas in Assam, Coke in Bihar and Firewood in Kerala, Karnataka, Andaman and Nicobar Islands and Tripura.

3) Industry-Effect

The three variables, namely, the level of industrialization, the industry-mix and the level of mechanization of a region, are considered together in the rest of the section.

(1) Level of Industrialization: The regional level of industrialization is considered in terms of the region's share of industrial production in the entire country. It is obvious

Table 3.15 : Comparison between Shares of Fuel Consumption and Industrial Production

	Consumption share		Industrial production share
	Value	TCR units	
Andhra Pradesh	4.20	4.70	4.36
Assam	1.22	6.52	1.56
Bihar	9.81	10.15	6.39
Gujarat	11.18	8.03	8.86
Jammu and Kashmir	0.23	0.17	0.08
Kerala	1.80	1.44	2.75
Madhya Pradesh	5.49	6.76	4.25
Tamil Nadu	8.63	9.48	9.86
Maharashtra	17.62	11.91	25.05
Karnataka	3.57	3.15	4.22
Orissa	5.90	6.77	2.04
Punjab	1.25	1.58	2.25
Rajasthan	2.03	1.81	1.67
Uttar Pradesh	10.70	10.69	7.47
West Bengal	12.11	13.48	14.67
Haryana	1.72	1.26	2.39
Andaman and Nicobar Islands	0.02	0.01	0.01
Delhi	2.12	1.80	1.68
Himachal Pradesh	0.15	0.11	0.16
Tripura	0.05	0.04	0.01
Pondicherry	0.10	0.08	0.16
Goa, Daman and Diu	0.05	0.04	0.03
Manipur	neg.	0.00	0.00
Chandigarh	0.05	0.03	0.08
India	100.00	100.00	100.00

that higher the level of industrialization, larger is the fuel consumption in the industrial sector. Table 3.15 summarizes the regional percentage shares of industrial production and fuel consumption, expressed in both value and energy units.

The above Table envisages an important fact that though the ranking of the fuel consumption and industrial production is similar, the magnitudes of the shares differ significantly. For example, Maharashtra produces one-fourth of the total industrial production of the country, while it consumes less than one-fifth of energy consumed in the total industrial sector of the country. On the other hand, Orissa consumes nearly 6 per cent of the total energy, while it produces only 2 per cent of the country's industrial production. This divergence between the shares in the industrial production and energy consumption is largely due to the industry-mix or the industrial composition of a region.

(2) Industry-mix: Since fuel requirement per unit of output differs from industry to industry and the industry-mix is different from region to region, the nature of industry-mix becomes an important variable for determining the fuel consumption of a region.

For the purpose of identification of the industry-mix at a regional level, the industrial sector is divided into two groups. One group is defined as heavy fuel using (HFU) industries and another as less fuel using (LFU) industries.* It is

* A detailed discussion of these groups is given in Chapter 4.

observed that the shares of HFU industries differ from region to region and hence the regional fuel consumption. This is analysed in the next section.

(3) Level of Mechanization: The level of mechanization is expected to have an impact on the regional fuel consumption. The ratio of fixed capital to man-hours worked is taken for our analysis as a proxy for studying the impact of the level of mechanization. Table 3.16 presents the relevant data about fixed capital, man-hours worked and also their ratio for each region. The impact of this level is also considered in the following section.

3.5 Multiple Regression Analysis

We have considered above the important variables influencing the regional fuel consumption. To quantify their impact on regional fuel consumption, we fit a multiple regression to the above variables.

This analysis is carried out at two levels; firstly at the aggregate level of all fuels taken together, and secondly at the individual fuel level.

3.5.1 Aggregate Fuel Consumption

The regression model for aggregate consumption is as follows -

$$\begin{aligned}
 \text{Fuel consumption} &= b_0 + b_1 \text{ (fuel price per energy unit: } X_1 \text{)} \\
 \text{of a region} &+ b_2 \text{ (percentage share of industrial} \\
 &\quad \text{output: } X_2 \text{)} \\
 &+ b_3 \text{ (share of HFU industries output: } X_3 \text{)} \\
 &+ b_4 \text{ (ratio of fixed capital to man-} \\
 &\quad \text{hours worked: } X_4 \text{)}
 \end{aligned}$$

Table 3.16 : Statewise Fixed Capital-Manhours Worked Ratio,
for 1970

State	Fixed Capital '000 Rs.	Manhours Worked '000	Fixed Capital/ Manhours Rs./Manhour
Andhra Pradesh	4,62,36,64	42,02,87	11.00
Assam	1,75,69,64	15,05,25	11.67
Bihar	6,27,69,91	45,27,29	13.86
Gujarat	5,07,36,83	71,66,37	7.08
Jammu and Kashmir	39,63,25	2,13,67	18.55
Kerala	1,82,22,31	27,59,26	6.60
Madhya Pradesh	5,18,14,53	31,62,92	16.38
Tamil Nadu	8,70,72,03	85,83,06	10.14
Maharashtra	12,86,25,82	1,58,82,67	8.10
Karnataka	3,83,27,78	35,06,76	10.93
Orissa	4,08,96,51	16,32,01	25.06
Punjab	2,55,82,96	14,43,27	17.73
Rajasthan	2,77,98,91	15,56,88	17.86
Uttar Pradesh	9,29,68,55	62,65,37	14.84
West Bengal	10,26,40,41	1,48,70,07	6.90
Haryana	2,13,06,11	17,13,28	12.44
Andaman and Nicobar Islands	81,30	46,99	1.73
Delhi	93,79,21	14,75,20	6.36
Himachal Pradesh	17,42,94	2,50,57	6.96
Tripura	15,52	29,50	0.53
Pondicherry	7,63,12	2,13,77	3.57
Goa, Daman and Diu	5,32,52	79,48	6.70
Manipur	11,92	21,45	0.56
Chandigarh	3,71,84	69,40	5.36
India	83,24,30,56	8,11,77,36	10.25

The above regression is fitted once with fuel consumption expressed in value terms and again with the same expressed in physical energy units.

Case 1: In the present case, the dependent variable viz. regional fuel consumption, is expressed in value terms. The following fit of the regression equation is obtained:

$$Y = -5069.96 + 6.46 X_1 + 4031.38 X_2 + 136.81 X_3 + 620.23 X_4$$

$$(9295) \quad (43.59) \quad (404.55) \quad (111.54) \quad (436.30)$$

(Figures in the brackets represent standard errors of 'b₁'s.)

The explained variation R^2 is 86.97 per cent with $F_{4,19} = 31.71$, significant at 1 per cent level. The statistical testing for the significance of individual regression parameters 'b₁' suggests that the percentage share of industrial output (X_2) is the only variable which has relationship with fuel consumption. All the other variables included in the regression equation have yielded insignificant values of b₁. In respect of the price variable, it is to be noted that b₁ surprisingly turns out to be positive, though it is statistically insignificant, while one expects negative relation between price and consumption.

Case 2: In this case the dependent variable is expressed in physical units and all other independent variables are the same as above. The following regression equation is obtained:

$$Y = 10397.74 - 72.18 X_1 + 3738.22 X_2 + 33.59 X_3 + 755.60 X_4$$

$$(13188) \quad (33.31) \quad (573.99) \quad (158.25) \quad (619.04)$$

The explained variation, R^2 , is 76 per cent (with $F_{4,19} = 15.16$) which is statistically significant at the 5 per cent level of significance.

In the above regression, two ' b_1 ' coefficients are statistically significant. In addition to the share of industrial output as in case of earlier regression, price of energy also turns out to be significant with proper (negative) sign. The ' b_1 ' coefficients of other variables viz. the share of HFU industries and the fixed capital to man-hours worked ratio are insignificant in this case as in the earlier.

Conclusions: The above analysis confirms the obvious fact that the absolute fuel consumption of a region (expressed in either units) is definitely related to the regional industrial output.

The fuel consumption expressed in value terms surprisingly does not show any relation with the energy price, while the same expressed in physical units gives a significant relation between the regional fuel consumption and its energy price, which may be explained as due to the substitutability between fuels; for with the same cost, different energy units are obtainable.

Fixed capital to man-hours ratio does not show a significant relation with regional fuel consumption. It should be noted here that the fixed capital data used by us is the depreciated Book Value of assets, which is not a proper indicator of fixed capital. It is well known that there are no firm estimates of fixed capital in the country. However, it was felt that in a cross section study like this, the bias in using the fixed capital data, as reported in A.S.I., would be uniform. But this does not turn out to be true, implying thereby that the

industrial mix and the age compositions of assets are not uniform across the regions. Further the regional level of mechanization as indicated by the ratio of fixed capital to man-hours worked, may increase the rate of energy consumption without showing any relation with absolute consumption of it.

The insignificant relation of the share of HFU industries may also be explained by a similar argument, which is illustrated below.

Suppose, there are two regions with their energy consumption as 100 TCR units and their HFU industries' shares as 25 per cent and 75 per cent respectively. In the first region the share of HFU industries being small, the total industrial output obtained with the same energy consumption is higher than that of the second region. Let the regional output levels be Rs.3,000 and Rs.1,000 respectively. Then we obtain:

<u>Region</u>	<u>Percentage share of HFU industries</u>	<u>Fuel consumption/ Rs.1,000 of output</u>
R ₁	25	33.33 TCRs
R ₂	75	100 TCRs

This indicates that the share of HFU industries does not have a significant impact on the regions' absolute consumption, but the regions' energy consumption per rupee of their industrial output or in other words, the rate of energy consumption is directly related to the share of HFU industries in it.

3.5.2 Consumption of Individual Fuels

The following analysis of the energy consumption at the individual fuel level is for the purpose of exploring the role

that the individual fuels play in the totality of regional variation of the aggregate fuel consumption. The fuels studied are Coal, Electricity and Other Fuel Oils. For each fuel two regression equations are fitted in value as well as in quantity terms.

Functional relationship for each of the fuels is as follows; for example:

Consumption of Coal = f [Price of Coal (X_1), Percentage share of industrial output (X_2), Percentage share of HFU industries (X_3), Ratio of fixed capital (F.C.) to man-hours (X_4), Relative price of Coal with respect to other fuels (X_5) Relative price of Electricity with respect to other fuels (X_6), Relative price of Other Fuel Oils with respect to other fuels (X_7), Production of Coal as a dummy variable (X_8), Production of any other important fuel as a dummy variable (X_9)].

In respect of the remaining individual fuels the same functional form in terms of independent variables is used with the following changes only. For the regression fitted for Electricity, instead of a dummy variable for production, actual production data are used. But since no production data are available for Other Fuel Oils, the production variable has been dropped in case of the regression fitted for Other Fuel Oils.

To avoid the problem arising out of multicollinearity,

the correlation coefficient matrices of the independent variables have been evaluated. And on the basis of these matrices, only the non-inter-correlated variables are chosen for fitting the regression equations.

The following regression equations are obtained:

Reg. 1 :

$$Y = 5381.68 - 371.09 X_1 + 7606.76 X_2 + 1105.56 X_3 \\ (57315.16) (438.90) (3027.29) (872.81) \\ + 3655.17 X_4 - 2488.50 X_5 + 24550.60 X_6 \\ (3169.04) (6862.06) (40359.86)$$

(figures in brackets are standard errors of b estimates)

where Y = consumption of Coal in value,

X_1 = price of Coal,

X_2 = % share of industrial output,

X_3 = share of HFU industries,

X_4 = F.C./man-hours ratio,

X_5 = Relative price of Electricity,

X_6 = Production of any other important fuel (dummy).

The above regression explains 53.56 per cent variation giving multiple R as 0.7318. The F ratio (3.26) obtained is significant at 5 per cent level. The test of b's gives variable X_2 only as statistically significant.

Reg. 2 :

$$Y = 1723.43 - 77.05 X_1 + 1519.04 X_2 + 187.49 X_3 + 525.66 X_4 \\ (10158.36) (37.78) (536.55) (154.69) (561.67) \\ - 48.71 X_5 + 1723.43 X_6 \\ (1216.21) (7153.26)$$

where Y is the consumption of Coal expressed in TCR units and

$X_1 \dots X_6$ are the same as in Reg. 1.

Here $R^2 = 0.5482$ with $R = 0.7404$. The F ratio is 3.36, statistically significant at 1 per cent level.

X_1 and X_2 are the two variables which give statistically significant b_1 estimates.

Reg. 3 :

$$\begin{aligned}
 Y = & 5574.61 + 9.2016 X_1 + 14121.97 X_2 + 510.40 X_3 \\
 & (21146.71) (5.76) \quad (2630.78) \quad (347.96) \\
 & + 240.07 X_4 - 28161.51 X_5 - 1789.59 X_6 + 8308.47 X_7 \\
 & (1345.10) \quad (23698.74) \quad (2874.56) \quad (15786.49)
 \end{aligned}$$

where Y = consumption of Electricity in value

X_1 = production of Electricity

X_2 = % share of industrial output

X_3 = share of HFU industries

X_4 = F.C./man-hours ratio

X_5 = relative price of Coal

X_6 = relative price of Electricity

X_7 = production of any other important fuel (dummy).

The regression gives $R^2 = 0.9500$ with $R = 0.9747$ and $F_{7,16} = 43.45$, significant at 1 per cent level. Tests of b_1 's indicate that only X_2 is significant.

Reg. 4 :

$$\begin{aligned}
 Y = & -539.58 + 1.29 X_1 + 759.06 X_2 + 18.88 X_3 + 84.54 X_4 \\
 & (1552.99) (0.42) \quad (193.20) \quad (25.55) \quad (98.78) \\
 & - 602.36 X_5 - 170.99 X_6 + 739.36 X_7 \\
 & (1740.41) \quad (211.10) \quad (1159.34)
 \end{aligned}$$

where Y is consumption of Electricity expressed in energy units and $X_1 \dots X_7$ are the same as in Reg. 3.

The results show that $R^2 = 0.9474$ with $F_{7,16} = 41.14$, is significant at 1 per cent. The tests of b_i 's show that production of Electricity (X_1) and share of industrial output (X_2) are significant.

Reg. 5 :

$$\begin{aligned}
 Y = & -4333.16 & - 1373.49 X_1 & + 8403.44 X_2 & + 19.71 X_3 \\
 & (21332.10) & (22420.10) & (1025.63) & (281.20) \\
 & - 701.81 X_4 & + 6817.47 X_5 & + 996.75 X_6 & + 6108.53 X_7 \\
 & (1009.24) & (17016.37) & (2017.15) & (12682.31)
 \end{aligned}$$

where Y = consumption of Other Fuel Oils in value

X_1 = price of Other Fuel Oils

X_2 = share of industrial output

X_3 = share of HFU industries

X_4 = F.C./manhours ratio

X_5 = relative price of Coal

X_6 = relative price of Other Fuel Oils

X_7 = production of any other important fuel (dummy).

The regression equation is a good fit with $R^2 = 0.8473$ ($R = 0.9208$), giving $F_{7,16} = 12.6787$, statistically significant at 1 per cent level. The share of industrial output X_2 is again the only significant variable from the point of view of b_i values.

Reg. 6 :

$$\begin{aligned}
 Y = & -307.55 & - 53.38 X_1 & + 613.67 X_2 & + 3.63 X_3 & - 66.67 X_4 \\
 & (1734.74) & (1823.21) & (83.40) & (22.87) & (82.07) \\
 & + 556.90 X_5 & + 70.95 X_6 & + 249.04 X_7 \\
 & (1383.77) & (164.03) & (1031.33)
 \end{aligned}$$

where Y is consumption of Other Fuel Oils expressed in energy units and $X_1 \dots X_7$ are the same as in Reg. 5.

The regression result gives a significant R^2 viz. 0.8185 with $R = 0.9047$. The F ratio obtained is 10.04. The b_1 's test indicates that only industrial output (X_2) is a significant variable.

The above six regressions suggest that the consumption of individual fuel does depend on the set of variables, considered earlier. However, the above regressions shed some more light if the individual independent variables are considered.

It is observed that the absolute fuel consumption depends on its production and price. The fuel consumption further depends on the share of industrial output. The insignificance of the share of HFU industries and level of mechanization supports the earlier finding about their relation with the rate of consumption even at the individual fuel level. The relation between relative prices and absolute consumption is insignificant due to a statistical lacuna of comparing absolute figures with the relative ones. This difficulty can be overcome and the relative prices can be compared with the relative consumption of fuels which is carried out in the following section.

3.6 Relationship between Relative Prices and Relative Consumption

3.6.1 Regression Analysis

The relation between relative price of a fuel and its relative consumption is explored by fitting a regression in the double log form, which gives the best fit. The relative

price P_1/P_2 is the same as defined earlier in 3.4 and the relative consumption C_1/C_2 is the ratio of the consumption in TCR units of a given fuel with respect to the same of the remaining fuels. The double log form of the regression fitted is as follows:

$$\log (C_1/C_2) = \alpha + \beta \log (P_1/P_2).$$

It is fitted to the three important fuels viz. Coal, Electricity and Other Fuel Oils. The regression equations obtained for each individual fuel are as follows:

Eqn. 1 [Coal in comparison with other fuels]

$$\log(C_1/C_2) = -2.3119 - 2.9910 \log(P_1/P_2)$$

(0.52) (0.70)

$$R^2 = 71.21\%.$$

[Figures in brackets are the Standard Deviation of the parameters.]

Here both α and β are statistically significant at 5 per cent level.

Eqn. 2 [Electricity in comparison with other fuels]

$$\log(C_1/C_2) = -0.4190 - 1.7018 \log(P_1/P_2)$$

(0.40) (0.47)

$$R^2 = 61.83 \%$$

Here α is insignificant but β is significant at 1 per cent level.

Eqn. 3 [Other Fuel Oils in comparison with other fuels]

$$\log(C_1/C_2) = -2.3434 - 1.1504 \log(P_1/P_2)$$

(0.43) (0.49)

$$R^2 = 45.81\%.$$

In this case also both the parameters α and β are found

statistically significant.

Since β is significant uniformly in all the above cases, we may conclude that there exists a relationship between relative price and relative consumption of a fuel. It is further noted that the relation is non-linear, which means that 1 per cent increase in the ratio (P_1/P_2) leads to a decrease of β per cent in the ratio (C_1/C_2) . It is found that the highest decrease (2.99) is observed in case of Coal consumption with one per cent increase in its relative price ratio. Similar decreases in case of Electricity and Other Fuel Oils are 1.70 and 1.15 per cent respectively.

3.6.2 Elasticity of Substitution

Elasticity of substitution for a single industry is defined as the proportionate change in the ratio of the amount of factors employed, divided by the proportionate change in the ratio of their prices to which it is due.² This may be written as:

$$\sigma = \frac{d \log(C_1/C_2)}{d \log(P_2/P_1)}$$

The above definition is based on the given production isoquant, where σ remains unchanged for any point on it. But there is a difference between elasticity of substitution for single industry and the economic system as a whole.³

A slightly different formulation for elasticity of

² Robinson, J. The Economics of Imperfect Competition. London, 1933, p. 256.

³ A discussion about this issue is between Hicks and J. Robinson; Robinson, J. Op.cit.

substitution has been used by Meade⁴ viz.:

$$\sigma = \frac{d \log(L/B)}{d \log(l/b)}$$

where capital letters relate to the amount of the two factors and small letters indicate prices of the respective factors. With this formulation, elasticity of substitution always comes out negative.

Incidentally, it is interesting to note that the ' β ' coefficients evaluated in the above double log regression give the elasticity of substitution as per Meade's formulation.*

$$\beta = \frac{d \log(C_1/C_2)}{d \log(P_1/P_2)}$$

However, objections are raised for labelling such β coefficients as elasticity of substitution.⁵ The first objection relates to the difference in the level of production of different regions. The concept of elasticity of substitution is applicable only for the points lying on the same isoquant. If the above ' β 's are to be used as elasticities of substitution, the regions across which the regressions are fitted need to have the same industrial output levels, which is far from

⁴ Meade, J.E., *The Review of Economic Studies*, Vol. II, 1933-34, p. 150.

* The two definitions of elasticity of substitution differ in their denominators, being reciprocals of each other. In the logarithmic calculations, reciprocals have a difference in sign, keeping the magnitudes same. Thus both these forms give the same magnitudes to elasticity of substitutions with opposite signs to them.

⁵ Minhas, B.S. *Contributions to Economic Analysis, An International Comparison of Factor Costs and Factor Use*. North Holland Publishing Company, Amsterdam, 1963, pp. 14-15.

the truth. This objection about different regional output levels, however, gets weakened by using the ratio of consumption in the formulation as the consumption ratio is less affected, by variation in regional output levels. Hence it is not very unrealistic to assume the same ratio of consumption of fuels for different output levels.

The second objection relates to the aggregation of industrial sector. The lumping together of all industries in one sector implies a uniform production function for each industry in each region. This indirectly implies homogeneity of fuel technology in all the industries. It further assumes the proportionate use of each fuel in each region. This is a serious limitation, which can be overcome only by comparing each industry at the regional level. This, however, is not possible in each case because of the insufficient number of observations. Hence we have estimated below the elasticities of substitution in respect of three individual industries only.

The industries selected for estimation of individual elasticities are Textiles, Basic Iron and Steel, and Electricity Generation. These three industries are regionally well diversified over the country and hence provide a sufficient number of observations to carry out the regression. The Table 3.17 shows the results of the three regressions along with the performance of each fuel at aggregate level.

The results indicate that the elasticity of substitution in case of Coal is always more than that of Electricity. No such trend is observed in case of Other Fuel Oils. It is to

Table 3.17 : Industrywise Elasticity of Substitution

Industry	Fuel	Coal	Electricity	Other Fuel Oils
Textiles		2.2242	0.6450	negligible consumption
Basic Iron and Steel		1.8045	0.5220	2.7326
Electricity Generation		1.7062	Not used	4.9476
Total Industrial Sector		2.99	1.70	1.15

be noted that these results suffer from the limitation of product-mix variation in the same industry across regions.

Though above analysis indicates the degree of substitutability of important fuels, it does not show inter-fuel elasticity of substitution. Therefore, it is now proposed to consider the elasticities of substitution for individual fuels. The following three pairs are considered viz. Coal and Electricity, Electricity and Other Fuel Oils, and Other Fuel Oils and Coal. This analysis is also carried out for the two individual industries along with the aggregated industry level.* The results obtained are presented below.

Table 3.18 : Inter-Fuel Elasticity of Substitution

Industry	Fuel	Coal x Electricity	Electricity x Other Fuel Oils	Other Fuel Oils x Coal
Textiles		1.32	3.28	5.21
Basic Iron and Steel		0.83	1.69	7.09
Total Industrial Sector		1.48	2.07	3.68

* In case of Electricity Generation industry there is only one pair whose elasticity can be evaluated, therefore it is excluded from the analysis.

The above Table indicates that though magnitudewise these estimates do differ from industry to industry, including the entire industrial sector, the order of values remain the same. This is similar to the result obtained earlier for elasticities of substitution of a single fuel against all other fuels. The product-mix within an industry across the regions may not be the same and naturally this will have some impact on the magnitude of the results. It is hoped, that this limitation is not so serious as to affect the trends.

The highest degree of substitutability is found between Other Fuel Oils and Coal. A moderate inter-fuel substitution is observed between Electricity and Other Fuel Oils. The substitution between Coal and Electricity is found to be the lowest.

Table A_{3.1} : Statewise Fuel Consumption Expressed in Tonne Coal Replacement Units for 1970

State	Coal	Coke	Coal gas	Firewood	Charcoal	Aviation and Motor Spirit	Diesel Oil	Other Fuel Oils	Lubricating Oil	Industrial and Power Alcohol	Electricity	Total
Andhra Pradesh	1933802	62221	7	38300	650	20077	36699	135756	5998	-	739386	2972896
Assam	113111	1434	3504644	51474	63	6643	192771	174893	3323	-	76253	4124609
Bihar	4297922	412558	36870	40309	258	10717	294136	431754	13524	21	883051	6421120
Gujarat	2482065	64657	1615	23177	307	21833	84823	988041	29585	202	1378563	5074868
Jammu and Kashmir	81118	71	-	5450	103	9928	4939	3	485	-	5758	107855
Kerala	14712	1381	-	174530	1712	2234	17189	305337	1802	5	391097	909999
Madhya Pradesh	3309104	33041	-	18798	116	6112	70304	45588	10919	-	779388	4273370
Tamil Nadu	3687658	32945	12	36841	2779	27141	102570	543763	11195	226	1546691	5991821
Maharashtra	2039465	70364	5847	37536	2520	155235	323404	1704997	39134	214	3149900	7528616
Karnataka	606280	55317	-	166710	37499	9954	112091	146510	6339	3	853553	1994256
Orissa	3113723	58135	575	7801	66	6286	77809	83337	8025	7	922947	4278711
Punjab	162012	18420	-	3282	133	9014	26464	22653	3901	-	751799	997678
Rajasthan	848568	11456	-	7310	147	2775	50340	43830	4892	-	176927	1146245
Uttar Pradesh	4153233	67851	76	180995	609	29485	94812	210949	16833	1177	2006571	6762591
West Bengal	5803844	204675	34895	34890	3306	83751	347451	360297	42701	181	1607419	8523410
Haryana	502820	15378	93	5210	69	9077	32519	47223	5025	549	180405	798368
Andaman and Nicobar Islands	20	16	-	454	61	95	2737	117	74	-	421	3995
Delhi	875638	9208	8	2076	163	5823	71718	40889	2023	-	129581	1137127
Himachal Pradesh	38879	1455	-	262	149	3222	11008	1016	384	-	11349	67724
Tripura	1113	-	-	3506	-	21	23073	325	187	-	118	28343
Pondicherry	22320	-	-	1224	-	84	149	84	239	-	25343	49443
Goa, Daman and Diu	-	-	-	838	367	541	21682	637	303	-	3945	28313
Manipur	-	-	-	-	-	-	89	2	11	-	142	244
Chandigarh	2799	113	-	6	3	668	714	4921	305	-	6222	15751
Total *	34090206	1120699	3584643	840979	51080	420716	1999491	5292922	207208	2584	15626876	63237353

* Total may not be exact to the total of all States, as it is direct conversion from All-India figures.

Table A_{3.2} : Purchaser's Prices - Statewise, Fuelwise, 1970 (in Rupees)

State	Coal (m. tonne)	Coke (tonne)	Coal-gas (Cu. metre)	Firewood (tonne)	Charcoal (tonne)	Aviation and Motor Spirit (litre)	Diesel Oil (litre)	Other Fuel Oils (litre)	Lubri- cating Oil (litre)	Alcohol (litre)	Electri- city (KWH)
INDIA	59.44	142.57	0.0043	56.95	188.15	1.16	0.59	0.25	1.91	0.37	0.10
Andhra Pradesh	53.90	120.28	1.13	61.89	209.88	1.20	0.68	0.27	2.07	-	0.09
Assam	53.49	123.72	0.0003	21.45	254.55	1.26	0.53	0.27	2.30	-	0.13
Bihar	60.78	141.43	0.09	49.75	262.22	1.17	0.63	0.27	1.94	1.02	0.09
Gujarat	82.03	185.85	0.78	79.93	268.66	1.18	0.65	0.21	1.83	0.24	0.12
Jammu and Kashmir	107.57	365.08	-	149.21	166.67	1.12	0.58	1.00	2.95	-	0.10
Kerala	110.73	217.68	-	41.48	185.41	1.24	0.60	0.24	1.85	0.20	0.08
Madhya Pradesh	45.80	167.85	-	56.30	287.13	1.20	0.81	0.28	1.99	-	0.11
Tamil Nadu	46.50	205.93	0.27	60.99	250.31	1.13	0.60	0.24	2.17	0.71	0.10
Maharashtra	53.23	190.13	0.30	83.85	271.94	1.15	0.55	0.24	1.93	0.35	0.10
Karnataka	85.20	173.35	-	42.90	169.70	1.21	0.71	0.28	2.17	2.83	0.07
Orissa	68.97	54.48	0.25	45.54	155.17	1.19	0.55	0.32	2.08	2.08	0.07
Punjab	95.94	179.44	-	114.04	405.17	1.32	0.55	0.36	2.17	-	0.04
Rajasthan	75.77	143.22	-	73.81	343.75	1.26	0.51	0.27	1.92	-	0.14
Uttar Pradesh	67.91	153.43	0.32	82.15	259.89	1.22	0.72	0.30	1.97	0.34	0.09
West Bengal	44.92	113.73	0.23	50.21	221.49	1.10	0.52	0.25	1.63	0.47	0.12
Haryana	91.37	158.87	0.99	79.69	366.67	1.10	0.50	0.34	2.25	0.28	0.12
Andaman and Nicobar Islands	200.00	214.29	-	140.17	301.89	1.00	1.22	1.16	2.39	-	0.33
Delhi	78.05	174.25	0.50	128.60	352.11	1.17	0.53	0.30	1.86	-	0.15
Himachal Pradesh	90.69	171.58	-	68.84	307.69	1.10	0.83	0.39	2.09	-	0.13
Tripura	115.00	-	-	31.97	-	1.25	0.74	0.50	2.44	-	0.19
Pondicherry	88.26	-	-	83.85	-	1.13	0.80	0.59	2.21	-	0.09
Goa, Daman and Diu	-	-	-	41.95	112.50	1.26	0.45	0.26	2.66	-	0.14
Manipur	-	-	-	-	-	-	2.17	1.00	2.50	-	0.21
Chandigarh	99.68	200.00	-	166.67	666.67	1.35	0.78	0.29	2.24	-	0.11

CHAPTER 4

INTENSITIES OF FUEL USE

Having considered the factors responsible for inter-regional variation in energy consumption at the aggregate level, we then, in this chapter try to study the intensities of energy consumption and the efficiencies of energy use in the different regions both at the aggregate and individual industry level.

Energy intensity like that of labour or capital, is defined here as the amount of energy required to produce say a rupee worth of output. In other words it is the reciprocal of energy productivity. The energy intensity is measured in monetary as well as in physical units. Thus defined, the term intensity, in the input-output frame of analysis is obviously the energy input coefficient. Hence the direct and indirect energy intensity can also be defined as the direct energy used in the production and also the energy required to produce the inputs, necessary in the production process et sequentes.*

* The direct plus indirect energy intensity is evaluated as follows:

Let A be the input coefficient matrix and $(I - A)^{-1}$ be its Leontief inverse. If E^d is the vector of direct energy intensity of the economy, the $(E^d)(I-A)^{-1} = E'$ is the row vector of sectoral direct plus indirect energy intensity.

A different concept namely energy embodied in the product as gross energy requirement (GER) is also used for the evaluation of energy intensities. This involves the direct and indirect intermediate use of energy as also the energy requirement for the capital equipment in the production process. However, it is difficult to evaluate GER because of the problems related to the measurement of capital use in the production process. A ranking of the industries on these three measures viz. the direct intensity, the direct and indirect intensity, and the gross energy requirement (GER) may yield different results.

4.1 Review of Studies on Energy Intensity

Before we analyse our present problem and discuss our results about the regional intensities, we give below a brief review of the important energy intensity studies found in the literature with particular reference to the methodology of analysis.

A study entitled "Trends in Energy Use in Industrial Societies"¹ by the Electric Power Research Institute (EPRI), California has examined the reasons behind the different Energy/GDP (i.e. gross domestic product) ratios of different countries. It has been found that the Energy/GDP ratio depends not only on the composition of GDP but also on the composition of industries in the industrial sector of a country. The study

¹ Electric Power Research Institute (EPRI), EA-1471, Project 864, California, 1980.

further indicates that the above shortcoming can be overcome by studying the individual industries. A method of isolating the effect of the income share of individual industry in the total industrial sector and the use of energy in the said industry within each region is suggested.

Darmstadter et al² have also attempted to explain the differential energy use per dollar of output in different economies adopting the techniques similar to that of EPRI study noted above. The study covers six European countries, U.S.A., Canada and Japan, which constitute a homogeneous group of industrially advanced countries. The study is for the year 1972. The main focus of the analysis is to study the various reasons which explain the variations in the energy intensities for different broad economic sectors between the countries. For the industrial sector the two factors, viz. the role and the energy intensities of the industrial sector are isolated. The main finding of the study is that with relatively smaller share of industrial income in the total Gross National Product (GNP) of U.S.A., it is found to use more amount of energy to produce the same income as that of any other country. On the other hand, Sweden is found to use the least amount of energy to produce the same level of GNP in comparison with other countries, under study.

² Darmstadter, J., Dunkerley, J., and Alterman, J. How Industrial Societies Use Energy: A Comparative Analysis. The John Hopkins University, Fern, Baltimore and London, 1977, Ch. 6, pp. 101-140.

The Economic Commission for Europe has made a study³ with a view to understand the existing energy intensities and efficiencies for seventeen European countries (ECE Region). The data relates to the year 1965. The sectoral energy intensities, as a ratio of energy inputs to the value of output of that sector, are evaluated for the seventeen countries. Direct plus indirect energy intensities are, however, calculated only for France, Italy and the U.S.A. The purpose of the study is to find energy intensive industries and to prescribe policy measures from energy saving point of view in the ECE Region as a whole.

Another study by the United States Conference Board⁴ examines the energy intensities of individual industries for the period 1947 to 1967 for the purpose of projections. It uses direct energy input coefficient as energy intensity and analyses industries at different process levels for the energy requirement in future.

Edwards and Ashok Parikh⁵ have a similar study for the five EEC countries over the period of one decade ending 1970. The study uses the direct energy intensities for finding the

3 "Increased Energy Economy and Efficiency in the EEC Region", Economic Commission for Europe, United Nations, Geneva, 1976.

4 "Energy Consumption in Manufacturing", The Conference Board in Cooperation with the National Science Foundation, Ballinger Publishing Company, U.S.A., 1974.

5 "Intensities of Energy Usage, An International and Intertemporal Comparison", Energy Policy, March 1978, pp.66-75.

inter-fuel substitution possibilities within each country.

In the Indian context, Henderson⁶ evaluated the commercial energy used per unit of value added for the four economic sectors, viz. Agriculture, Mining and Manufacturing, Transport and Communication, and Others, of the Indian economy for 1960-61 and 1970-71. He finds that economy as a whole shows an increase of 40 per cent in its commercial energy intensity. The sectors consuming less commercial energy have showed a sharp increase in comparison with those already using a relatively higher commercial energy. He has further separated the total increase in energy intensity in the following three components:

1. Sectoral output rising alone.
2. Change in the sectoral energy coefficient alone.
3. Interaction element of both, change in output as well as energy input coefficient.

The total increase in the sectoral energy consumption has been divided into above three components. Industrial sector shows that output change alone contributes the highest share in explaining the increase in energy consumption, viz. 28.7 mtr out of 37.4 mtr.

The article by Parikh Jyoti and Chaitanya Arunk⁷ deals with the energy efficiency of Indian industries. The study has found out Large Energy Consuming (LEC) industries as Textiles,

⁶ India : The energy Sector. Oxford University Press, 1975, Chap. 3, pp. 25-35.

⁷ "Are Industries Energy Efficient?" Economic and Political Weekly, March 15, 1980, pp. 559-564.

Fertilizers, Inorganic Heavy Chemicals, Paper, Non-Ferrous Metals and Iron and Steel. The energy intensities, on value added basis, are evaluated for 1971. The results, though available at the individual industry level, their conversion ratios being not very precise, their reliability is doubtful. The study also presents the norms of energy intensities at the single industry level for 1970, which are estimated on the tonne output basis. Hence direct comparison of existing energy intensities with the norms are not made.

The above discussion underlines the scope for studying the energy intensities both at regional and industry level in the Indian Economy. Hence the following chapter is devoted to the analysis of the energy intensities at the regional level, for the aggregate industry sector as also for the individual industries.

4.2 Regional Energy Intensity

The energy intensities can be evaluated at different levels such as the firm, industry, sector, region and economy.

The regional energy intensity is defined as follows:

$$TR_j = \frac{F_{.j}}{O_{.j}} = \frac{\sum_{i=1}^n F_{ij}}{\sum_{i=1}^n O_{ij}} \quad \text{for } j = 1, 2, \dots, m,$$

where F_{ij} is the energy consumed by the i^{th} industry in j^{th} region either in physical units or in money terms; O_{ij} is the output or the value added of i^{th} industry in j^{th} region and TR_j is the energy intensity of the j^{th} region, in physical or value terms depending on the units of F_{ij} .

The regional energy intensities per unit of industrial output as also for value added both in physical and value basis are presented in Table 4.1.

Let us consider the regional energy intensities per unit of industrial output on value basis. Jammu and Kashmir and Orissa are the two States with higher energy intensities and among the Union Territories, Tripura has the highest energy intensity. Assam tops the list of States for the energy intensity based on the physical units; while Tripura maintains its first position even on the physical basis. Orissa and Jammu and Kashmir have a high energy intensity on the physical basis too.

A comparison of the regional energy intensities, on the physical and value basis, shows that differential relative positions for the States because of the regional energy price differentials. To understand the variability between them, they are compared with the all India energy intensity for its industrial sector. The comparison is made by using a measure defined as

$$\gamma_j = \frac{TR - TR_j}{\frac{1}{2}(TR + TR_j)}$$

where TR_j is the energy intensity for the industrial sector of j^{th} region and TR is the same for all India. The ' γ ' values for the energy intensities based on physical and value terms are presented in Table 4.2.

A positive value of ' γ ' indicates that the energy intensity of a region is less than the energy intensity of

Table 4.1 : Regional Energy Intensities for Industrial Sector
in 1970

Region	Intensity in value Rs./Output	Intensity in Physi- cal units TCR/000 Rs.Output	Intensity in value Rs./Value added	Intensity in Physi- cal units TCR/000 Rs. Value added
Andhra Pradesh	0.0523	0.6463	0.2277	2.7318
Assam	0.0428	2.5119	0.1774	10.1918
Bihar	0.0814	0.9528	0.3409	3.7768
Gujarat	0.0654	0.5432	0.2768	2.1272
Jammu and Kashmir	0.1632	1.2778	1.0655	8.3318
Kerala	0.0357	0.3138	0.1448	1.2390
Madhya Pradesh	0.0698	0.9539	0.3232	4.2569
Tamil Nadu	0.0479	0.5761	0.1814	2.1338
Maharashtra	0.0336	0.2849	0.1374	0.9946
Karnataka	0.0461	0.4479	0.1291	1.2218
Orissa	0.1606	1.9858	0.6896	8.4740
Punjab	0.0309	0.4203	0.1407	1.8951
Rajasthan	0.0676	0.6499	0.2226	2.1250
Uttar Pradesh	0.0796	0.8581	0.3275	3.5067
West Bengal	0.0450	0.5506	0.1782	2.1231
Haryana	0.0396	0.3173	0.2069	1.3181
Andaman and Nicobar Islands	0.0825	0.3545	0.3611	1.5013
Delhi	0.0640	0.6397	0.2379	2.6699
Himachal Pradesh	0.0491	0.3954	0.0734	0.5565
Tripura	0.2749	2.6648	1.0914	10.5797
Pondicherry	0.0344	0.2983	0.1887	1.6165
Goa, Daman and Diu	0.1038	1.0382	0.4991	4.7972
Manipur	0.1909	0.5545	0.0567	0.1646
Chandigarh	0.0290	0.1669	0.0714	0.3565
India	0.0530	0.5994	0.2102	2.2509

Table 4.2 : Comparison of Regional Intensities with All India

State	' γ_j ' on Value Coefficient Basis	' γ_j ' on Physical Coefficient Basis
Andhra Pradesh	0.0138	-0.0753
Assam	0.2129	-1.2294
Bihar	-0.4227	-0.4554
Gujarat	-0.2088	0.0984
Jammu and Kashmir	-1.1093	-0.7228
Kerala	0.3911	0.6256
Madhya Pradesh	-0.2742	-0.4564
Tamil Nadu	0.1014	0.0396
Maharashtra	0.4482	0.7115
Karnataka	0.1388	0.2895
Orissa	-1.0073	-1.0726
Punjab	0.5271	0.3513
Rajasthan	-0.2422	-0.0808
Uttar Pradesh	-0.4011	-0.3549
West Bengal	0.1625	0.0849
Haryana	0.2882	0.6156
Andaman and Nicobar Islands	-0.4356	0.5134
Delhi	-0.1881	-0.0650
Himachal Pradesh	0.0759	0.4102
Tripura	-1.3534	-1.2655
Pondicherry	0.4244	0.6707
Goa, Daman and Diu	-0.6483	-0.5359
Manipur	-1.1303	0.0778
Chandigarh	0.5857	1.1287

the country as a whole. On the other hand a negative value of ' γ ' suggests a higher energy use by a region than that of the all-India, to produce one rupee worth of its industrial output.

Table 4.3 : Comparison of Regional Intensities with All-India (Statewise)

	Physical Units Basis	Value Units Basis
Positive ' γ_j '	Gujarat, Kerala, Tamil Nadu, Maharashtra, Karnataka, Punjab, West Bengal, Andaman and Nicobar Islands, Himachal Pradesh, Pondicherry, Manipur, Haryana, Chandigarh	Andhra Pradesh, Assam, Kerala, Tamil Nadu, Maharashtra, Karnataka, Punjab, West Bengal, Himachal Pradesh, Pondicherry, Haryana, Chandigarh
Negative ' γ_j '	Andhra Pradesh, Assam, Bihar, Jammu and Kashmir, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, Delhi, Tripura, Goa	Bihar, Gujarat, Jammu and Kashmir, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, Andaman and Nicobar Islands, Delhi, Tripura, Goa, Manipur

It is interesting to find the comparative picture in the tetrapartite classification of the ' γ ' indices evaluated on the physical and value basis classified by the sign of the indices as presented in Table 4.3. It is found that Kerala, Tamil Nadu, Maharashtra, Karnataka, Punjab, West Bengal and Haryana use less than average energy to produce one rupee worth of their industrial output, on both physical as well as value basis. On the other hand, Bihar, Madhya Pradesh, Orissa, Rajasthan and Uttar Pradesh consume more than average energy on either basis. Gujarat is the only State which requires less than average energy on the physical basis and more than the same in value terms. On the contrary, Andhra Pradesh and Assam use more than average energy on physical basis while

the same in value terms is less than the average.

The picture presented by the ' γ ' indices, evaluated on value added basis and classified as above, is not much different from the one presented above on output basis.

Before we spell out the implications of the above picture, we turn to consider the energy intensities of different industries at the all-India level, as the aggregate of that has been used as a norm to compare the regional intensities.

4.3 Industry Intensity Variation

The one factor which accounts for the variability in the energy intensities noted above, is the differential industry-mix between the regions, as different industries operate with different energy intensities. We, therefore, consider below the industrywise intensities which are defined on the same lines as regional intensities as:

$$TI_i = \frac{\sum_{j=1}^m F_{ij}}{\sum_{j=1}^m O_{ij}} = \frac{F_i}{O_i}, \quad \text{for } i = 1, 2, \dots, n,$$

Where F_{ij} and O_{ij} are the energy consumed and output realized respectively of i^{th} industry in the j^{th} region, and TI_i is the energy intensity of i^{th} industry. These energy intensities at the industry level can also be evaluated on output as well as value added basis. However, different industries have different value added coefficients, depending on its input requirement, and hence the value added does not reflect the real output of the industry. Therefore for the comparison between the industry energy intensities, the output is a better variable for evaluation of energy intensities at industry level. Thus, these

Table 4.4 : Industry Energy Intensity at All India Level for 1970

Industry	Intensity in value (Rs./Output)	Intensity in energy (TCR/000 Rs. Output)	Industry	Intensity in value (Rs./Output)	Intensity in energy (TCR/000 Rs. Output)
201	0.047230	0.281805	312	0.016802	0.127713
202	0.019537	0.123737	313	0.009722	0.056311
203	0.023419	0.192325	319	0.026667	0.177137
204	0.018468	0.099618	321	0.020243	0.070650
205	0.010058	0.065812	329	0.267585	0.162092
206	0.018256	0.117499	331	0.161633	2.108212
207	0.017996	0.128107	332	0.181436	1.390973
208	0.031255	0.260961	333	0.162184	1.520917
209	0.021611	0.183370	334	0.248828	2.844323
211	0.114535	1.174380	339	0.033511	0.244873
212	0.039717	0.351103	341	0.106332	1.039432
213	0.043152	0.254385	342	0.086400	0.902329
214	0.014816	0.062962	350	0.031997	0.188058
220	0.004709	0.029897	360	0.023904	0.114455
231	0.045284	0.332667	370	0.020522	0.104060
232	0.015030	0.093765	381	0.029395	0.192199
233	0.028654	0.118053	382	0.042235	0.571947
239	0.030821	0.213045	383	0.022324	0.149669
241	0.005560	0.021085	384*	1.261926	4.559630
243	0.008604	0.036998	385	0.020348	0.101058
251	0.033159	0.253782	386	N.A.	N.A.
252	0.014682	0.058751	389	0.013163	0.089518
259	0.028594	0.399909	391	0.015316	0.067848
260	0.016005	0.080258	392	0.035758	0.282087
271	0.103975	1.028998	393	0.010551	0.042473
280	0.019611	0.072043	394	0.040829	0.306708
291	0.010410	0.063760	395	0.017592	0.135807
293	0.035353	0.114466	399	0.041463	0.513292
300	0.026051	0.182531	511	0.149899	3.057792
311	0.094632	0.875871	512	0.022274	0.317101

*This, being a service industry, has not been considered in the study.

intensities are evaluated on output basis only, in physical as well as value terms.

The energy intensities in both physical and value terms are evaluated at the three digit level of industries in Table 4.4. The variation in the industry intensities of energy consumption is found to lie in the range with a minimum as 0.004709 (Tobacco manufacturing) and maximum as 0.248828 (Cement) on value basis. The said range on the physical basis of evaluation lies between 0.021085 TCR/000 Rs. output of Shoe-making industry and 3.057792 TCR/000 Rs. output of Electricity Generation. The average energy intensity for the manufacturing sector as a whole is 0.053007 rupees per rupee of output, which is equivalent to 0.599425 TCR per thousand rupees of industrial output in physical units. These desiderata will be used subsequently for the classification of the industries as heavy fuel using (HFU) industries and less fuel using (LFU) ones.

4.4 Isolation of Effects of Intensity and Industrial Structure

Industry sector being the most important sector in terms of development of the regions, it is necessary to analyse the impact of industrial energy use in relation to the overall income generated in the State. The relation is a function of the energy use in the industrial sector and the importance of the industrial sector in the region. The effects of these two need to be isolated, as it helps in identifying the regions which are energy efficient in the sense that they use less energy per unit of output. For this purpose, we follow the model developed by Darmstadter and others in their study: How

Industrial Societies Use Energy?⁸4.4.1 The Darmstadter Model

The Model is based on the ratio of energy consumed in a sector to Gross Domestic Product, which is denoted as Energy/GDP ratio. The above ratio can be written as a product of two ratios as below:

$$\frac{\text{Energy consumed by a sector}}{\text{Gross Domestic Product}} = \frac{\text{Energy consumed by a sector}}{\text{Value added of the said sector}} \times \frac{\text{Value added of the said sector}}{\text{Gross Domestic Product}}$$

While the first ratio of the two in the right hand side above is a ratio of energy consumption to value added for a given sector, or alternatively the intensity of a sector, the second ratio represents the share of the said sector in the total economy. These two ratios, related to the industrial sector are taken to represent regional energy intensity and industrial structure, the latter defined by the relative importance of the industrial sector in the economy. With the help of above equation, a method of isolation of the intensity and the structure effects in energy use is developed below:

Let us define the ratio of energy consumed to GDP for two regions R_1 and R_2 as E_1/G_1 and E_2/G_2 , where E_1 and E_2 represent industrial energy consumption in TCR units in regions R_1 and R_2 respectively and G_1 and G_2 are their respective gross domestic products. Let X_1 and X_2 be the incomes generated in the industrial sector of the two regions R_1 and R_2 . Then E_1/X_1

⁸ Darmstadter, J., Dunkerley, J., and Alterman, J., op.cit.

and E_2/X_2 are the respective regional energy intensities for the industrial sector and X_1/G_1 and X_2/G_2 represent the respective regional structure effect due to industry sector. The following two equations are thus generated with the above defined variables:

$$(E_1/G_1) = (E_1/X_1) \times (X_1/G_1) \quad \text{and}$$

$$(E_2/G_2) = (E_2/X_2) \times (X_2/G_2).$$

The difference between the two energy/GDP ratios viz. $[(E_2/G_2) - (E_1/G_1)]$, is now to be allocated between intensity and structure as follows.

To start with we evaluate the difference in the energy/GDP ratio between R_1 and R_2 as due to differential energy intensities on the assumption of uniform structure for R_1 and R_2 . Let a uniform structure, say of R_1 , be assumed and on the basis of it, income generated in region R_2 estimated. This estimate is given by $(G_2)(X_1/G_1)$ and is denoted as X_2^1 . Then the energy required to generate X_2^1 in region R_2 is $(X_2^1)(E_2/X_2) = E_2^{21}$.

This leads to a hypothetical energy/GDP ratio of R_2 under the uniform structure assumption as (E_2^{21}/G_2) . This gives the difference between two energy/GDP ratios on the same structure assumption as

$$\left(\frac{E_2^{21}}{G_2} - \frac{E_1}{G_1} \right) \quad \dots (1)$$

Secondly, we evaluate the said difference in energy/GDP ratio between R_1 and R_2 as due to differential industrial structure on the assumption of uniform energy intensities.

Under this uniform intensity assumption, energy requirement of Region R_2 is given by :

$$E_2^{12} = (X_2)(E_1/X_1)$$

and the hypothetical energy/GDP ratio turns out E_2^{12}/G_2 . This leads to the difference between the two energy/GDP ratios as:

$$\left(\frac{E_2^{12}}{G_2} - \frac{E_1}{G_1} \right) \dots (2)$$

With the help of (1) and (2) above the following identity can be derived.

$$\left(\frac{E_2}{G_2} - \frac{E_1}{G_1} \right) = \left(\frac{E_2^{21}}{G_2} - \frac{E_1}{G_1} \right) + \left(\frac{E_2^{12}}{G_2} - \frac{E_1}{G_1} \right) + \left(\frac{E_2}{G_2} - \frac{E_2^{21}}{G_2} - \frac{E_2^{12}}{G_2} + \frac{E_1}{G_1} \right) \dots (3)$$

The first expression of the right hand side of above identity explains the difference between the two energy/GDP ratios on the assumption of uniform structure for the two regions as noted above, explaining the variation between the intensities of two regions which is termed as the intensity effect. The second expression explains, as noted above, the variation between the said energy/GDP ratios on the assumption of uniform energy intensities for the two regions. Such a variation explains the effect of the relative importance of the industrial sector in the two regions and is termed as the structure effect. The last expression represents the interaction between the two effects, which exists because of the non-additive nature of the identity and does not have any significant meaning and interpretation.

4.4.2 Application of the Darmstadter Model

The study carried out by Darmstadter and others has inter-country comparisons with U.S.A. as the standard of comparison. Since we have to compare all regions of India, there is no reason for selecting any one region as a standard against others. Though it is better to carry out pairwise comparisons for all regions, such comparisons do not lead to any meaningful results. Hence we have carried out comparisons for different regions against all India as the norm. As some of the regions have very small share of industrial output, they are not included in the present analysis.*

The basic data, required for the analysis are presented in Table 4.5, which presents the three ratios for each region under study:

- (1) Share of income from industrial sector in the total state income (SDP).
- (2) Energy/SDP ratio in TCR units per lakh rupees of SDP.
- (3) The consumption of energy in the industrial sector per lakh rupees of industrial income.

Using the method, discussed above, regional intensity and structure effects are evaluated. The two effects along with the actual difference between the energy/GDP ratios of a State and all-India are presented in Table 4.6.

The actual difference between energy/SDP ratio of a State and Indian Union is defined as energy/GDP of all-India

* The regions which are excluded are all Union Territories except Delhi and the State of Jammu and Kashmir.

Table 4.5 : Energy Consumption in Industry and GDP Originating in Industry, 1970

State	GDP(Industry)/ GDP (State) (%)	Energy (ter) consumption/ GDP (Industry)	E/G (State)
Andhra Pradesh	4.33	273.19	11.84
Assam	5.23	154.06	8.07
Bihar	7.57	375.52	28.43
Gujarat	10.78	212.65	22.93
Kerala	5.99	123.91	7.42
Madhya Pradesh	5.02	425.68	21.36
Tamil Nadu	11.60	213.38	24.75
Maharashtra	18.96	99.38	18.85
Karnataka	8.26	122.17	10.09
Orissa	4.72	847.32	39.96
Punjab	3.81	189.49	7.22
Rajasthan	3.40	212.50	7.22
Uttar Pradesh	4.53	350.66	15.89
West Bengal	12.50	211.44	26.45
Haryana	7.24	187.77	13.59
Delhi	8.20	187.43	15.38
India	8.17	225.09	17.36

minus energy/SDP ratio of a State. A higher state ratio indicates that energy per lakh rupees of SDP of a State is more than that of all-India. On the other hand a smaller State ratio indicates that the State requires less energy to generate the same income as that of all-India.*

* The smaller State ratio is indicated by a positive difference while a large ratio is indicated by a negative difference.

Table 4.6 : Statewise Structure - Intensity Effect and Actual Difference in Energy/SDP Ratios

(TCR per lakh rupees of SDP)				
State	Structure Effect	Intensity Effect	Inter-action	Actual Difference* in E/G Ratio
Andhra Pradesh	8.15	-4.97	2.34	5.52
Assam	6.24	4.76	-1.71	9.29
Bihar	1.28	-13.34	0.99	-11.07
Gujarat	-5.54	-0.03	0.00	-5.57
Kerala	4.65	7.23	-1.94	9.94
Madhya Pradesh	6.70	-17.44	6.73	-4.01
Tamil Nadu	-7.27	-0.09	-0.03	-7.39
Maharashtra	-22.91	9.23	12.19	-1.49
Karnataka	-0.18	7.37	0.08	7.27
Orissa	7.34	-51.91	21.97	-22.60
Punjab	9.27	1.87	-1.00	10.14
Rajasthan	10.14	-0.01	-0.01	10.14
Uttar Pradesh	7.74	-11.31	5.04	1.47
West Bengal	-9.20	0.07	-0.11	-9.09
Haryana	1.99	2.01	0.23	3.77
Delhi	-0.06	2.04	0.00	1.98

Note: *Difference is between State and all India.

The variation in the intensity of fuel use i.e. the intensity effect of a region as against all-India evaluated on the basis of the given structure of the region, implies that a higher intensity effect means that the given region uses more than average energy and the smaller one, less than average of it to produce the same value added as that of the

entire country.* On the other hand, a variation in the structure evaluated, as explained, exhibits the relative importance, in terms of the share of the industrial sector in the economy of a region as against the country as a whole. A higher ratio for a region indicates relatively higher share of industrial sector than that of the country and a smaller value to State's energy/GDP ratio shows relatively smaller share of industrial value added in its domestic product than the country as a whole.**

In the light of the above discussion, Table 4.6 can be read as follows. For example, we consider the case of Maharashtra. It is seen that the difference in the actual energy/GDP ratios of Maharashtra and India is -1.49, which indicates that Maharashtra uses 1.49 TCR units more than all-India per lakh rupees worth of its income. These 1.49 additional TCR used by Maharashtra are not due to its higher intensity, as the Table shows that with its existing intensity Maharashtra requires 9.23 TCR units less per lakh rupees of its income, than India. This low intensity effect gets offset by its higher structure effect. The Table shows that due to the higher share of the industrial sector in the SDP of Maharashtra, it requires 22.91 TCR units more than India to generate the same income. The

* The negative intensity effect implies higher State intensity, while positive intensity effect means smaller energy use than all-India.

** The positive value of the structure effect implies relatively less importance of the industrial sector in a region, while the negative value of the same indicates higher share of industrial value added in the State domestic product.

residual of 12.19 TCR units is due to the interaction effect.*

4.4.3 Results

Considering the sign of the actual difference in the two energy/GDP ratios, which, as stated, indicates the comparative use of energy to produce the same GDP as that of India, the Table 4.6 reveals that Bihar, Gujarat, Madhya Pradesh, Tamil Nadu, Maharashtra, Orissa and West Bengal constitute one group of States which use more energy than all-India. The remaining States require less energy to produce the same SDP as that of India.

The actual difference in the energy/GDP ratios in different States with India are explained by their structure and the use of energy in its industrial sector. Smaller use of energy (i.e. positive intensity effect) is always a desirable situation. Assam, Kerala, Punjab, Haryana, Maharashtra, West Bengal, Karnataka and Delhi have positive intensity effect. On the other hand, Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Tamil Nadu, Orissa, Rajasthan and Uttar Pradesh use more than all-India energy to produce the same income with their energy intensities. Maharashtra ranks first with regard to the intensity effect with its 9.23 TCR units per lakh rupees of its SDP indicating energy efficiency in its industrial sector. From energy efficiency point of view, Karnataka and Kerala follow Maharashtra. On the other hand, Orissa has the highest negative intensity effect (51.91 TCR units per lakh rupees of its SDP).

* The interaction effect, in general, is negligible except in the case of Maharashtra and Orissa.

Madhya Pradesh, Bihar and Uttar Pradesh are the other three States with a significantly high negative intensity effect, indicating inefficient use of energy in their industrial sector. Gujarat, Rajasthan, Tamil Nadu and West Bengal have very small values for their intensity effect.

A negative structure effect indicates that the energy/SDP ratio of a State is more than all-India because of the higher share of industrial value added in the State domestic product, which is observed in the following States: Gujarat, Tamil Nadu, Maharashtra, Karnataka and West Bengal. Maharashtra stands first with -22.91 TCR units per lakh rupees of its SDP, indicating the highest level of industrialization among all the Indian States. Next in line are West Bengal and Tamil Nadu respectively. For the remaining States the structure effect is positive. Rajasthan has the highest positive effect indicating the lowest level of industrialization. The Punjab follows Rajasthan giving a higher positive structure effect. Andhra Pradesh, Uttar Pradesh and Orissa show nearly the same value for their structure effect while Karnataka and Delhi are found to have a negligible value for the structure effect.

A further examination of the above results indicates that not only the signs but the magnitudes of these effects are also important. Hence the percentage shares of intensity and structure effect for each region are calculated (with the absolute value) and presented in Table 4.7.

In the differences between actual energy/GDP ratios of States and all-India, it is noted that Bihar, Gujarat, Madhya

Table 4.7 : Statewise Percentage Contribution of Intensity and Structure Effect between Energy Consumption Per Lakh Rupees of SDP Ratio with All India

State	Percentage share of structure effect	Percentage share of intensity effect
Andhra Pradesh	62.12	37.88
Assam	58.18	41.82
Bihar	8.76	91.24
Gujarat	99.46	0.54
Kerala	39.14	60.86
Madhya Pradesh	27.75	72.25
Tamil Nadu	98.78	1.22
Maharashtra	71.28	28.72
Karnataka	2.38	97.62
Orissa	12.39	87.61
Punjab	83.21	16.79
Rajasthan	99.90	0.10
Uttar Pradesh	40.63	59.37
West Bengal	99.24	0.76
Haryana	49.75	50.25
Delhi	2.86	97.14

Pradesh, Tamil Nadu, Maharashtra, Orissa and West Bengal have more than country's energy requirement per lakh rupees of their SDP, with their prevailing structures and energy intensities. Table 4.7 additionally indicates that in the case of Maharashtra the higher energy/GDP ratio is explained by its highest share of industrial income in its SDP together with its lowest energy use. On the contrary, in case of Orissa the position is exactly reverse where the highest energy use goes with a significantly

small share of industrial income in its SDP. Gujarat, Tamil Nadu and West Bengal explain their higher than average energy/GDP ratio by industrial structure alone as they use energy nearly equal to the nation's average. Bihar and Madhya Pradesh have different shares for their intensity and structure effect such as the intensity effect, in case of Bihar, is 91.24 per cent followed by 72.75 per cent for Madhya Pradesh.

For the remaining States, viz. Andhra Pradesh, Assam, Kerala, Karnataka, Punjab, Rajasthan, Uttar Pradesh, Haryana and Delhi, the energy/GDP ratio is less than that of all-India. For the Punjab and Rajasthan, it is fully explained by their low level of industrialization. But Delhi and Karnataka have equal share of industrial value added in their SDP and the lower energy/GDP ratio for them seem to be due to their efficient use of energy. For the States of Andhra Pradesh, Assam, Kerala, Haryana and Uttar Pradesh, both these effects are between 40 and 60 per cent and neither of the two factors seems to be dominant.

4.5 Heavy Fuel Using Industries

The structure effect considered above in terms of the relative importance of the industrial sector in the regional economy does not take note of the industry-mix in the said industrial sector. We have already noted that the variation in the energy intensities between industries is of a significant order and the industry-mix of a region plays an important role in explaining the regional energy intensity. To uncover and understand the role of the industry-mix we propose to study the industries at their individual level. As the main focus of our

analysis is to study the energy intensities, those industries which are important energy consumers, are considered for this analysis. The industries which have more than average energy intensity, are categorized as Heavy Fuel Using (HFU) industries and the ones with less than average energy intensity are categorized as Less Fuel Using (LFU) industries. The following industries are covered by the HFU industries category.*

1. Distilling, rectifying and blending of spirits (211)
2. Cotton Textiles (231)**
3. Paper and Paper Products (271)
4. Chemical Fertilizers (311.1.1)
5. Heavy Chemicals (311.2)
6. Chemicals (other than chemical fertilizers and heavy chemicals) (311 R)
7. Structural Clay Products (331)
8. Glass and Glass Products (332)
9. Pottery, China and Earthenware (333)
10. Cement (334)
11. Basic Iron and Steel (341.1)
12. Iron and Steel (other than Basic) (341 R)

* There exists one industry for Miscellaneous Petroleum Products (329) which has slightly higher than average value for its energy intensity, and occurs only in two regions. Therefore this industry has not been listed in the HFU industries category. The industries Chemicals (311) and Iron and Steel (341) are further disaggregated for the purpose of homogeneity of products.

** The energy intensity of the Textile industry is not above the average. However, considering the importance of this industry in the Indian economy, we have included it in the HFU industries category.

13. Non-Ferrous Metals (342)

14. Electricity Generation (511).

Before we analyse each of these industries in terms of energy intensity and structure effects to study the variation across regions, the role of HFU industries in the different regions is presented below.

Different regions show different output shares of the above HFU industries. As these industries require more energy to produce one rupee output, a higher share of them leads to a higher regional intensity. Since detailed regional comparison at the individual industry level, which also exhibits the relative importance of HFU and LFU categories, becomes rather involved, we study the role at the category level only. For the purpose, the regional output levels of HFU and LFU industries along with the percentage share of HFU industries within a region are presented in Table 4.8.

The highest share due to HFU industries is observed in Orissa, contributing nearly three-fourth of its total industrial output. This is followed by Madhya Pradesh and Gujarat with 66.50 per cent and 60 per cent shares due to HFU industries in their total industrial output. The following four States, viz. Bihar, Tamil Nadu, Maharashtra and Rajasthan, have the output of share due to HFU industries is around the national average of the said share. Kerala and Assam have the least shares due to HFU industries category in their industrial output.

The picture described above shows the role of HFU industries within the region. If Orissa has 70 per cent share due

Table 4.8 : Regional Energy Consumption in HFU and LFU Industries for 1970

Region	Output for HFU industries '000 Rs.	Output for LFU industries '000 Rs.	Percentage share of HFU industries
Andhra Pradesh	12,90,319	33,09,381	28.05
Assam	73,539	15,68,487	4.48
Bihar	26,76,728	40,62,187	39.72
Gujarat	56,13,751	37,29,061	60.09
Jammu and Kashmir	23,636	60,768	28.00
Kerala	5,28,663	23,71,529	18.23
Madhya Pradesh	29,78,784	15,00,991	66.50
Tamil Nadu	46,91,939	57,08,238	45.11
Maharashtra	1,08,67,572	1,55,61,157	41.12
Karnataka	16,98,440	27,54,390	38.14
Orissa	15,84,593	5,70,053	73.54
Punjab	7,69,263	16,04,432	32.41
Rajasthan	7,76,203	9,87,562	44.01
Uttar Pradesh	24,67,586	54,13,306	31.31
West Bengal	72,92,162	81,87,125	47.11
Haryana	6,03,223	19,13,177	23.97
Andaman and Nicobar Islands	-	11,269	0.00
Delhi	3,59,955	14,17,565	20.25
Himachal Pradesh	1,05,187	66,092	61.41
Tripura	3,014	7,622	28.34
Pondicherry	1,23,416	42,302	74.47
Goa, Daman and Diu	-	27,270	0.00
Manipur	-	440	0.00
Chandigarh	-	94,370	0.00
All India	4,45,27,973	6,09,68,774	42.21

to HFU industries in its total industrial output, it does not imply that Orissa contributes the highest share in the total HFU industries output if evaluated at the country level. To examine, which of the State contributes the highest in the share of HFU industries output, the Statewise percentage shares of output due to HFU industries are presented in Table 4.9.

Table 4.9 : Statewise Percentage Shares of HFU Industries Output

State	Percentage share of HFU industries output
Andhra Pradesh	2.88
Assam	0.16
Bihar	6.70
Gujarat	12.53
Kerala	1.18
Madhya Pradesh	6.65
Tamil Nadu	10.47
Maharashtra	24.37
Karnataka	3.79
Orissa	3.54
Punjab	1.72
Rajasthan	1.73
Uttar Pradesh	5.51
West Bengal	16.61
Haryana	1.35
Delhi	0.80
Total	100.00

The Table shows that Maharashtra contributes the highest (24.37 per cent) output due to HFU industries in the country. West Bengal stands second in the rank. These two States hold

the same ranks in respect of their total industrial output also. Gujarat and Tamil Nadu also found to contribute significantly in the output due to HFU industries of the country as a whole. Besides, Kerala, Punjab and Rajasthan which show very small share of output due to HFU industries, Assam and Delhi are found to show the said share even less than one per cent.

The association of a higher regional output share due to HFU industries with a higher regional energy intensity does not seem to hold good as seen by a comparison of the results in Section 4.4 with the shares due to HFU industries presented in Table 4.8. We find that in Bihar and Maharashtra, though the share of output due to HFU industries is of the same order (around 40 per cent of their industrial output), the isolation of factors of industry-mix and energy intensity indicates that in Maharashtra the structure effect is dominant as against that in Bihar, where intensity effect is significantly high. A similar situation is observed in Gujarat and Madhya Pradesh. It is to be noted that the above results confound the effect of the industrial composition of the regional industrial sector. As noted earlier, to overcome the above we study the HFU industries at their individual level.

4.6 Regional Energy Intensities at Industry Level

At the individual industry level one does not expect any regional variation in the energy consumption per unit of output if no other factors, other than energy technology are assumed to be operating. We test below for the existence of such uniform energy intensities by comparing the regional

energy intensities with the all-India average in physical terms for each individual industry by the measure ' γ ' defined earlier.* Table 4.10 presents the classification of industries on the basis of the said ' γ ' values regionwise.

The results in the Table 4.10 do not substantiate the existence of uniform energy intensities across regions for the HFU industries as hypothesized above. On the other hand, they exhibit the following differential pattern of energy intensities for the regions. Assam and Punjab are the States where all HFU industries are found to use less than average energy per rupee of their output. Contrary, Orissa is seen to use more than all-India energy to produce one rupee output for each of its HFU industries. While Bihar and Uttar Pradesh are the two States which show for most of their HFU industries a higher intensity than all-India; Maharashtra, West Bengal, Tamil Nadu, Kerala, Rajasthan and Haryana are the States which are seen to require energy less than the average for their existing industries. In the case of Andhra Pradesh, Gujarat, Madhya Pradesh, Karnataka and Delhi about a half of the HFU industries use less than average energy and the remaining half use more than average energy.

The following reasons may be adduced for the differential pattern of regional energy intensities:

1. Variation in the energy efficiency.
2. Differences in the levels at which the industries operate.

* Vide Section 4.2.

Table 4.10 : Regionwise Classification of HFU Industries on the Basis of ' γ '

State	Industry	
	Positive ' γ ' *	Negative ' γ ' *
Andhra Pradesh	211, 231, 311.1.1, 341.1, 341(R)	271, 311.2, 311(R), 333, 334, 511
Assam	231, 341.1, 341(R)	
Bihar	231, 342, 511	311.1.1, 311.2, 331, 332, 334, 341.1, 341(R)
Gujarat	311.1.1, 311(R), 341.1, 341(R), 342, 511	231, 271, 311.2, 331, 333, 334
Jammu & Kashmir	231, 341.1	
Kerala	231, 311.2, 311(R), 511	331
Madhya Pradesh	211, 231, 271, 334, 341.1	331, 333, 341(R), 511
Tamil Nadu	231, 271, 311.1.1, 311(R), 331, 334, 341.1, 341(R), 342	311.2, 511
Maharashtra	271, 311.1.1, 311.2, 311(R), 331, 332, 341.1, 341(R), 342, 511	231
Karnataka	231, 311(R), 341(R), 511	271, 331, 334, 341.1, 342
Orissa		231, 271, 331, 341.1, 341(R), 511
Punjab	231, 341.1, 341(R), 511	
Rajasthan	231, 341(R), 342, 511	334
Uttar Pradesh	341.1, 341(R)	211, 231, 271, 311.2, 332, 333, 511
West Bengal	231, 311.2, 311(R), 332, 333, 341.1, 341(R), 342	271, 331, 511
Haryana	211, 231, 332, 341.1, 341(R)	271, 333
Delhi	341.1, 341(R)	231, 332, 333

* On the basis of physical ' γ ' values.

3. Variation in the factors such^{as}/regional level of mechanization and the product-mix in the regional output.

For an assessment of the variation in the regional efficiency in energy use, all other factors will have to be held constant or controlled. In the following, we assess the said variation in the regional efficiency in energy use for all the individual HFU industries by using the method, noted earlier, in connection with the aggregate industry level analysis of fitting the Darmstadter model to isolate the structure and intensity effect.

The necessary ratios are defined as follows. The basic energy/GDP ratio, used here, relates to the ratio of energy consumed by a single industry to the total value added by the industrial sector and is denoted by E_1/V . It can be expressed as a product of two ratios:

$$\frac{E_1}{V} = \left(\frac{E_1}{V_1}\right) \cdot \left(\frac{V_1}{V}\right)$$

where, E_1 and V_1 are respectively the energy consumed and value added of the i^{th} industry and V is the value added of the entire industrial sector of a region. While the ratio E_1/V_1 represents the energy intensity, V_1/V stands for output relative⁹ of the i^{th} industry.

The results of the above model are presented in the Tables A₄.3 and A₄.4 relating to the intensity and the structure

9 Op.cit. EPRI Study, 'Trends in Energy Use in Industrial Societies', has used a similar method, where the structure effect at the individual level is called output relative.

effect respectively. The results are discussed below with Bihar as an illustrative case.

We have already discussed about the nature and significance of these twin effects. Suffice it to say here that a higher State ratio for intensity effect implies an inefficient use of energy in the given industry and vice versa. And a higher State ratio for structure effect implies a higher relative output for the given industry and vice versa. For instance, in the case of Bihar for Basic Iron and Steel industry, the intensity effect is -0.0553 TCR units indicating that due to Bihar's large use of energy in the Basic Iron and Steel industry, it requires 0.0553 TCR units more than all-India for generating thousand rupees worth of industrial income.*

The structure effect of the above State for the said industry is -1.3364 TCR units more per thousand rupees worth of industrial income of Bihar.

For assessing the performance of a region for the energy use, the regions and industries are classified into a four-fold grouping on the basis of the intensity and structure effects. Group I consists of those regions which have relatively higher share of value added and uses less than average energy for a given industry (positive intensity effect and negative structure effect). Group II consists of those regions having relatively higher value added share and also use more than average energy

* The value 0.0553 TCR units per thousand rupees of Bihar's industrial value added amounts to nearly Rs. 4 crores (in 1970 prices), evaluated as $(0.0553 \times \text{Bihar's average energy price} \times \text{industrial value added of Bihar})$.

for a given industry (both intensity and structure effects are negative). The Group III comprises those regions which have relatively smaller value added share and use energy efficiently (negative intensity effect and positive structure effect). The last Group IV contains those regions which use energy inefficiently but have smaller relative output (both intensity and structure effects positive). The States falling in Group I may be called 'efficient', in the sense that they use energy efficiently and also contribute significantly to the industries output. The States in Group II are 'inefficient', in the sense that they contribute relatively high value added with inefficient fuel use.

The following two Tables viz. 4.11 and 4.12, present the regionwise classification of industries and the industrywise classification of the regions respectively falling in the above four groups. The Table 4.11 indicates that Bihar and Uttar Pradesh are the two States which do not have a single energy efficient industry in its HFU industries category, while for Orissa and Madhya Pradesh, a significant number of HFU industries fall in the energy inefficient group. In the case of Gujarat, it is observed that the HFU industries fall into Group II and Group IV almost in equal numbers. Andhra Pradesh and Tamil Nadu do not have a single energy inefficient industry in their HFU industries category. On the other hand, Maharashtra, West Bengal and Haryana have a large number of their HFU industries as energy inefficient. The variations in the product-mix within an industry group across the regions affect the energy intensities. These

Table 4.11 : Structure and Intensity Effect (Statewise)

State	Total Effect		Structure Positive Intensity Positive	Structure Negative Intensity Positive	Structure Negative Intensity Negative	Structure Positive Intensity Negative
	Positive	Negative				
Andhra Pradesh	211, 231, 311.2, 311(R), 341.1, 341(R)	271, 311.1.1, 333, 334, 511	231, 271, 311(R), 341.1	211, 311.1.1, 334, 511	-	311.2, 333, 341(R)
Assam	231, 341.1, 341(R)	511	341(R)	-	-	231, 341.1, 511
Bihar	231, 311.2, 332, 511	311.1.1, 331, 334, 341.1, 341(R), 342	231, 341(R), 511	-	311.1.1, 331, 334, 341.1, 342	311.2, 332
Gujarat	271, 311(R), 331, 341.1, 341(R), 342, 511	231, 311.1.1, 311.2, 333, 334	271, 331, 341.1, 342, 511	311.1.1, 311(R)	231, 311.2, 333, 334	341(R)
Kerala	231, 311(R), 511	311.2, 331	231, 311(R)	311.2, 511	331	-
Madhya Pradesh	341(R)	211, 231, 271, 331, 333, 334, 341.1, 511	-	211, 334, 341.1	231, 271, 331, 511	333, 341(R)
Tamil Nadu	231, 271, 311.1.1, 311(R), 341.1, 341(R), 342	311.2, 331, 334, 511	311(R), 341.1	231, 331, 334, 341(R), 511	-	271, 311.1.1, 311.2, 342
Maharashtra	271, 311.1.1, 331, 341.1, 342, 511	231, 311.2	331, 341.1, 342, 511	311.2, 311(R), 332, 341(R)	231	271, 311.1.1
Karnataka	231, 311(R), 341(R), 511	271, 331, 334, 341.1, 342	311(R), 341(R)	271, 334, 511	331, 342	231, 341.1
Orissa	231	271, 331, 341.1, 341(R), 511	-	271	341.1, 341(R), 511	231, 331
Punjab	231, 341.1, 341(R), 511	-	231, 341.1, 341(R)	511	-	-
Rajasthan	231, 341(R), 342, 511	334	341(R)	342, 511	334	231
Uttar Pradesh	231, 271, 341.1, 341(R)	211, 311.2, 311(R), 332, 511	231, 271, 341.1, 341(R)	-	211, 311(R), 332, 511	311.2
West Bengal	231, 311.2, 331, 341.1, 341(R)	271, 311(R), 332, 333, 342, 511	-	271, 332, 333, 341.1, 341(R)	231	311.2, 311(R), 331, 511
Haryana	231, 341.1, 341(R)	211, 271, 332, 333	231, 341.1	211, 332, 341(R)	271, 333	-
Delhi	332, 341.1, 341(R)	231, 333	341.1, 341(R)	231	333	332

Table 4.12 : Structure and Intensity Effect (Industrywise)

Industry	Total Effect		Structure Positive Intensity Positive	Structure Negative Intensity Positive	Structure Negative Intensity Negative	Structure Positive Intensity Negative
	Positive	Negative				
211	A.P.	M.P., U.P., Haryana	-	A.P., M.P., Haryana	U.P.	-
231	A.P., Assam, Bihar, Kerala, Tamil Nadu, Karnataka, Orissa, Punjab, Rajasthan, U.P., W.B., Haryana	Gujarat, M.P., Maharashtra, Delhi	A.P., Bihar, Kerala, Punjab, U.P., Haryana	Tamil Nadu, Delhi	Gujarat, M.P., Maharashtra, W.B.	Assam, Karnataka, Orissa, Rajasthan
271	Gujarat, Tamil Nadu, Maharashtra, U.P.	A.P., M.P., Karnataka, Orissa, W.B., Haryana	A.P., Gujarat, U.P.	Karnataka, Orissa, W.B.	M.P., Haryana	Tamil Nadu, Maharashtra
311.1.1	Tamil Nadu, Maharashtra	A.P., Bihar, Gujarat	-	A.P., Gujarat	Bihar	Tamil Nadu, Maharashtra
311.2	A.P., Bihar, W.B.	Gujarat, Kerala, Tamil Nadu, Maharashtra, U.P.	-	Kerala, Maharashtra	Gujarat	A.P., Bihar, Tamil Nadu, U.P., W.B.
311(R)	A.P., Gujarat, Kerala, Tamil Nadu, Karnataka	Maharashtra, U.P., W.B.	A.P., Kerala, Tamil Nadu, Karnataka	Gujarat, Maharashtra	U.P.	W.B.
331	Gujarat, Maharashtra, W.B.	Bihar, Kerala, M.P., Tamil Nadu, Karnataka, Orissa	Gujarat, Maharashtra	Tamil Nadu	Bihar, Kerala, M.P., Karnataka	Orissa, W.B.
332	Bihar, Delhi	Maharashtra, U.P., W.B., Haryana	-	Maharashtra, W.B., Haryana	U.P.	Bihar, Delhi
333	-	A.P., Gujarat, M.P., W.B., Delhi, Haryana	-	W.B.	Gujarat, Delhi, Haryana	A.P., M.P.
334	-	A.P., Bihar, Gujarat, M.P., Tamil Nadu, Karnataka, Rajasthan	-	A.P., M.P., Tamil Nadu, Karnataka	Bihar, Gujarat, Rajasthan	-
341.1	A.P., Assam, Gujarat, Tamil Nadu, Maharashtra, Punjab, U.P., W.B., Delhi, Haryana	Bihar, M.P., Karnataka, Orissa	A.P., Gujarat, Tamil Nadu, Maharashtra, Punjab, U.P., Delhi, Haryana	M.P., W.B.	Bihar, Orissa	Assam, Karnataka
341(R)	A.P., Assam, Gujarat, M.P., Tamil Nadu, Karnataka, Punjab, Rajasthan, U.P., W.B., Delhi, Haryana	Bihar, Maharashtra, Orissa	Assam, Bihar, Karnataka, Punjab, Rajasthan, U.P., Delhi	Tamil Nadu, Maharashtra, W.B., Haryana	Orissa	A.P., Gujarat, M.P.
342	Gujarat, Tamil Nadu, Maharashtra, Rajasthan	Bihar, Karnataka, W.B.	Gujarat, Maharashtra	Rajasthan, W.B.	Bihar, Karnataka	Tamil Nadu
511	Bihar, Gujarat, Kerala, Maharashtra, Karnataka, Punjab, Rajasthan	A.P., Assam, M.P., Tamil Nadu, Orissa, U.P., W.B.	Bihar, Gujarat, Maharashtra	A.P., Kerala, Tamil Nadu, Karnataka, Punjab, Rajasthan	M.P., Orissa, U.P.	Assam, W.B.

variations could not be considered in the analysis as data are not available in that detail. This limitation, it is hoped, would not seriously affect the above conclusions.

From industry point of view, as gleaned from Table 4.12, out of the four groups the two groups which use less than average energy, showing positive intensity effect, are important, because of efficient energy use. The regions with less than average energy use and relative output, are more important from the point of view of expansion of the relevant industry. The third and fourth columns of the Table 4.12, represent these States for each of the MFU industries. The following observations emerge from a scan of the said columns.

Alcohol, Fertilizers, Heavy Chemicals, Glass and Glass Products, Pottery—China and Earthenware and Cement industries show that all States, which use less than average energy, contribute more than average value added. On the other hand, industries such as Textiles and Iron and Steel have a large number of regions which are energy efficient but their value added shares are less than all-India. The industries such as Non-Ferrous Metals, Structural Clay Products and Chemical (General) are found as per the Table (4.12) in those regions which are not energy efficient. In the case of Electricity Generation industry, it may be observed that those regions which are energy efficient and have more than average value added share, are known for their hydel based power generation. Therefore, it is difficult to assess the energy efficient regions for the electricity generation.

To quantify the above results, the shares of value added in the above four groups are calculated for each industry and are presented in Table 4.13. It is observed that about one-third value added of the total HFU industry group comes from the energy efficient (both structure and intensity basis) regions. About 43 per cent income from the same group is generated from the energy inefficient group. The regions which use energy efficiently but produce less than average share, contribute only 14 per cent and the other group which uses energy inefficiently and also produces less than average income share has the lowest income share (7.4 per cent).

Table 4.13 : Industrywise Percentage Share of Value Added for Four Groups Based on Intensity and Structure Effect

Industry	Group I	Group II	Group III	Group IV
211	-	53.96	46.04	-
231	10.48	13.11	72.19	4.22
271	7.11	39.85	23.63	29.41
311.1.1	-	74.80	9.58	15.62
311.2	-	59.35	22.37	18.28
311(R)	3.30	79.32	8.26	9.12
331	25.83	11.63	53.89	8.65
332	-	78.56	19.32	2.12
333	-	46.38	48.16	5.46
334	-	66.94	33.06	-
341.1	16.55	36.09	46.40	0.06
341(R)	10.55	76.30	4.43	8.72
342	21.12	29.89	41.00	7.99
511	28.86	46.05	15.25	9.84
Average of all Industries	14.15	35.46	42.98	7.41

Alcohol industry has half of its income generated from the energy efficient States and the remaining half from the energy inefficient regions, both having more than average share of value added. Chemical industries in general, have quite high share of their income from energy efficient States. In the aggregate Chemical industry about 70 per cent value added comes from the said group. The Structural Clay Products shows a different picture, producing only 11.63 per cent of its income from energy efficient (higher value added share) States. Glass and Glass Products and Cement industries have a significant share of their income from energy efficient regions. Basic Iron and Steel and Non-Ferrous Metal industries contribute to their high income share by energy inefficient States as against Iron and Steel industry (other than Basic) which has three-fourths of its income from energy efficient region. Electricity Generation industry has a small share of its income from the energy inefficient States.

The above analysis shows that Bihar and Uttar Pradesh use energy very inefficiently and particular attention may have to be paid in these two regions for better utilization of the energy. More than half (57 per cent) of the value added of HFU industries comes from energy inefficient regions. Textiles, Structural Clay Products and Non-Ferrous Metals are the major industry groups where large part of the output comes from energy inefficient regions. Even after accounting for product-mix differences and other locational factors there appears to be considerable room for energy saving either by reallocating the industries or/and by improving the efficiency of energy utilization in some of the States.

Table A₄.1 : Data for State Domestic Product and Energy Consumption

State	SDP* (Rs. lakh)	SDP* (Industry) (Rs. lakh)	Energy (Industry) TCR units	Energy (Industry) '000 Rs.
Andhra Pradesh	251070	10882	2972896	247882
Assam	77300	4047	4124609	71801
Bihar	224540	17001	6421120	579564
Gujarat	221270	23857	5074868	660317
Kerala	122670	7344	909999	106343
Madhya Pradesh	200030	10039	4273370	324410
Tamil Nadu	242070	28080	5991821	509363
Maharashtra	399170	75096	7528616	1040363
Karnataka	197620	16323	1994256	210777
Orissa	107060	5049	4278711	348183
Punjab	138180	5265	997678	74061
Rajasthan	158730	5394	1146245	120094
Uttar Pradesh	425650	19285	6762591	631688
West Bengal	320970	40146	8523410	715291
Haryana	83670	6056	798368	125346
Delhi	51910	4259	1137119	101310
India	3436800	280945	63237353	5905364

* Source : National Accounts Statistics, 1970-71 to 1976-77, January 1979, C.S.O., Government of India.

Table A_{4.2} : Fuel Intensity or Total Fuel Input Coefficient, State x HFU Industries, 1970 [In TCR/000 Rs. Output]

	211	231	271	311.1.1	311.2	311(R)	331	332	333	334	341.1	341(R)	342	511
Andhra Pradesh	0.091802	0.249489	1.349233	0.681652	1.557681	0.674497	-	-	3.571417	2.888505	0.307098	0.353502	-	3.182644
Assam	-	0.224219	-	-	-	-	-	-	-	-	0.355583	0.457801	-	67.244141
Bihar	-	0.291985	-	2.684442	1.838632	-	2.249477	3.263142	-	3.095799	2.254381	1.433298	0.792627	1.057480
Gujarat	-	0.401480	1.282852	0.715135	1.159484	0.381995	2.361552	-	1.950835	3.140957	0.172879	0.256781	0.209214	2.530782
Kerala	-	0.210767	-	-	0.784366	-	3.350648	-	-	-	-	-	-	0.004659
Madhya Pradesh	0.912836	0.324797	0.938355	-	-	-	2.629067	-	2.420971	2.760204	0.495594	0.729518	-	5.599266
Tamil Nadu	-	0.236425	0.821035	0.525154	2.232364	0.202957	1.508627	-	-	2.692190	0.213953	0.337905	0.424095	3.221136
Maharashtra	-	0.400788	0.397605	0.869256	0.608459	0.453549	1.761578	0.961082	-	-	0.298629	0.513900	0.107229	1.149945
Karnataka	-	0.275967	1.282342	-	-	-	3.731068	-	-	3.049629	3.618153	0.482003	0.505197	0.001083
Orissa	-	0.338466	1.581177	-	-	-	2.744392	-	-	-	2.377623	2.508951	-	3.736618
Punjab	-	0.254963	-	-	-	-	-	-	-	-	0.310621	0.533705	-	0.071657
Rajasthan	-	0.292802	-	-	-	-	-	-	-	3.086040	-	0.566470	0.134510	0.389216
Uttar Pradesh	1.925141	0.338419	1.293537	-	2.163478	-	-	2.222274	2.934701	-	0.616813	0.334045	-	4.495228
West Bengal	-	0.257938	1.286582	-	0.833688	0.413567	2.564418	1.358141	1.292420	-	0.454686	0.559747	0.165214	4.836025
Delhi	-	0.414313	-	-	-	-	-	1.981235	2.536819	-	0.255240	0.495114	-	-
Haryana	0.497412	0.237456	1.055062	-	-	-	-	0.711008	1.883145	-	0.350719	0.108936	-	-

Table A_{4.3} : Intensity Effect* for All HFU Industries at Regional Level

State	Industry	211	231	271	311.1.1	311.2	311(R)	331	332	333	334	341.1	341(R)	342	51.
Andhra Pradesh		(+ve) 0.0025	(+ve) 0.0051	(-ve) 0.1133	(+ve) 0.0174	(-ve) 0.0817	(+ve) 0.0310			(-ve) 0.0076	(+ve) 0.0296	(+ve) 0.1924	(-ve) 0.2271		(+ve) 0.12
Assam			(-ve) 0.1564									(-ve) 1.6371	(+ve) 0.0275		(-ve) 21.48
Bihar			(+ve) 0.0355		(-ve) 0.1351	(-ve) 0.0570		(-ve) 0.0037	(-ve) 0.0213		(-ve) 0.0676	(-ve) 0.0556	(-ve) 0.3557	(-ve) 0.0089	(+ve) 0.41
Gujarat			(-ve) 0.0432	(-ve) 0.0598	(+ve) 0.0245	(-ve) 0.0099	(+ve) 0.0200	(+ve) 0.0049		(-ve) 0.0005	(-ve) 0.0321	(+ve) 0.2502	(+ve) 0.0266	(+ve) 0.0025	(+ve) 0.09
Kerala			(+ve) 0.0448			(+ve) 0.0181	(+ve) 0.0452	(-ve) 0.0008				(+ve) 0.1768			(+ve) 0.74
Madhya Pradesh		(+ve) 0.0007	(-ve) 0.0435	(+ve) 0.0293				(-ve) 0.0034		(-ve) 0.0006	(+ve) 0.0370	(+ve) 0.1284	(-ve) 0.0041		(-ve) 0.51
Tamil Nadu			(+ve) 0.0352	(+ve) 0.0068	(-ve) 0.0153	(-ve) 0.0734	(+ve) 0.0351	(+ve) 0.0018			(+ve) 0.0059	(+ve) 0.2500	(+ve) 0.0262	(-ve) 0.0035	(+ve) 0.03
Maharashtra			(-ve) 0.0057	(+ve) 0.0367	(-ve) 0.0263	(+ve) 0.0236	(+ve) 0.0140	(+ve) 0.0090	(+ve) 0.0059			(+ve) 0.2264	(+ve) 0.0119	(+ve) 0.0054	(+ve) 0.43
Karnataka			(-ve) 0.0149	(-ve) 0.0172			(+ve) 0.0447	(-ve) 0.0049			(+ve) 0.0114	(-ve) 1.9893	(+ve) 0.0291	(-ve) 0.0038	(+ve) 0.74
Orissa			(-ve) 0.0390	(-ve) 0.0410				(-ve) 0.0204				(-ve) 0.4340	(-ve) 0.1407		(-ve) 0.12
Punjab			(+ve) 0.0197									(+ve) 0.2009	(+ve) 0.0137		(+ve) 0.72
Rajasthan			(-ve) 0.0260								(-ve) 0.0298		(+ve) 0.0100	(+ve) 0.0057	(+ve) 0.67
Uttar Pradesh		(-ve) 0.0022	(-ve) 0.0334	(-ve) 0.0476		(-ve) 0.1025	(-ve) 0.1281		(-ve) 0.0159			(+ve) 0.1741	(+ve) 0.0186		(-ve) 0.59
West Bengal			(+ve) 0.0595	(-ve) 0.0163		(-ve) 0.0065	(-ve) 0.0299	(-ve) 0.0015	(+ve) 0.0011	(+ve) 0.0013		(+ve) 0.1715	(+ve) 0.0387	(+ve) 0.0066	(-ve) 0.93
Delhi			(-ve) 0.0568						(-ve) 0.0141	(-ve) 0.0024		(+ve) 0.1945	(+ve) 0.0052		
Haryana		(+ve) 0.0008	(-ve) 0.0190	(+ve) 0.0006					(+ve) 0.0078	(-ve) 0.0000		(+ve) 0.1855	(+ve) 0.0346		

* Energy (TCR) required to produce '000 Rs. of income of industrial sector at regional level, 1970.

Table A₄.4 : Structure Effect* for All HFU Industries at Regional Level

State	Industry	211	231	271	311.1.1	311.2	311(R)	331	332	333	334	341.1	341(R)	342	511
Andhra Pradesh		(-ve) 0.0192	(+ve) 0.1318	(+ve) 0.0315	(-ve) 0.1985	(+ve) 0.0477	(+ve) 0.0406			(+ve) 0.0020	(-ve) 0.3479	(+ve) 0.2669	(+ve) 0.0420		(-ve) 0.5801
Assam			(+ve) 0.2204									(+ve) 0.2843	(+ve) 0.0340		(+ve) 0.4477
Bihar			(+ve) 0.2161		(-ve) 0.0228	(+ve) 0.0495		(-ve) 0.0483	(+ve) 0.0127		(-ve) 0.1176	(-ve) 1.3364	(+ve) 0.0295	(-ve) 0.0478	(+ve) 0.2699
Gujarat			(-ve) 0.2831	(+ve) 0.0445	(-ve) 0.1998	(-ve) 0.0906	(-ve) 0.0322	(+ve) 0.0001		(-ve) 0.0103	(-ve) 0.0731	(+ve) 0.2446	(+ve) 0.0049	(+ve) 0.0155	(+ve) 0.0972
Kerala			(+ve) 0.1569			(-ve) 0.0999	(+ve) 0.0350	(-ve) 0.1146				(+ve) 0.2458			(-ve) 0.5069
Madhya Pradesh		(-ve) 0.0052	(-ve) 0.0070	(-ve) 0.2288				(-ve) 0.0061		(+ve) 0.0004	(-ve) 0.7845	(-ve) 0.8753	(+ve) 0.0311		(-ve) 0.3525
Tamil Nadu			(-ve) 0.0313	(+ve) 0.0274	(+ve) 0.0261	(+ve) 0.0070	(+ve) 0.0355	(-ve) 0.0037			(-ve) 0.1761	(+ve) 0.2094	(-ve) 0.0119	(+ve) 0.0033	(-ve) 0.3723
Maharashtra			(-ve) 0.0349	(+ve) 0.0073	(+ve) 0.0221	(-ve) 0.0515	(-ve) 0.0628	(+ve) 0.0088	(-ve) 0.0096			(+ve) 0.2237	(-ve) 0.0212	(+ve) 0.0037	(+ve) 0.2626
Karnataka			(+ve) 0.1422	(-ve) 0.0232			(+ve) 0.0447	(-ve) 0.0419			(-ve) 0.1797	(+ve) 0.2466	(+ve) 0.0332	(-ve) 0.0298	(-ve) 0.6453
Orissa			(+ve) 0.1679	(-ve) 0.3164				(+ve) 0.0004				(-ve) 1.7112	(-ve) 0.0626		(-ve) 0.0643
Punjab			(+ve) 0.0075									(+ve) 0.0690	(+ve) 0.0101		(-ve) 1.1570
Rajasthan			(+ve) 0.0403								(-ve) 0.6772		(+ve) 0.0392	(-ve) 0.0000	(-ve) 0.6882
Uttar Pradesh		(-ve) 0.0148	(+ve) 0.0637	(+ve) 0.0343		(+ve) 0.0266	(-ve) 0.0088		(-ve) 0.0312			(+ve) 0.1644	(+ve) 0.0114		(-ve) 0.1120
West Bengal			(-ve) 0.0523	(-ve) 0.0253		(+ve) 0.0386	(+ve) 0.0167	(+ve) 0.0127	(-ve) 0.0156	(-ve) 0.0102		(-ve) 0.1481	(-ve) 0.0095	(-ve) 0.0151	(+ve) 0.2641
Delhi			(-ve) 0.0155						(+ve) 0.0121	(-ve) 0.0079		(+ve) 0.2199	(+ve) 0.0368		
Haryana		(-ve) 0.0102	(+ve) 0.1164	(-ve) 0.1172					(-ve) 0.0557	(-ve) 0.0296		(+ve) 0.2491	(-ve) 0.0638		

* Energy (TCR) required to produce 000 Rs. income from industrial sector at Regional level, 1970.

CHAPTER 5

COST EFFICIENCY OF FUEL USE

In the earlier chapter the analysis was based on physical energy efficiency and the emphasis was on its effect on income generated. While physical energy saving is an important factor, the costwise consideration of energy consumption is equally important. The fuelwise price variation across regions and the interfuel substitutability lead to differences in the level of consumption of various fuels in different regions, for the same industry. In view of this, we try to understand the cost efficiency across regions. We propose to analyse the cost efficiency for each of the HFU industries.

5.1 Regionwise Use of Fuels at Individual Industry Level

In Table A₅.1 are presented the regionwise fuel use per unit output for different HFU industries.* The following

* The fuelwise consumption variability across regions for a single industry has been technically tested by the use of the following model -
$$Y_{ij} = Y_i + Y_j + E_{ij}$$

where for a given industry, Y_{ij} is the i^{th} fuel consumed in j^{th} region, Y_i is the fuel effect and Y_j is the location effect and E_{ij} is a random effect.

Under the assumption of systematic variation alone, E_{ij} , a residual term, becomes a random variable, which is normally distributed. This assumption is tested by testing the normality of these E_{ij} 's for each of the HFU industry group. The results showed that all industries except Pottery—China and Earthenware, have a non-normal distribution for their residual terms.

observations based on it serve as a background for the cost efficiency of fuel use across the regions for a given HFU industry. The observations pertain mostly to industries showing significant differentials in fuel usage across the regions.

As regards the Paper industry, Haryana seems to prefer Coal as against Electricity, while Tamil Nadu seems to substitute Coal by Other Fuel Oils and Maharashtra seems to make more than average use of fuels except Electricity and Coal. In the case of Fertilizer industry, Bihar shows high Coal consumption as one expects because of its resource endowment, but it is surprising that its Heavy Chemicals industry shows a greater usage of Electricity than Coal. For the Chemical industry, both Heavy and Others, Gujarat and Maharashtra show more than average use of Other Fuel Oils in preference to other fuels.

For the Structural Clay Products industry, it is interesting to note that a significant consumption of Firewood is found in the States of Kerala and Karnataka. In the case of Pottery—China and Earthenware industry, surprisingly use of Coal is relatively very low for West Bengal, despite its locational advantage for it. As for the Cement industry while Rajasthan shows higher Coal consumption, Gujarat shows higher use of Other Fuel Oils as the major fuel for the industry.

For Iron and Steel industry, Bihar and Orissa show a different picture from all other States, by making a high use of Coal.

It is well known that fuel use for Electricity Generation is different for the different technologies used for the same.

The States of Punjab, Kerala and Karnataka are the three States with hydel based power generation, indicating a very low fuel use. On the other hand, all other States have thermal power generation showing the high consumption either of Coal or Oil, depending on the technique of the region.

5.2 Method for Evaluation of Cost Efficiency

We have already noted that there is a variation in the consumption pattern of fuels across regions for a given industry, we further note here that a region reasonably adopts the minimum energy cost pattern for an industry. This minimum cost can be on the basis of absolute money value at the existing technology and the regional price and the relative cost in comparison with other regions. Hence the cost efficiency is examined on both the considerations above as absolute cost and the relative cost. The evaluation of the above defined cost efficiencies is considered below.

Let

Q_{ij} = quantity of i^{th} fuel consumed in j^{th} region
($i = 1, 2, \dots, m$ fuels and $j = 1, 2, \dots, n$ regions)

V_{ij} = value of Q_{ij}

A_{ij} = Quantity of i^{th} fuel consumed in j^{th} region, expressed in TCR units*

P_{ij} = price of the i^{th} fuel in j^{th} region per TCR unit,
= V_{ij}/A_{ij}

* A_{ij} is derived by multiplying the consumption quantity by its respective conversion factor.

$a_{ij} = A_{ij}/X_j$ is the fuel input coefficient in energy unit where X_j is the output of the j^{th} region for the given industry.

Then $(a_{ij} \cdot P_{ij})$ is the value of the energy requirement per unit of output of the i^{th} fuel in the j^{th} region and

$\sum_{i=1}^m a_{ij} P_{ij}$ is the value of total energy required in the j^{th} region to produce one unit of output of the said industry in the i^{th} region.

Now $[a_{ij}]$ is the given fuel input coefficient vector for the j^{th} region for a given industry. The cost evaluation of this fuel technology at the prevailing prices in the j^{th} region for all fuels is the real fuel cost per unit of output of the said industry. The cost of the j^{th} region's fuel technology evaluated by the price vector of other regions are the hypothetical costs of fuels for the said industry with j^{th} region's fuel technology. Such real and hypothetical costs are represented by the elements of the cost matrix $E (E_j^1)$ with its order (n) equal to the number of regions, in which the industry, under study, exists.

Then $E_j^1 = \sum_{i=1}^m a_{ij} P_{il}$ ($j = 1, 2, \dots, n$ and $l = 1, 2, \dots, n$
and m is the number of fuels)

denotes the cost of energy with j^{th} regions technology and prices of the region 'l' for a given industry. For the same value of j and l , i.e. the diagonal elements of the matrix E , the existing energy cost for the j^{th} region is obtained. The off-diagonal elements represent the hypothetical energy costs.

The above cost matrices (E) are evaluated for each of

the HFU industries and are presented in Tables 5.1 to 5.14.

Table 5.1 : Industrywise Cost Matrices (E_j^1) :
Industry 211 - Alcohol Industry

State prices	State technologies			
	1	2	3	4
1. Andhra Pradesh	10	9	10	10
2. Madhya Pradesh	81	78	86	91
3. Uttar Pradesh	162	160	178	189
4. Haryana	46	43	47	51

To understand the cost matrix E , let us, for example, consider the same for the Chemical Fertilizer industry (311.1.1). As the industry operates in five regions ($n = 5$), the order of the E matrix is five. The matrix is given below, where the column represents the cost of fuel use at a region's price with varying technologies, while the row represents the said cost at a region's technology for varying prices.

E Matrix for Chemical Fertilizer Industry (311.1.1)

Regional Prices	Regional Technologies				
	1	2	3	4	5
1. Andhra Pradesh	75	72	134	89	82
2. Bihar	160	134	144	276	274
3. Gujarat	72	52	100	93	85
4. Tamil Nadu	57	53	95	67	62
5. Maharashtra	93	87	163	111	103

Consider the first row of the above matrix. The element E_{11} is the existing fuel cost viz. Rs.75 per 000 Rs. of Fertilizer output. The element E_{12} is the cost of 000 Rs. of

Table 5.2 : Industrywise Cost Matrices (E_j^1): Industry 231 - Cotton Textiles

State Prices	State Technologies															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Andhra Pradesh	36	34	38	36	38	36	34	29	27	42	31	38	39	36	45	39
2. Assam	34	31	36	34	36	34	31	27	24	39	28	35	37	34	42	35
3. Bihar	30	33	32	36	37	33	33	29	30	32	34	37	35	29	39	37
4. Gujarat	52	49	54	54	57	55	50	43	41	63	49	60	59	52	67	60
5. Kerala	36	32	38	34	35	39	32	27	24	50	31	41	40	38	49	42
6. Madhya Pradesh	40	40	43	43	45	42	42	34	33	45	38	45	45	40	52	45
7. Tamil Nadu	41	35	41	38	40	43	35	30	27	53	33	44	45	41	52	44
8. Maharashtra	67	56	63	61	63	84	60	51	50	110	68	86	81	72	94	90
9. Karnataka	47	40	46	43	45	57	47	36	34	74	46	59	56	51	66	61
10. Orissa	41	43	45	48	50	44	118	38	38	45	44	50	48	41	55	50
11. Punjab	32	32	34	35	36	34	32	28	27	36	31	36	36	32	41	37
12. Rajasthan	38	37	41	41	43	40	53	33	31	43	36	43	43	38	49	43
13. Uttar Pradesh	42	42	45	46	48	44	45	36	35	48	40	47	47	42	54	48
14. West Bengal	38	37	40	40	41	39	39	32	31	43	35	41	41	37	47	41
15. Delhi	43	47	47	52	54	47	93	41	43	47	49	54	51	42	57	54
16. Haryana	31	30	33	33	34	32	37	26	25	35	29	34	34	30	39	34

Table 5.3 : Industrywise Cost Matrices (E_j^1) : Industry 271 - Paper and Paper Products

State Prices	State Technologies									
	1	2	3	4	5	6	7	8	9	10
1. Andhra Pradesh	142	191	166	162	139	143	133	165	153	170
2. Gujarat	134	187	142	150	127	136	118	151	134	156
3. Madhya Pradesh	131	176	147	149	125	133	118	150	136	155
4. Tamil Nadu	89	131	101	99	89	89	82	103	95	106
5. Maharashtra	44	63	54	49	46	43	43	51	50	53
6. Karnataka	143	197	162	162	139	144	131	164	150	170
7. Orissa	179	231	179	201	159	183	151	197	170	203
8. Uttar Pradesh	145	189	154	164	134	148	127	163	144	168
9. West Bengal	134	167	122	149	113	138	106	144	118	148
10. Haryana	143	185	150	162	130	146	124	160	140	165

Table 5.4 : Industrywise Cost Matrices (E_j^1) :
Industry 311.1.1 - Fertilizers (Chemical)

State Prices	State Technologies				
	1	2	3	4	5
1. Andhra Pradesh	75	72	134	89	82
2. Bihar	160	134	144	276	274
3. Gujarat	72	52	100	93	85
4. Tamil Nadu	57	53	95	67	62
5. Maharashtra	93	87	163	111	103

Table 5.5 : Industrywise Cost Matrices (E_j^1) :
Industry 311.2 - Heavy Chemicals

State Prices	State Technologies							
	1	2	3	4	5	6	7	8
1. Andhra Pradesh	202	219	226	143	139	188	148	158
2. Bihar	252	273	285	159	154	229	154	180
3. Gujarat	173	163	172	174	176	178	208	163
4. Kerala	113	124	121	84	74	104	97	93
5. Tamil Nadu	326	360	355	218	194	292	237	249
6. Maharashtra	87	94	91	69	62	81	81	74
7. Uttar Pradesh	238	242	277	185	206	236	177	188
8. West Bengal	104	112	119	71	72	97	69	78

Table 5.6 : Industrywise Cost Matrices (E_j^1): Industry 311(R) -
Chemicals (excluding Fertilizers and Heavy Chemicals)

State Prices	State Technologies				
	1	2	3	4	5
1. Andhra Pradesh	130	113	146	90	128
2. Gujarat	63	60	87	49	59
3. Tamil Nadu	39	34	44	27	38
4. Maharashtra	78	71	113	60	78
5. West Bengal	63	58	73	46	59

Table 5.7 : Industrywise Cost Matrices (E_j^1) :
Industry 331 - Structural Clay Products

State Prices	State Technologies								
	1	2	3	4	5	6	7	8	9
1. Bihar	150	207	277	169	227	164	281	199	190
2. Gujarat	149	203	259	158	224	182	265	186	217
3. Kerala	185	269	203	163	223	326	177	138	376
4. Madhya Pradesh	162	227	289	172	310	175	287	207	209
5. Tamil Nadu	218	218	239	246	199	200	279	218	426
6. Maharashtra	141	206	235	180	182	152	240	212	226
7. Karnataka	192	286	221	168	240	351	191	147	397
8. Orissa	212	265	315	212	373	208	321	237	294
9. West Bengal	140	214	300	161	245	165	297	205	149

Table 5.8 : Industrywise Cost Matrices (E_j^1) :
Industry 332 - Glass and Glass Products

State Prices	State Technologies					
	1	2	3	4	5	6
1. Bihar	118	176	278	182	323	297
2. Maharashtra	276	130	165	135	158	154
3. Uttar Pradesh	180	160	225	168	247	234
4. West Bengal	232	137	185	135	187	182
5. Delhi	181	147	213	146	230	219
6. Haryana	221	106	131	115	129	115

Table 5.9 : Industrywise Cost Matrices (E_j^1) :
Industry 333 - Pottery, China and Earthenware

State Prices	State Technologies						
	1	2	3	4	5	6	7
1. Andhra Pradesh	234	373	266	339	234	344	325
2. Gujarat	216	237	226	303	226	363	422
3. Madhya Pradesh	219	277	236	309	225	349	377
4. Uttar Pradesh	227	329	248	313	218	311	292
5. West Bengal	155	177	157	187	150	201	209
6. Delhi	180	274	201	255	176	254	240
7. Haryana	146	211	160	200	140	199	185

Table 5.10 : Industrywise Cost Matrices (E_j^1) :
Industry 334 - Cement

State Prices	State Technologies						
	1	2	3	4	5	6	7
1. Andhra Pradesh	219	226	306	220	281	250	284
2. Bihar	238	239	330	233	310	273	304
3. Gujarat	398	412	351	296	340	356	350
4. Madhya Pradesh	237	242	319	230	296	265	296
5. Tamil Nadu	274	286	288	229	272	266	279
6. Karnataka	233	240	324	233	299	265	300
7. Rajasthan	226	202	303	196	305	264	271

Table 5.11 : Industrywise Cost Matrices (E_j^1) : Industry 341.1 - Basic Iron and Steel

State Prices	State Technologies													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Andhra Pradesh	67	66	40	58	49	53	47	37	56	66	50	41	61	65
2. Assam	78	76	43	67	53	61	52	41	61	70	56	45	69	71
3. Bihar	265	299	191	297	187	264	201	251	226	272	232	147	292	229
4. Gujarat	40	40	24	34	30	31	28	23	34	38	30	25	30	38
5. Madhya Pradesh	138	117	56	113	71	97	80	51	78	82	83	61	112	99
6. Tamil Nadu	51	47	27	42	34	38	34	24	38	45	35	29	44	46
7. Maharashtra	76	69	37	62	47	55	49	32	53	61	50	41	64	65
8. Karnataka	916	731	397	725	487	656	549	310	519	626	550	459	732	678
9. Orissa	270	310	183	308	173	267	187	249	221	253	224	134	292	218
10. Punjab	50	51	30	49	33	43	34	34	38	42	39	27	48	43
11. Uttar Pradesh	146	125	64	120	81	104	89	58	90	103	91	70	121	113
12. West Bengal	102	96	52	89	63	78	69	52	70	72	71	52	89	82
13. Delhi	708	540	239	524	332	446	389	160	361	412	373	297	529	496
14. Haryana	75	70	39	65	47	57	49	37	54	63	52	40	66	64

Table 5.12 : Industrywise Cost Matrices (E_j^1): Industry 341(R) - Iron and Steel(Other than Basic)

State Prices	State Technologies														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Andhra Pradesh	92	101	64	77	75	73	54	92	51	72	108	81	64	82	63
2. Assam	85	68	53	79	71	83	67	126	55	66	88	68	53	76	64
3. Bihar	280	279	138	232	189	261	151	242	112	192	271	223	167	251	179
4. Gujarat	59	55	39	52	46	53	42	56	34	44	64	50	37	54	41
5. Madhya Pradesh	201	213	108	152	138	144	91	153	73	121	190	161	116	168	106
6. Tamil Nadu	92	101	55	72	67	67	44	78	39	61	95	77	56	79	52
7. Maharashtra	147	159	80	110	101	101	63	114	52	87	138	118	85	122	75
8. Karnataka	114	99	67	98	85	103	77	91	56	74	103	91	67	103	73
9. Orissa	824	871	377	572	511	509	276	500	193	389	633	606	430	648	340
10. Punjab	126	118	69	104	91	106	74	112	55	80	115	99	73	109	75
11. Rajasthan	113	71	74	110	92	126	112	105	76	81	106	91	66	108	85
12. Uttar Pradesh	59	53	38	56	48	64	46	66	37	50	67	51	40	57	48
13. West Bengal	121	100	74	107	92	117	95	110	67	84	118	99	75	110	82
14. Delhi	84	64	57	84	69	100	80	88	60	73	96	73	56	84	72
15. Haryana	29	31	18	23	21	21	15	26	13	20	31	24	18	25	17

Table 5.13 : Industrywise Cost Matrices (E_j^1) :
Industry 342 - Non-Ferrous Metals

State Prices	State Technologies					
	1	2	3	4	5	6
1. Bihar	74	73	78	110	85	89
2. Gujarat	37	32	37	52	44	32
3. Tamil Nadu	65	55	68	69	87	57
4. Maharashtra	18	17	19	18	22	17
5. Karnataka	78	70	80	80	98	71
6. West Bengal	27	26	29	29	35	25

Table 5.14 : Industrywise Cost Matrices (E_j^1) : Industry 511 - Electricity Generation

State Prices	State Technologies													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Andhra Pradesh	160	159	134	230	165	123	114	153	160	86	338	475	214	135
2. Assam	103	109	154	157	110	108	111	86	156	86	92	101	152	642
3. Bihar	110	99	131	102	211	152	84	111	109	86	108	586	112	83
4. Gujarat	195	180	199	204	326	230	141	198	181	136	281	693	215	160
5. Kerala	0.89	0.90	1.0	0.95	0.95	0.83	1.0	0.65	1.0	0.76	0.85	0.88	1.1	0.53
6. Madhya Pradesh	274	274	224	400	274	204	193	262	274	145	595	813	372	234
7. Tamil Nadu	162	161	135	231	171	127	114	156	161	88	343	491	216	139
8. Maharashtra	58	58	51	85	59	44	42	55	60	32	121	164	80	49
9. Karnataka	.25	.26	.29	.26	.25	.23	.30	.19	.29	.22	.26	.23	.32	.16
10. Orissa	203	204	184	288	208	160	158	188	213	117	400	543	277	165
11. Punjab	4	5	5	6	4	4	4	4	5	3	7	9	6	3
12. Rajasthan	26	28	33	39	27	24	26	22	35	19	36	45	38	18
13. Uttar Pradesh	221	321	182	322	221	165	157	211	221	117	478	652	300	188
14. West Bengal	250	250	215	357	259	195	184	237	254	139	516	720	337	209

Fertilizer output if Bihar uses Andhra Pradesh fuel technology with Bihar's prices, which is Rs.72. Reading the table column-wise the element E_{21} i.e. the element in the 2nd row and the first column, is the hypothetical cost if Bihar's fuel technology is evaluated with Andhra Pradesh prices, which is Rs. 160.

A comparison of the diagonal elements gives the absolute cost efficiency as defined above. Looking at the above table for this, Tamil Nadu is found to have the lowest energy cost viz. Rs.67 per 000 Rs. of Fertilizer output, and Bihar has the highest cost viz. Rs.134 per 000 Rs. of Fertilizer output.

The relative cost efficiency can be studied from the above table in two ways. One way is to consider the hypothetical costs with given price vector and comparing them over different technologies. On this basis the above table for the Chemical Fertilizer industry shows that while Bihar's prices lead to the lowest cost per 000 rupees of its output, Gujarat's prices broadly show the highest cost for the same.

The second way to consider the relative cost efficiency is based on the assumption that the fuel technologies remain same and the prices vary across the regions. On this basis, the above table shows that the relative costs of all regions are broadly minimum when the Tamil Nadu fuel technology for Fertilizer industry is used. On the other hand, a region has to pay the highest cost per 000 rupees of Fertilizer output if Bihar's fuel technology is used.

While interpreting the relative cost efficiencies, it is important to note that homogeneity of product-mix across

regions is assumed. And this assumption can be a limitation, to some extent, in the assessment of region's cost efficiency.

5.3 Industrywise Cost Differentials Across Regions

The following two Tables (5.15 and 5.16) with information abstracted from Tables 5.1 to 5.14 present HFU industrywise minimum and maximum costs of fuel use both actual as well as hypothetical together with the names of the regions to whom the said costs are attributable. We discuss said costs industry-wise below.

In the case of Alcohol industry, it is found that Uttar Pradesh shows the highest absolute cost viz. Rs.177.89 to produce Rs.1,000 worth of Alcohol output and its technology leads to the highest cost for energy input at all prevailing fuel prices of different regions. Thus Alcohol industry in Uttar Pradesh is cost inefficient. On the other hand Andhra Pradesh technology is found to lead to the lowest cost for energy input per Rs. 1,000 worth of Alcohol output at all prevailing prices of different regions.

On the same lines, noted above, the Cotton Textiles industry is found inefficient in terms of fuel cost in Gujarat, Maharashtra and Delhi. In spite of the marked heterogeneity in product-mix, the energy cost per Rs.1,000 of Textile output for all the remaining States is nearly same.

In case of Paper industry, Maharashtra not only has the absolute minimum cost but it also shows the lowest cost fuel technology for the prices of all regions. This may be taken as an indication of the cost efficiency of the Paper industry

Table 5.15: Industrywise Minimum and Maximum Energy Costs (Actual)

Industry	Minimum cost		Maximum cost	
	State	Cost Rs. per 000 Rs. of output	State	Cost Rs. per 000 Rs. of output
1. Alcohol	Andhra Pradesh	9.89	Uttar Pradesh	177.89
2. Cotton Textiles	Assam and Punjab	31	Delhi	57
3. Paper and Paper Products	Maharashtra	46	Gujarat	187
4. Chemical Fertilizers	Tamil Nadu	67	Bihar	134
5. Heavy Chemicals	West Bengal	78	Bihar	273
6. Chemicals (other than fertilizers and heavy chemicals)	Tamil Nadu	44	Andhra Pradesh	130
7. Structural Clay Products	West Bengal (Bihar)	149 (150)	Orissa	237
8. Glass and Glass Products	Haryana	115	Delhi	230
9. Pottery, China and Earthenware	West Bengal	150	Uttar Pradesh	313
10. Cement	Andhra Pradesh	219	Gujarat	351
11. Basic Iron and Steel	Gujarat	34	Karnataka	310
12. Iron and Steel (other than Basic)	Uttar Pradesh (Gujarat)	51 (52)	Orissa	193
13. Non-ferrous Metals	Maharashtra	18	Karnataka	98
14. Electricity* Generation	Maharashtra	55	Uttar Pradesh	300

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* Other than hydel power generation.

Table 5.16: Industrywise Minimum-Maximum Energy Costs (Hypothetical)

Industry		Minimum cost		Maximum cost	
		State	Cost Rs. per 000 Rs. of output	State	Cost Rs. per 000 Rs. of output
1. Alcohol	T	Andhra Pradesh	8.76	Uttar Pradesh	189.00
	P	Madhya Pradesh		Haryana	
2. Cotton Textiles	T	Assam and Kerala	24	Maharashtra	94
	P	Karnataka		Delhi	
3. Paper and Paper Products	T	Maharashtra	43	Orissa	231
	P	Karnataka or Orissa		Gujarat	
4. Chemical Fertilizer	T	Gujarat	52	Bihar	276
	P	Bihar		Tamil Nadu	
5. Heavy Chemicals	T	Maharashtra	62	Tamil Nadu	360
	P	Tamil Nadu		Bihar	
6. Chemicals (other than Fertilizers and Heavy Chemicals)	T	Tamil Nadu	27	Andhra Pradesh	146
	P	Maharashtra		Tamil Nadu	
7. Structural Clay Products	T	West Bengal	140	Tamil Nadu	426
	P	Bihar		West Bengal	
8. Glass and Glass Products	T	Haryana	106	Bihar	323
	P	Maharashtra		Delhi	
9. Pottery, China and Earthenware	T	Haryana	140	Gujarat	363
	P	West Bengal		Delhi	
10. Cement	T	Rajasthan	196	Gujarat	398
	P	Madhya Pradesh		Andhra Pradesh	
11. Basic Iron and Steel	T	Gujarat	24	Karnataka	916
	P	Bihar		Andhra Pradesh	
12. Iron and Steel (other than Basic)	T	Gujarat	34	Orissa	871
	P	Orissa		Assam	
13. Non-Ferrous Metals	T	Maharashtra	17	Bihar	110
	P	Gujarat and West Bengal		Maharashtra	
14. Electricity* Generation	T	Maharashtra	42	West Bengal	357
	P	Tamil Nadu		Gujarat	

T = Technology

P = Prices.

* Other than hydel power generation.

in Maharashtra. Orissa, with the advantage of the lowest cost price structure for all existing fuel technologies, leads to the highest hypothetical cost indicating its technological inefficiency. On the other hand, Gujarat prices lead to the highest cost for all the regions' technologies indicating its high price structure.

Tamil Nadu indicates efficient or low cost fuel technology for the Chemical industries with the exception of the Heavy Chemical industry. It is to be noted, however, that the State's prices being on the higher side, the efficient technologies do not turn out to be relatively cost efficient. Maharashtra is also found to be cost efficient in respect of Chemical industries. Gujarat, on the other hand, has the price structure such that it leads to maximum cost for the said industries. Bihar, with its own price structure leads to minimum cost for all Fertilizer technologies of the regions, but on the other hand its own fuel technology leads to maximum cost for any other regional price structure, indicating its cost efficiency as due to its price advantage rather than its technology.

For the industries, belonging to the Non-metallic mineral products, West Bengal is broadly observed to be cost efficient. Bihar remains cost inefficient, even with the advantage of its existing fuel prices due to its technological inefficiency. While West Bengal, Maharashtra and Bihar are found to be operating with the lowest costs, Orissa requires the highest cost to produce Rs.1,000 worth output of Structural Clay Products. For the Glass and Glass Products industry, Haryana and Bihar show

lower energy costs. In the case of former region, it is due to its technology and in the case of the latter it is due to its price structure. West Bengal is the most cost efficient State for the Pottery, China and Earthenware industry as it is found to have the minimum absolute cost and the hypothetical costs based on its prices and technology are the lowest for all regions. Andhra Pradesh is not found technologically efficient for this industry. In case of Cement industry, where no significant cost variation is observed, Gujarat is found to require the highest energy cost. The higher energy cost for Cement products in Gujarat are on both the accounts viz. technology and prices. Andhra Pradesh technology for this industry is noticed to lead to the lower costs for all States.

For the Basic Iron and Steel industry, though apparently homogeneous for its products, surprisingly, it is seen to show the largest variation in its lowest and the highest energy cost per Rs.1,000 of its output. Its maximum cost is found to be nearly ten times its minimum. Under such situation the cost comparisons lose their meaning as the cost behaviour is found to be neither due to technology nor prices. It is noted that among high cost technologies, Bihar and Orissa have lower costs than Karnataka. For the Iron and Steel industry, other than Basic, Uttar Pradesh and Gujarat technologies lead to minimum cost, while Andhra Pradesh and Rajasthan prices lead to higher costs for all technologies indicating their price disadvantage. Orissa requires the maximum absolute cost viz. Rs. 193 to produce Rs. 1,000 output of Iron and Steel products. The maximum

cost is observed even with the lower order fuel prices, indicating its technological inefficiency. This higher energy requirement, it is noted, is not only due to the energy inefficiency, but may also be due to the product-mix differences which may cause the higher energy requirement in Orissa.

The Non-Ferrous Metals is a heterogeneous product industry. Outputwise it is not important in the regional as well as national economy. For this industry, costs evaluated with the same technology but with different prices do not reveal any trend. Even so, Bihar and Karnataka technologies show higher cost for all prices and Maharashtra technology is found to be relative cost efficient.

Electricity Generation industry is peculiar in that it has a uniproduct output with no scope for any product-mix variation. But its production technologies are significantly different such as hydro, thermal with Oil based or Coal based, etc. Therefore, comparisons across regions need to be made carefully. As the hydel power technology is obviously the cheapest among all alternative technologies, excluding those regions which have their main power generation on the hydel basis, the remaining States are compared below for their energy costs of Electricity production. It is observed that Maharashtra has the cheapest non-hydel Electricity generation, not only in absolute terms but its technology also broadly leads to the lowest costs. On the other hand, West Bengal, Uttar Pradesh, Madhya Pradesh and Orissa show a high cost for non-hydel power generation. Bihar is the only State in the coal-belt regions,

showing relatively low cost for the said Electricity production. Gujarat is also found to be inefficient for non-hydel Electricity generation. Andhra Pradesh and Tamil Nadu are noticed to be in neither of the cost-efficient or cost-inefficient group of States and thus are found to show a border line behaviour with respect to the fuel cost of non-hydel Electricity generation.

5.4 Technology and Price Factors in Minimum Observed Costs

In the foregoing, we have identified the most efficient regional fuel technology and the most advantageous regional price configuration (see Table 5.16), for the fuel-mix of a given industry. The regions which have absolute minimum cost for each industry are given in Table 5.15. Juxtaposing Tables 5.15 and 5.16, we observe that the minimum cost is largely due to more efficient technology rather than the price advantage. In other words, those States which have more efficient technologies also have the minimum cost for most of the industry groups. Out of the fourteen industry groups in the case of four viz. Chemical Fertilizers, Heavy Chemicals, Pottery—China and Earthenware, and Cement, the States which are technologically most efficient, do not have the absolute minimum cost. Thus it seems that the variation in regional fuel technologies is relatively more important factor than the regional price variation in explaining the variation in energy costs. As mentioned earlier at several places, the homogeneity of product-mix (within an industry group) across the regions can be a limitation to some extent on the inferences drawn above.

Table A5.1 : State x Fuel Input Coefficient Data (Value Coefficient)

State	Fuels	1	2	3	4	5	6	7	8	9	10	11
<u>Industry 211 : Alcohol</u>												
1. Andhra Pradesh		.005824	-	-	-	-	-	-	.000330	.000220	-	.004066
2. Madhya Pradesh		.061977	-	-	-	-	-	.005151	-	.001610	-	.008693
3. Uttar Pradesh		.148226	-	-	.000598	-	.001478	.001321	.012329	.001761	-	.010725
4. Haryana		.041249	-	-	.001312	-	.000937	-	-	.000562	-	.006562
<u>Industry 231 : Textiles</u>												
1. Andhra Pradesh		.004791	.000048	-	.000003	.000078	.000389	.000106	.000429	.001569	-	.028510
2. Assam		.005052	-	-	-	-	.000980	.000226	-	.001584	-	.023226
3. Bihar		.014090	.000516	-	-	-	.000352	.000223	-	.002438	-	.014629
4. Gujarat		.016461	.000025	-	.000021	.000016	.000218	.000113	.002433	.001605	.000020	.033260
5. Jammu and Kashmir		.003342	.000212	-	.032704	.000423	.000004	-	-	.000465	-	.009054
6. Kerala		.000222	.000016	-	.000924	.000021	.000179	.000037	.003178	.001251	-	.029151
7. Madhya Pradesh		.011816	.000138	-	.000047	.000005	.000239	.000014	.000193	.001882	-	.027262
8. Tamil Nadu		.002164	.000015	-	.000023	.000014	.000280	.000112	.003011	.001041	-	.279755
9. Maharashtra		.004797	.000195	.000060	.000015	.000021	.000685	.000953	.016191	.001616	.000014	.025713
10. Karnataka		.002987	.000038	-	.000228	.000079	.000376	.000148	.010490	.001317	-	.017636
11. Orissa		.013145	.000171	-	-	-	.000100	-	.000060	.001657	-	.018417
12. Punjab		.011941	.000066	-	.000210	-	.001229	.000310	.000450	.002524	-	.014716
13. Rajasthan		.013154	.000177	-	.000005	-	.000190	.001028	.000266	.001986	-	.023844
14. Uttar Pradesh		.013165	.000062	-	.000070	-	.000624	.000092	.000479	.001921	-	.030247
15. West Bengal		.005731	.000162	.000003	.000003	.000083	.000230	.000129	.000140	.002152	-	.025017
16. Delhi		.026941	.000136	-	.000032	.000006	.000026	-	.000352	.001739	-	.020504
17. Pondicherry		.015873	-	-	.000049	-	.000146	.000130	.000227	.001799	-	.024640
18. Haryana		.010618	.000050	-	.000007	-	.000588	.000344	.000427	.001381	-	.019866

(continued)

Table A_{5.1}: (continued)

State	Fuels	1	2	3	4	5	6	7	8	9	10	11
<u>Industry 271: Paper</u>												
1. Andhra Pradesh		.064072	.000118	-	.000162	.000015	.002304	.002437	.005288	.002289	-	.058592
2. Gujarat		.065502	-	-	-	-	.001530	.000136	.041555	.003127	-	.074850
3. Madhya Pradesh		.029658	.000006	-	-	-	.000119	.000063	.004724	.002334	-	.027832
4. Tamil Nadu		.032916	-	-	.000020	-	.001824	.000179	.020844	.001116	-	.042476
5. Maharashtra		.007645	.000028	-	.000038	.000005	.001532	.001996	.007228	.001022	-	.026018
6. Karnataka		.069819	-	-	.000176	.000015	.001675	.001448	.013834	.002114	-	.042452
7. Orissa		.058439	.000055	-	.000490	-	.001292	.000193	.003684	.002367	-	.044123
8. Uttar Pradesh		.071709	.000086	-	.000029	.000014	.000634	.000418	.004796	.004090	-	.052986
9. West Bengal		.048339	.000262	-	.000963	-	.000595	.000380	.001475	.001310	-	.040364
10. Haryana		.077556	-	-	.000139	-	.000634	-	.000515	.002258	-	.013982
<u>Industry 311.1.1: Fertilizers</u>												
1. Andhra Pradesh		-	-	-	-	-	.000233	.000210	.027518	.002511	-	.044409
2. Bihar		.103695	.003470	-	-	-	.001712	.006768	.000011	.015134	-	.003235
3. Gujarat		.000003	-	-	-	-	.000717	.000188	.007295	.002283	-	.089002
4. Tamil Nadu		.000401	-	-	.000059	-	.000773	.002496	.016867	.001185	-	.045491
5. Maharashtra		.000089	-	-	-	-	.000397	.000330	.028239	.000988	-	.072706
<u>Industry 311.2.1: Heavy Chemicals</u>												
1. Andhra Pradesh		.018009	-	-	-	-	.000828	.001035	.021114	.001380	-	.160422
2. Bihar		.010733	.004116	-	-	-	-	-	-	.000565	-	.257828
3. Gujarat		.027865	.014710	-	.000006	-	.000484	.003249	.067176	.010190	-	.018942
4. Kerala		-	-	-	.000081	.000020	-	.000061	.034226	.000111	-	.049038
5. Tamil Nadu		.001493	.002327	-	-	.001360	.000435	.000231	.046827	.000582	-	.141132
6. Maharashtra		.001735	.000036	-	-	-	.002105	.000445	.027082	.000442	-	.049000
7. Uttar Pradesh		.060277	.009599	-	-	-	.000685	.000175	.013975	.002188	-	.088872
8. West Bengal		.012876	.000910	-	-	-	.000328	.000434	.002412	.000423	-	.060496

(continued)

Table A5.1 : (continued)

State	Fuels	1	2	3	4	5	6	7	8	9	10	11
<u>Industry 311(R) : Chemicals (Other)</u>												
1. Andhra Pradesh	-	-	-	-	-	-	.004876	-	-	.003657	-	.121495
2. Gujarat	.010849	.000033	-	.000026	-	.000350	.000048	.016405	.000534	-	-	.021524
3. Tamil Nadu	-	-	-	.000136	.000238	.000919	-	.000714	.000817	-	-	.040964
4. Maharashtra	.000002	.000040	-	.000042	-	.000743	.000556	.022377	.001808	-	-	.033740
5. West Bengal	.006417	-	.000023	-	.000394	.000636	.001230	.003628	.001475	-	-	.043146
<u>Industry 331 : Structural Clay Products</u>												
1. Bihar	.082760	.000095	-	-	-	.001347	.000190	.029989	.003469	-	-	.031890
2. Gujarat	.117593	.002773	-	.025008	-	.006522	.001951	.033943	.003132	-	-	.012375
3. Kerala	.004131	-	-	.161375	.000095	.000350	.001494	.007405	.002479	-	-	.026091
4. Madhya Pradesh	.100539	.027717	-	.002050	-	.000330	.005012	.006606	.003037	-	-	.026805
5. Tamil Nadu	.013374	.000062	-	.002766	.000021	.000021	.001477	.155390	.002309	-	-	.023524
6. Maharashtra	.043699	.001012	-	.001615	-	.014968	.022127	.038589	.002748	-	-	.027285
7. Karnataka	.017451	-	-	.146753	.000115	.001037	.003801	.004752	.001814	-	-	.015090
8. Orissa	.123903	.037170	-	.001487	-	.005823	.000248	.028869	.005452	-	-	.033081
9. West Bengal	.110635	.000052	-	.000052	-	-	.001932	.000418	.003968	-	-	.032214
<u>Industry 332 : Glass and Glass Products</u>												
1. Bihar	.095151	-	-	.006380	-	.000729	.006562	.000547	.002370	-	-	.006198
2. Maharashtra	.001455	-	.001205	.000043	.000064	.002795	.005447	.084355	.008150	-	-	.026952
3. Uttar Pradesh	.139877	.000050	.000012	.011128	-	.000087	.008492	.032741	.014904	-	-	.018097
4. West Bengal	.035213	-	.001357	-	.000088	.000219	.001981	.068215	.006631	-	-	.021031
5. Delhi	.154957	-	-	-	-	-	-	.051492	.007218	-	-	.016362
6. Haryana	.002070	-	-	-	.000087	.000146	.005657	.056071	.020323	-	-	.030820

(continued)

Table A_{5.1} : (continued)

State	Fuels	1	2	3	4	5	6	7	8	9	10	11
<u>Industry 333 : Pottery—China and Earthenware</u>												
1. Andhra Pradesh		.195811	-	-	.003410	-	.003410	-	-	.001461	-	.030200
2. Gujarat		.122042	.000785	-	.000491	-	.003338	.001620	.065489	.005596	-	.037359
3. Madhya Pradesh		.127357	-	-	.003057	-	-	-	.056037	.005604	-	.043811
4. Uttar Pradesh		.237473	-	-	-	-	.002905	-	.003631	.008715	-	.060276
5. West Bengal		.035447	.028902	.014222	.000031	-	.001070	.002049	.028443	.001957	-	.038322
6. Delhi		.212638	-	-	.002528	-	.002844	-	.000632	.004107	-	.031596
7. Haryana		.148541	-	-	.000181	-	-	.000091	.000906	.003172	-	.031720
<u>Industry 334 : Cement</u>												
1. Andhra Pradesh		.143227	.000128	-	.000013	.000006	.000434	.003410	.000128	.003040	-	.068756
2. Bihar		.130848	.000166	-	.000009	.000005	.000810	.003848	.000046	.003319	-	.086124
3. Gujarat		.185336	.000117	-	.000023	-	.000501	.005056	.068465	.002896	-	.068011
4. Madhya Pradesh		.118290	.000936	-	-	-	.000087	.001298	.005231	.003393	-	.062391
5. Tamil Nadu		.172381	.000511	-	.000009	.000003	.000608	.002595	.035461	.002013	-	.057966
6. Karnataka		.182908	.000289	-	.000018	-	.000412	.004135	.000702	.003646	-	.072010
7. Rajasthan		.217262	.000403	-	.000023	-	.001221	.002201	.001757	.004153	-	.036228
<u>Industry 341.1 : Basic Iron and Steel</u>												
1. Andhra Pradesh		.001659	-	-	-	-	.001626	-	.020751	.000358	-	.042739
2. Assam		.005589	-	.001164	-	-	-	.000466	.028412	.002329	-	.037727
3. Bihar		.119715	.031753	-	.000159	.000005	.000031	.003590	.013286	.002540	-	.018393
4. Gujarat		.000348	.000053	-	.000011	-	.001212	.000105	.013516	.001812	-	.017246
5. Jammu and Kashmir		.000029	-	-	-	.000378	-	.009994	.015223	.000494	-	.022311
6. Madhya Pradesh		.011382	.000017	-	-	-	.000271	.004870	.000322	.004872	-	.036643

(continued)

Table A5.1 : (continued)

State	Fuels	1	2	3	4	5	6	7	8	9	10	11
7. Tamil Nadu		.000318	.001055	-	.000267	.000013	.000362	.000178	.013246	.000502	-	.022350
8. Maharashtra		.000426	.000291	.000197	.000023	-	.000944	.000306	.013827	.001746	-	.030669
9. Karnataka		.033105	.042508	-	.001959	.033347	.000653	.030194	.020872	.003445	-	.144360
10. Orissa		.169635	-	-	-	-	.000505	.002651	.009917	.005183	-	.033439
11. Punjab		.015494	.000981	-	.000135	.000025	.001074	.001860	.008673	.001724	-	.013575
12. Uttar Pradesh		.010980	.004321	-	.000185	-	.001206	.002714	.012129	.001861	-	.057735
13. West Bengal		.006642	.000141	.001580	.000002	.000024	.004762	.001807	.006772	.004468	-	.026203
14. Delhi		.001930	.008091	-	.000544	-	.000841	.000371	.020314	.001287	-	.013386
15. Haryana		.006522	.000403	-	-	-	.000989	.000256	.019748	.000953	-	.035173
<u>Industry 341(R) : Iron and Steel (other than Basic)</u>												
1. Andhra Pradesh		.000574	.004991	-	.000088	.000044	.003887	.001855	.020054	.008834	-	.051681
2. Assam		.003710	.016863	-	-	-	-	.009444	.007083	.002361	-	.029005
3. Bihar		.024713	.012140	-	.000118	.000111	.001329	.002135	.005435	.001591	-	.090410
4. Gujarat		.000386	.020404	-	.001646	-	.000590	.000357	.009510	.002534	-	.016152
5. Madhya Pradesh		.002675	.012230	-	.000437	-	.000874	.000109	.022057	.003658	-	.095872
6. Tamil Nadu		.000172	.006717	-	.000537	.000122	.001667	.000587	.014281	.002808	-	.039627
7. Maharashtra		.000320	.007414	.000001	.000084	.000009	.001787	.000975	.013199	.002250	-	.036673
8. Karnataka		.002883	.042076	-	.002793	.000541	.001261	.001261	.002162	.004235	-	.033607
9. Orissa		.001269	.014405	-	.000132	.000011	.000431	.000464	.002671	.000177	-	.173082
10. Punjab		.007700	.020773	-	.001119	.000134	.001477	.004387	.005327	.002552	-	.036352
11. Rajasthan		.003073	.087402	-	.002731	-	.001366	.000341	.001024	.002048	-	.008194
12. Uttar Pradesh		.008808	.013011	.000096	.000718	.000067	.002585	.001561	.006367	.002346	-	.015175
13. West Bengal		.004366	.032755	.003562	.000382	-	.000799	.000667	.006020	.002537	.000053	.023733
14. Delhi		.013003	.046440	-	.003715	.000826	.000826	-	.008875	.002890	-	.007843
15. Himachal Pradesh		.002030	-	-	-	.000135	-	-	.000406	.000541	-	.008525
16. Haryana		.000034	.001654	-	.000101	.000008	.000244	.000479	.005836	.001486	.000017	.007415

(continued)

Table A_{5.1} : (continued)

State	Fuels	1	2	3	4	5	6	7	8	9	10	11
<u>Industry 342 : Non-Ferrous Metals</u>												
1. Bihar		.028130	.000859	-	.000225	.000033	.000141	.000296	.021276	.001272	-	.010197
2. Gujarat		-	-	-	-	-	.002699	-	.010439	.000900	.002699	.015479
3. Tamil Nadu		-	.000029	-	.000068	-	.001469	.002900	.002637	.001080	-	.059397
4. Maharashtra		.000047	.000147	-	.000010	.000218	.000819	.000061	.005733	.001884	.000012	.009484
5. Karnataka		-	-	-	-	.000208	.000104	.000443	.024132	.001016	-	.072341
6. Rajasthan		.000216	.000744	-	.000984	.000504	-	.000384	.003000	.001440	-	.019921
7. West Bengal		.000245	.000359	.000004	.000045	.000047	.000611	.000225	.006401	.002525	.000056	.014407
<u>Industry 511 : Electricity Generation</u>												
1. Andhra Pradesh		.151722	-	-	-	-	-	.001607	.004568	.001819	-	-
2. Assam		-	-	.019917	-	-	.000245	.076520	-	.012467	-	.000038
3. Bihar		.009222	-	-	-	-	.000120	.025504	.094717	.001598	-	.000018
4. Gujarat		.124530	-	-	.000030	.000002	.000708	.002382	.074253	.001151	-	.000802
5. Kerala		-	-	-	-	-	.000011	.000253	.000075	.000585	-	.000023
6. Madhya Pradesh		.201889	-	-	-	-	.000360	.000684	.000342	.001050	-	-
7. Tamil Nadu		.107883	-	-	-	-	.000877	-	.005379	.000071	-	.000003
8. Maharashtra		.051066	-	-	-	-	.000684	.002273	.000266	.000325	-	.000267
9. Karnataka		-	-	-	-	-	.000042	.000081	-	.000162	-	.000002
10. Orissa		.088649	-	-	-	-	-	.010527	.002288	.014985	-	.000991
11. Punjab		.004966	-	-	-	.000005	.000210	.001186	-	.000502	-	.000005
12. Rajasthan		.029222	-	-	.000017	-	.000235	.010889	.000006	.004418	-	.000006
13. Uttar Pradesh		.295349	-	-	.000008	-	.000226	.001558	-	.002453	-	.000512
14. West Bengal		.194481	-	.000156	-	-	.000120	.003372	.005429	.005744	-	.000135
15. Himachal Pradesh		.031606	-	-	-	-	.002035	.002515	-	.000215	-	.000256
16. Tripura		-	-	-	-	-	-	.723623	-	.069675	-	-

CHAPTER 6

OPTIMUM LOCATION OF INDUSTRIES ON ENERGY BASIS

The regional energy efficiency both in physical and value terms has been discussed in the earlier chapters. It is found that while there are certain regions which are generally energy efficient, there are some others which are mostly energy inefficient on physical or cost basis or both. Further, in some cases indications about industry specific energy efficient regions are obtained.

Normally locational models are formulated with a view to minimize the transport costs. Energy which was not earlier considered as an important locational determinant is likely to play a major role in the location of industries in future. To our knowledge, so far there has been no study in location with a view to minimize the energy costs. In this chapter we have formulated a model which gives the most efficient locations solely from the viewpoint of minimizing energy inputs.

6.1 Linear Programming Model

With the aim to save maximum energy in the inter-industry use, the present model tries to specify the regional allocations of industrial activity, such that both inter-industry and final demand requirements of the entire economy are satisfied.

Let the economy be divided into 'm' sectors and 'n' regions. The above requirement of the problem leads to the usual input-output relationships as:

$$\sum_s X_i^s - \sum_s \sum_j a_{ij}^s X_j^s ;$$

where X_i^s is the output of i^{th} sector in s^{th} region and $\sum_s \sum_j a_{ij}^s X_j^s$ is the inter-industry demand of i^{th} sector in the said region, which is the production available for the final use in the economy.

The regional variability between the technical coefficients (a_{ij}^s) is really not so much due to the substitutability between the raw material inputs, but is basically due to the product-mix variation in these regions. Thus, the existing differences in the regional technical coefficients are largely due to the variation in the regional product mix, which however is assumed to be homogeneous across regions for the present problem. A deletion of this assumption leads to confounding of the energy saving effect with that of the regional technology, the isolation of which would be difficult. On the other hand, due to inter-fuel substitutability and variation in the availability of fuels, there exists a real variation in energy requirements to produce the same product across regions. To avoid the impact of the variation in technical coefficients and to get an industrial allocation pattern, which is related to energy minimization alone, the technical coefficients are assumed to be same across regions for all sectors except those for energy.

As a result, the demand constraints work out as

$$\sum_{s=1}^n X_i^s - \sum_{s=1}^n \sum_{j=1}^m a_{ij} X_j^s \geq F_i \quad \left[\text{for } i = 1, 2, \dots, m \right. \\ \left. \text{(except energy)} \right]$$

and

$$\sum_{s=1}^n X_1^s - \sum_{s=1}^n \sum_{j=1}^m a_{1j}^s X_j^s \geq F_1 \quad (\text{for energy sector})$$

It is likely that some regions may not get any industries in the optimum pattern. Clearly this is undesirable, as in that case a region cannot grow industrially at all and the important consideration of regional development should not be ignored. Therefore, we have to set some restrictions on the regional industrial income levels such that though a region does not improve its industrial income, at least its position does not deteriorate. The requirement that at least the present industrial income levels of regions are maintained, is developed on the basis of the value added coefficients as follows -

$$1 - \sum_j a_{1j}^s = v_j^s$$

where v_j^s is the value added coefficient of j^{th} sector in s^{th} region. The variation in each 's' for the same 'j' is due to differential energy input coefficient alone. Then $\sum_j v_j^s X_j^s$ is the total industrial income of the region 's' if X_j^s are the sectoral production levels for s^{th} region. If V^s is the existing industrial value added of the s^{th} region, then the above constraint becomes -

$$\sum_j v_j^s X_j^s \geq V^s \quad (\text{for } s = 1, 2, \dots, n)$$

It may be noted that the primary sectors such as agriculture, mineral extractions are natural resource based sectors, where no such reallocation is feasible and meaningful too. Therefore the model also has to supply the constraints towards

this end. Hence, minimum regional output levels are provided exogenously for such sectors as follows -

$$X_j^s \geq \hat{X}_j^s$$

There are certain industries which do not exist in certain regions for the year under study. The knowledge of the reallocation of industries in these regions is also of interest from the planning point of view. However, for the inclusion of such sectors in such regions a knowledge about their energy coefficients becomes a prerequisite. Since we do not have such data at our disposal, we could not consider this aspect in our model.

6.2 Data Source and Adjustments

The model also is worked out for the year 1970 to synchronize with the data base of the other analysis in this study.

The regional economies are divided into 18 sectors. Out of these, one relates to the primary activities comprising of agriculture, allied activities and mining, while another relates to the sector 'others', which contains transport and construction activities. However, out of the entire mineral extraction activity, Coal has been separated and combined with the energy sector. The total industrial activity is divided into sixteen sectors, where fourteen HFU industries are separately distinguished of which one pertains to energy. The rest of the industries are clubbed into two categories, one pertaining to those of Division 2 manufacturing and the other to that of Division 3. The model covers fifteen regions of which fourteen are major States and the fifteenth region covers all residual ones of the country.

The following data are required for the model -

- 1) All India input coefficient matrix of order 17 x 18 (except energy row).
- 2) Regional energy input coefficient estimates.
- 3) Regional value added coefficients.
- 4) Final demand estimates at all India level.
- 5) Regional value added estimates for the industrial sector.
- 6) Output estimates for the primary and 'other' sectors.
- 7) Output estimates for Basic Iron and Steel industry for certain regions.

Since the data-requirements of the model are quite extensive and in some cases the direct data are not readily available, we discuss the data sources and adjustments, if necessary, in the following.

(i) Input Coefficient Matrix: In developing the L.P. model, it is already mentioned that if product-mix across regions is assumed to be the same, it is reasonable to assume that the regions have the same technical coefficients except those for energy sector. This assumption leads to the same technical coefficient matrix except for the energy row for all the regions. The uniform technical coefficients are assumed to be those of all India. Since the all India input coefficient matrix for the year 1970 is not available, the 1968-69 input coefficient matrix has been used. The relative price changes between inputs and outputs from 1968-69 to 1970 are of negligible order and have been ignored. Energy coefficients have been estimated for 1970. The 77 x 77 transaction table for

1968-69 prepared by Central Statistical Organization¹ (C.S.O.) has 49 sectors which cover the production activities to which alone the present exercise relates. This 49 x 49 transaction matrix is then reduced to the above-stated 18 sector input coefficient matrix from which the energy row has been excluded.

(ii) Regional Energy Inputs: The energy input coefficients are estimated for each region under study by using the energy consumption data for the large scale industrial sector available in the A.S.I. reports for 1970. However, the regional energy consumption data for the remaining sectors are not available and the regional input-output tables for 1970 are also not available. Hence we have made use of the 8 x 8 Regional Input-Output tables, which relate to the year 1965.*

The regional energy input coefficients for the 'primary' sector and 'others' sector are taken from these Input-Output tables and are adjusted for price changes. To arrive at the regional energy input coefficients for the energy sector, the regional energy inputs of the three energy sectors viz. Coal, Petroleum Products and Electricity, are added together with 1970 production levels as their weights.

(iii) Regional Value Added Coefficients: The regional value added coefficients are estimated for the industrial sector alone by subtracting all the inputs from unity. As the income

1 'Inter-Industry Transactions 1968-69', National Accounts Statistics, January 1978. C.S.O., Government of India, New Delhi, p. 123.

* The details regarding these tables are given in Chapter 7.

constraints are restricted to the industrial sector alone, there is no need to have the value added coefficients for the remaining sectors.

(iv) Final Demand Estimates: Final demand estimates at the national level for the year 1970 are not readily available. As the nearest transaction matrix available is that of 1968-69, the direct estimates of final demand are available for the same year. The 1970 final demand estimates are then obtained by distributing the total national income pro-rata on the 1968-69 sectoral final demand composition.

(v) Regional Value Added Estimates: The regional value added estimates for the broad economic sectors are provided by C.S.O. for 1970-71.² The addition of the value added for the entire manufacturing sector and electricity, gas and water supply, has provided the required regional value added estimates.

(vi) Regional Output Estimates: As noted, there are certain sectors which are mostly natural resource based, whose output levels cannot be shifted from region to region by planning. For such sectors, information in the L.P. model is provided exogenously. In the present situation, while 'primary' and 'others' sectors are treated as entirely exogenous sectors, Basic Iron and Steel industry is treated as partially exogenous, where some minimum output levels for certain regions are specified.

² National Accounts Statistics, January 1979. C.S.O., Government of India, New Delhi, Appendix A2.2.

For the 'primary' and 'others' sectors, the regional output estimates are not directly available. The output estimates are based on the C.S.O.³ value added estimates and are obtained by inflating them by value added coefficients, obtained above.

In the case of Basic Iron and Steel sector, some minimum output levels are specified for certain regions. The specified four States are Bihar, Madhya Pradesh, Orissa and West Bengal; whose minimum output estimates are based on their 1970 production levels reported in the A.S.I. reports.

As already mentioned, if an industry's output level is zero in a particular region in 1970, in the model, constraints are imposed that the regional output should be zero.

The L.P. Model, thus discussed above, can be written as -
To minimize the energy consumption with the objective function

$$\text{as - } \sum_{s=1}^{15} \sum_{j=1}^{18} a_{ej}^s X_j^s ;$$

where a_{ej}^s is the energy input in j^{th} sector of s^{th} region and X_j^s is the output of j^{th} sector of s^{th} region. The sets of constraints are as follows:

$$\left. \begin{aligned} \sum_{s=1}^{15} X_i^s - \sum_{s=1}^{15} \sum_{j=1}^{18} a_{ij}^s X_j^s &\geq F_i && \text{for } i=1,2,\dots,17 \\ &&& \text{(except energy)} \end{aligned} \right\} \text{I}$$

and

$$\left. \begin{aligned} \sum_{s=1}^{15} X_{18}^s - \sum_{s=1}^{15} \sum_{j=1}^{18} a_{18,j}^s X_j^s &\geq F_{18} \\ &&& \text{(for energy sector where 18} \\ &&& \text{is the energy sector number)} \end{aligned} \right\}$$

3 Ibid.

$$\sum_{\substack{j=2 \\ j \neq 17}}^{18} v_j^s x_j^s \geq v^s \quad \text{for } s=1, 2, \dots, 15 \quad \left. \vphantom{\sum} \right\} \text{ II}$$

$$x_j^s \geq \hat{x}_j^s \quad \text{for certain 'j' and 's'} \quad \text{III}$$

$$x_j^s = 0 \quad \text{for certain 'j' and 's'} \quad \text{IV}$$

The above model thus has 77 constraints and 270 (15x18) unknowns. However, the 34 known outputs and 13 'zero' output levels are provided exogenously, thus giving ultimately 223 unknowns in the L.P. model.

6.3 Limitations of the Model

Before discussing the results of the above model, we may note the limitations of the same. The model is developed solely in terms of minimization of energy costs. While energy is becoming increasingly important, this cannot be the sole determinant of the industrial location. The optimum pattern of magnitudes thrown out by the model should not be interpreted as the actual desirable magnitudes of those locations. But the model will be useful in indicating the directions of energy efficient regions. It would have been more useful to incorporate in the objective function the cost of energy due to the transportation of both inputs and outputs from and into different regions. But this is beyond the scope of the present study. The model could have been also formulated in physical energy coefficients minimizing the energy in physical units. Our limited resources prevented us from undertaking this aspect of the study.

6.4 Results of the L.P. Model

The solution of the above model has given the optimal allotments of the industries in different regions and also the minimum energy cost, required to satisfy the 1970 final demand of the entire economy. The last row of the solution represents the industrywise regional cost coefficients, which provides the information of the additional cost required to be paid if the industry is operating in the said region with its present energy use. These results are discussed below.

6.4.1 Optimum Industrial Locations

The optimal locations for each industry along with the production levels, obtained from the above model, are presented in Table 6.1. Table 6.2 abstracts the necessary information from Table 6.1 for the following discussion.

We observe from the Table 6.2 that West Bengal is optimal location for three HFU industries while Maharashtra and Haryana are optimal in the case of two. Uttar Pradesh and Rest of India are not found optimal for any of the HFU industries. All the remaining locations (States) are found to be optimal ones for one of the HFU industries.

In Chapter 5, for each industry, we have identified the State for which the energy cost is minimum per thousand rupees worth output as observed in 1970. The model by and large picks up those States for which the energy cost is minimum for a given industry as detailed in Table 5.15 as is to be expected. However, there are a few exceptions. Other Chemicals [311(R)], Cement (334) and Other Iron and Steel [341(R)] get located in

Table 6.1 : Sectoral Optimum Output Levels Across Regions for 1970

Sector	State	Andhra Pradesh	Bihar	Gujarat	Kerala	Madhya Pradesh	Tamil Nadu	Maha-rashtra	Karna-taka	Orissa	Punjab	Raja-sthan	Uttar Pradesh	West Bengal	Haryana	Rest of India
1. Primary		186139	177367	150189	72252	189460	127820	160605	138450	104716	119619	156729	332276	728081	78843	131124
2. Manufacturing Division 2		41064	-	-	-	29262	11951	189809	-	-	239285	-	93128	-	-	-
3. Manufacturing Division 3		-	-	34565	-	-	-	-	-	-	-	-	-	-	-	306193
4. Alcohol		19190	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Cotton Textiles		-	-	-	-	-	-	-	-	21320	250551	-	-	-	-	-
6. Paper and Paper Products		-	-	-	-	-	-	20624	-	-	-	-	-	-	-	-
7. Chemical Fertilizers		-	-	-	-	-	62927	-	-	-	-	-	-	-	-	-
8. Heavy Chemicals		-	-	-	-	-	-	-	-	-	-	-	-	25457	-	-
9. Chemicals (Other than 311.1.1 and 311.2)		-	-	-	68876	-	-	-	-	-	-	-	-	-	-	-
10. Structural Clay Products		-	33333	-	-	-	-	-	-	-	-	-	-	583631	-	-
11. Glass and Glass Products		-	-	-	-	-	-	-	-	-	-	-	-	-	91696	-
12. Pottery-China and Earthenware Products		-	-	-	-	-	-	-	-	-	-	-	-	91696	-	-
13. Cement		-	-	-	-	14714	-	-	-	-	-	-	-	-	-	-
14. Basic Iron and Steel		-	10000	82175	-	10000	-	-	-	7500	-	-	-	12500	-	-
15. Iron and Steel (other than Basic)		-	-	-	-	-	-	-	-	-	-	-	-	-	122175	-
16. Non-Ferrous Metals		-	-	-	-	-	-	28808	-	-	-	21104	-	-	-	-
17. Others		38766	43525	38390	20352	29344	40617	79828	483158	11857	30180	26094	72484	44232	17148	41512
18. Energy		-	-	-	-	-	-	-	32398	-	-	-	-	-	104732	-

Note: Sectors No. 1 and 17 are given exogenously in the solution.

Table 6.2 : Industrywise Optimal Locations for 1970

Industry	Optimal Location
211 Alcohol	Andhra Pradesh
231 Textiles	Orissa, Punjab
271 Paper and Paper Products	Maharashtra
311.1.1 Chemical Fertilizers	Tamil Nadu
311.2 Heavy Chemicals	West Bengal
311(R) Other Chemicals	Kerala
331 Structural Clay Products	Bihar, West Bengal
332 Glass and Glass Products	Haryana
333 Pottery—China-Earthenware	West Bengal
334 Cement	Madhya Pradesh
341(R) Iron and Steel (Other than Basic)	Haryana
342 Non-Ferrous Metals	Maharashtra, Rajasthan
511* Energy	Karnataka, Haryana

* This includes the three energy sources viz. Coal, Petroleum Products and Electricity.

Kerala, Madhya Pradesh and Haryana respectively while the minimum energy cost is in Tamil Nadu, Andhra Pradesh and Uttar Pradesh for 311(R), 334 and 341(R) respectively. This is because of the constraint that each State should produce a minimum income from the industrial sector which we have postulated in the L.P. model.

6.4.2 Energy Saving by Optimal Allocation of Industries

The solution of the model has provided the minimum energy cost to satisfy the inter-industry demand of 1970, which amounts to Rs.119803 lakh. The actual energy cost to satisfy the same 1970 inter-industry demand with the existing allocation of

industries is Rs. 155667 lakh, evaluated on the basis of the relation $(I-A)^{-1} F = X$.^{*} This results into energy saving to the tune of Rs. 35864 lakh, which is equivalent to 23 per cent saving of energy for inter-industry use alone. As a consequence of this energy saving, there will be an additional reduction in the use of other inputs that are used by the energy sector. This saving works out to Rs. 20310 lakh.

6.4.3 A Classification of Regions for an Industry on the Basis of Additional Energy Cost

It is not feasible to allocate one industry in only one region to minimize the energy cost. Also the cost of energy cannot be the only criterion in selecting a location of the industry. Further, that an industry should be located only in one or two regions is not desirable for other reasons. Hence, in order to know the other acceptable regions for an industry, the last row of the L.P. solution, which provides the cost coefficients for different regions, is used. The cost coefficients provide the additional cost required to be paid if the industry is operating in the region. The lower the cost coefficient, the higher is the acceptability and vice-versa. A broad classification of the regions on the basis of the high and the low values of these cost coefficients for various HFU industries is developed below. The regional cost coefficients for each industry^{**} are presented in Table 6.3. We may now try

* The Gross output estimate of the energy sector worked out as Rs.172994 lakh where the 1970 final demand estimate is Rs.17327 lakh. This gives inter-industry demand as Rs.155667 lakh.

** The cost coefficients do not exist for those sectors for which output levels are provided exogenously.

Table 6.3 : Industrywise Regional Cost-Coefficients for 1970 (on L.P. Model Basis)

Sector	State	Andhra Pradesh	Bihar	Gujarat	Kerala	Madhya Pradesh	Tamil Nadu	Maha-rashtra	Karna-taka	Orissa	Punjab	Raja-sthan	Uttar Pradesh	West Bengal	Haryana	Rest of India
Manufacturing Division 2	-	0.0046	0.0012	0.0024	-	-	-	0.0039	0.0220	-	0.0067	-	0.0069	0.0023	0.0055	
Manufacturing Division 3	0.0137	0.0014	-	-	0.0107	0.0080	0.0008	0.0035	0.0158	0.0125	0.0936	0.0779	0.0112	0.0014	0.0077	
Alcohol	-	-	-	-	0.0680	-	-	-	-	-	-	0.1676	-	0.0436	0.1024	
Cotton Textiles	0.0008	0.0003	0.0153	0.0035	0.0067	0.0011	0.0176	0.0017	-	-	0.0025	0.0105	0.0022	-	0.0123	
Paper and Paper Products	0.0869	-	0.1334	-	0.0157	0.0513	-	0.0883	0.0643	-	-	0.0845	0.0505	0.0519	0.0530	
Chemical Fertilizers	0.0067	0.0723	0.0243	-	-	-	0.0391	-	-	-	-	-	-	-	0.0375	
Heavy Chemicals	0.1197	0.1956	0.0517	0.0057	-	0.1120	0.0006	-	-	-	-	0.0903	-	-	0.0367	
Chemicals (other than 311.1.1 and 311.2)	0.1267	-	0.0407	-	-	0.0400	0.0577	0.0002	-	-	-	-	0.0568	-	0.0597	
Structural Clay Products	-	-	0.0421	0.0543	0.0172	0.0450	0.0006	0.0415	0.0840	-	-	-	-	-	0.0105	
Glass and Glass Products	-	0.0023	-	-	-	-	0.0131	-	-	-	-	0.1032	0.0196	-	0.0597	
Pottery-China and Earthenware Products	0.0787	-	0.0751	-	0.0806	-	-	-	-	-	-	0.1595	-	0.0343	0.0099	
Cement	0.0278	-	0.1390	-	-	0.0811	-	0.0751	-	-	0.0708	-	-	-	0.0581	
Basic Iron and Steel	0.0371	-	-	-	-	0.0084	0.0202	0.2842	-	0.0165	-	0.0604	-	0.0370	0.0896	
Iron and Steel (other than Basic)	0.0722	0.1209	0.0276	-	0.1188	0.0468	0.0445	0.0737	0.1749	0.0628	0.0843	0.0293	0.0578	-	0.0547	
Non-Ferrous Metals	-	0.0458	0.0034	-	-	0.0467	-	0.0820	-	-	-	-	0.0086	-	0.0694	
Energy	0.1236	0.1152	0.1894	0.0009	0.1105	0.0977	0.0538	-	0.0676	0.0069	0.0290	0.2928	0.1262	-	0.1362	

to indicate the acceptable regions for the industry such that if situated in these locations, the increase in the energy cost is not substantial. Also we try to indicate those locations which are energy cost inefficient.

In the case of the Alcohol industry, though Andhra Pradesh is the optimal location, it produces only 15.75 per cent output in 1970. On the contrary, Uttar Pradesh, with the highest cost coefficient, produces the highest Alcohol output (55.03 per cent). Thus the solution suggests the promotion of the above industry in Andhra Pradesh as also in Haryana and Madhya Pradesh.

In the case of the Textile industry, a number of States are found with very small order cost coefficients, thereby indicating that the location can be widespread for this industry. But surprisingly, Maharashtra and Gujarat turn out to be the most inefficient locations along with Uttar Pradesh as they have uniformly high cost coefficient values.

The existing regional allocation for the Paper industry is found reasonably good by the criterion of its production share (67.22 per cent) in those States which are either energy efficient or with very low cost coefficients.

For the Fertilizer industry, the two States viz. Maharashtra and Bihar, with higher cost coefficients produce more than 40 per cent share of industry's output against the most efficient State of Tamil Nadu which produces around 10 per cent output. Hence it seems desirable to expand this industry in Tamil Nadu as well as in Andhra Pradesh and Gujarat on their cost coefficient basis. The present regional allocation of the

Heavy Chemical industry is desirable though the most efficient State viz. West Bengal has a production share of 6.02 per cent only. In the case of Other Chemicals, to our surprise, Kerala comes up as an optimal location with a very low output share (1.24 per cent). The State of Karnataka is found as the lowest cost efficient State which also produces a negligible output. On the other hand, Maharashtra, being last but one on the ascending ranking of the States, produces more than 60 per cent output of Other Chemicals. Hence, there seems to be some scope for promoting the Other Chemicals industry in Kerala and Karnataka.*

In the case of Structural Clay Products, industry of the Non-metallic mineral products group, Bihar and West Bengal are the optimal locations from the solution of the L.P. model, wherein Bihar produces more than one-fifth of the industry's output while there is a considerable scope to expand the same in West Bengal. Maharashtra and Madhya Pradesh are the other two locations where the above industry can be promoted, particularly in Madhya Pradesh where the present output share is less than by even 5 per cent. For the Glass and Glass Products industry, Haryana is the most efficient location though it produces only 9.68 per cent of the industry's output. The two locations, having low cost coefficient values, are Bihar and Maharashtra where Maharashtra produces about 40 per cent of the industry's output against a negligible output in Bihar. On the contrary

* However, in interpreting the results of this industry, it should be noted that Kerala and Karnataka produce only mixed-fertilizer products while other States produce entirely different products.

Uttar Pradesh, with the highest cost coefficient, produces more than one-fifth of the industry's output. Hence, on the basis of cost coefficient, Bihar and Haryana are the possible locations for promoting the Glass and Glass Products industry. West Bengal is found as the optimal location for the China-Pottery and Earthenware industry which is already producing about one-third of the industry's output. On the cost coefficient basis, Haryana comes next to West Bengal producing about 20 per cent output of it. The production of the Cement industry is not highly concentrated in any of the locations. As Madhya Pradesh and Bihar are found optimal locations for the same, the industry can have a significant scope for its expansion from energy cost point of view. Similarly, Andhra Pradesh and Rajasthan are two other locations which can be encouraged to promote the Cement industry.

The Basic Iron and Steel industry is considered as natural resource based industry whose output levels are provided exogenously. Hence the comparison of cost coefficients is not valid for this. The principal production locations of the Iron and Steel (other than Basic) industry have more or less the same cost coefficients in the middle range. Haryana turns out to be cost efficient followed by Gujarat and Uttar Pradesh.

In the case of Non-Ferrous Metals industry, Maharashtra and Rajasthan are found to be the optimal locations wherein Maharashtra is already producing substantially high output (36.82 per cent) while Rajasthan produces only 2.66 per cent of the industry's output. Considering the low cost coefficient of Gujarat the Non-Ferrous Metals industry can be promoted in Rajasthan and Gujarat.

Table 16.1 : Input Coefficient Matrix of India for 1968-69 (Excluding Energy Row)

Sector	1	2	3	4	5	6	7	8	9
1. Primary	0.129725	0.320876	0.035297	0.028651	0.260254	0.049518	0.023504	0.020837	0.065280
2. Manufacturing Division 2	0.005161	0.122641	0.018599	0.011484	0.031947	0.034351	0.014653	0.044682	0.084821
3. Manufacturing Division 3	0.000524	0.017845	0.169597	0.026632	0.009140	0.020127	0.039234	0.060205	0.031745
4. Alcohol	0.0	0.000040	0.000395	0.002950	0.0	0.0	0.002422	0.0	0.000280
5. Cotton Textiles	0.003730	0.018089	0.001775	0.0	0.210016	0.000778	0.0	0.0	0.007876
6. Paper and Paper Products	0.000006	0.020574	0.003694	0.005512	0.002951	0.081492	0.000119	0.000139	0.021174
7. Chemical Fertilizers	0.021972	0.000015	0.000423	0.0	0.0	0.0	0.045215	0.0	0.000301
8. Heavy Chemicals	0.0	0.002931	0.011895	0.244662	0.005322	0.034064	0.034360	0.058877	0.069203
9. Chemicals (other than 311.1.1 and 311.2)	0.001786	0.016159	0.030254	0.021507	0.021436	0.017585	0.009360	0.010488	0.144556
10. Structural Clay Products	0.0	0.000307	0.003615	0.032766	0.0	0.0	0.0	0.0	0.010238
11. Glass and Glass Products	0.0	0.000307	0.003615	0.032766	0.0	0.0	0.0	0.0	0.010238
12. Pottery-China and Earthenware Products	0.0	0.000307	0.003615	0.032766	0.0	0.0	0.0	0.0	0.010238
13. Cement	0.0	0.000060	0.000003	0.0	0.0	0.004345	0.000059	0.001538	0.000020
14. Basic Iron and Steel	0.0	0.001929	0.100856	0.0	0.000698	0.000163	0.000029	0.002447	0.001664
15. Iron and Steel (other than Basic)	0.0	0.001929	0.100856	0.0	0.000698	0.000163	0.000029	0.002447	0.001664
16a Non-Ferrous Metals	0.0	0.001139	0.074062	0.0	0.000150	0.000081	0.000029	0.030417	0.009728
17. Others	0.007960	0.045797	0.055015	0.210032	0.036748	0.058905	0.057386	0.079994	0.046166

(continued)

Table A_{6.1} : (continued)

Sector	10	11	12	13	14	15	16	17	18
1. Primary	0.031322	0.031322	0.031322	0.104614	0.037030	0.037030	0.033341	0.052030	0.000019
2. Manufacturing Division 2	0.004214	0.004214	0.004214	0.148019	0.002831	0.002831	0.002564	0.058963	0.003298
3. Manufacturing Division 3	0.013179	0.013179	0.013179	0.035503	0.024699	0.024699	0.031171	0.062475	0.016539
4. Alcohol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000001	0.0
5. Cotton Textiles	0.000290	0.000290	0.000290	0.0	0.0	0.0	0.0	0.0	0.0
6. Paper and Paper Products	0.003420	0.003420	0.003420	0.002949	0.000717	0.000717	0.002367	0.000482	0.0
7. Chemical Fertilizers	0.0	0.0	0.0	0.006005	0.0	0.0	0.0	0.0	0.0
8. Heavy Chemicals	0.007162	0.007162	0.007162	0.000316	0.001560	0.001560	0.040148	0.0	0.0
9. Chemicals (other than 311.1.1 and 311.2)	0.004489	0.004489	0.004489	0.000105	0.001660	0.001660	0.004241	0.004551	0.002311
10. Structural Clay Products	0.026481	0.026481	0.026481	0.0	0.008543	0.008543	0.0	0.078509	0.0
11. Glass and Glass Products	0.026481	0.026481	0.026481	0.0	0.008543	0.008543	0.0	0.078509	0.0
12. Pottery-China and Earthenware Products	0.026481	0.026481	0.026481	0.0	0.008543	0.008543	0.0	0.078509	0.0
13. Cement	0.007406	0.007406	0.007406	0.007690	0.0	0.0	0.000049	0.011934	0.000038
14. Basic Iron and Steel	0.006337	0.006337	0.006337	0.027391	0.160780	0.160780	0.007447	0.041027	0.0
15. Iron and Steel (other than Basic)	0.006337	0.006337	0.006337	0.027391	0.160780	0.160780	0.007447	0.041027	0.0
16. Non-Ferrous Metals	0.000183	0.000183	0.000183	0.0	0.039547	0.039547	0.256128	0.0	0.0
17. Others	0.040744	0.040744	0.040744	0.179204	0.159824	0.159824	0.071763	0.044196	0.035352

Note : Sector 18 relates to Energy.

Table A_{6.2} : Statewise Sectoral Total Energy Coefficient (Rs./000 Rs. Output)

State	Industry	01 (1)	20 (2)	30 (3)	211 (4)	231 (5)	271 (6)	311.1.1 (7)	311.2 (8)	311 (R) (9)
Andhra Pradesh		0.002432	0.016841	0.034022	0.010440	0.035923	0.135277	0.074881	0.202788	0.130028
Bihar		0.003493	0.017578 ¹⁷⁵⁷⁸	0.018653	-	0.032048	-	0.134025	0.273242	-
Gujarat		0.003922	0.022581	0.024423	-	0.054172	0.186700	0.099488	0.142622	0.049769
Kerala		0.000455	0.015041	0.017026	-	0.034979	-	-	0.083537	0.000350
Madhya Pradesh		0.000731	0.016660	0.030938	0.077431	0.041596	0.064736	-	-	-
Tamil Nadu		0.007141	0.016227	0.027965	-	0.035635	0.099375	0.067272	0.194387	0.043788
Maharashtra		0.002639	0.014163	0.019009	-	0.050260	0.045512	0.102749	0.080845	0.059308
Karnataka		0.001478	0.016701	0.020602	-	0.033299	0.131533	-	-	0.000686
Orissa		0.000388	0.036908	0.034641	-	0.033550	0.110643	-	-	-
Punjab		0.002618	0.012702	0.029489	-	0.031446	-	-	-	-
Rajasthan		0.001450	0.026796	0.115113	-	0.040650	-	-	-	-
Uttar Pradesh		0.001940	0.018228	0.098402	0.176438	0.046660	0.134762	-	0.175771	-
West Bengal		0.000221	0.019587	0.028229	-	0.033650	0.093688	-	0.077879	0.056949
Haryana		0.002618	0.014989	0.018467	0.050622	-	0.095084	-	-	-
India		0.002221	0.018203	0.024652	0.109276	0.043677	0.096135	0.098911	0.114445	0.059851

(continued)

Table A_{6.2} ; (continued)

State	Industry	331 (10)	332 (11)	333 (12)	334 (13)	341.1 (14)	341 (R) (15)	342 (16)	40 (17)	50 (18)
Andhra Pradesh	-	-	-	0.234292	0.219142	0.067133	0.092008	-	0.066652	0.130960
Bihar	0.149740	0.117937	-	0.225175	0.189472	0.137982	0.062429	0.067132	0.115448	
Gujarat	0.203297	-	0.236720	0.330405	0.034303	0.051579	0.032216	0.045700	0.203858	
Kerala	0.203420	-	-	-	-	-	-	0.043260	0.000947	
Madhya Pradesh	0.172146	-	0.235866	0.191626	0.058377	0.137912	-	0.062904	0.117640	
Tamil Nadu	0.198944	-	-	0.271547	0.038291	0.066518	0.067580	0.042654	0.104213	
Maharashtra	0.152043	0.130466	-	-	0.048429	0.062712	0.018415	0.027853	0.056563	
Karnataka	0.190813	-	-	0.264120	0.310443	0.090819	0.098244	0.014360	0.000287	
Orissa	0.236033	-	-	-	0.221330	0.192642	-	0.042592	0.072155	
Punjab	-	-	-	-	0.043541	0.079821	-	0.062110	0.006874	
Rajasthan	-	-	-	0.263248	-	0.106179	0.027193	0.056998	0.044793	
Uttar Pradesh	-	0.225388	0.313000	-	0.091131	0.050734	-	0.052647	0.300106	
West Bengal	0.149271	0.134735	0.150443	-	0.052401	0.074874	0.024925	0.060229	0.125761	
Haryana	-	0.115174	0.184611	-	0.064044	0.017274	-	0.062110	-	
India	0.159770	0.174644	0.160293	0.247119	0.116419	0.071818	0.085446	0.056436	0.135717	

Table A_{6.3} : Statewise Sectoral Value Added Coefficients for 1970 (For Industrial Sector)

Industry	20 (2)	30 (3)	211 (4)	231 (5)	271 (6)	311.1.1 (7)	311.2 (8)	311(R) (9)
State								
Andhra Pradesh	0.432214	0.352412	0.339832	0.384717	0.563151	0.698720	0.585141	0.354780
Bihar	0.431477	0.367781	-	0.388592	-	0.639576	0.514687	-
Gujarat	0.426474	0.362011	-	0.366468	0.511728	0.674113	0.645307	0.435039
Kerala	0.434014	0.369408	-	0.385661	-	-	0.704392	0.484458
Madhya Pradesh	0.432395	0.355496	0.272841	0.379044	0.633692	-	-	-
Tamil Nadu	0.432828	0.358469	-	0.385005	0.599053	0.706329	0.593542	0.441020
Maharashtra	0.434892	0.367425	-	0.370380	0.652916	0.670852	0.707084	0.425500
Karnataka	0.432354	0.365832	-	0.387341	0.566895	-	-	0.484122
Orissa	0.412147	0.351793	-	0.387090	0.587785	-	-	-
Punjab	0.436353	0.356945	-	0.389194	-	-	-	-
Rajasthan	0.422259	0.271321	-	0.379990	-	-	-	-
Uttar Pradesh	0.430827	0.288032	0.173834	0.373980	0.563666	-	0.612158	-
West Bengal	0.429468	0.358205	-	0.386990	0.604740	-	0.710050	0.427859
Haryana	0.434066	0.367967	0.299650	-	0.603344	-	-	-
India	0.430852	0.361782	0.240996	0.376963	0.602293	0.674690	0.673484	0.424957

Industry	331 (10)	332 (11)	333 (12)	334 (13)	341.1 (14)	341(R) (15)	342 (16)	50 (18)
State								
Andhra Pradesh	-	-	0.561182	0.241671	0.317810	0.292935	-	0.811483
Bihar	0.645734	0.677537	-	0.235638	0.195471	0.246961	0.580905	0.826995
Gujarat	0.592177	-	0.558754	0.130408	0.350640	0.333364	0.611118	0.738585
Kerala	0.592054	-	-	-	-	-	-	0.941496
Madhya Pradesh	0.623328	-	0.559608	0.269187	0.326566	0.247031	-	0.824803
Tamil Nadu	0.596530	-	-	0.189266	0.346652	0.318425	0.575754	0.838230
Maharashtra	0.643431	0.665008	-	-	0.336514	0.322231	0.624919	0.835880
Karnataka	0.604661	-	-	0.196693	0.074500	0.294124	0.545090	0.942156
Orissa	0.559441	-	-	-	0.163613	0.192301	-	0.870288
Punjab	-	-	-	-	0.341402	0.305122	-	0.935569
Rajasthan	-	-	-	0.197565	-	0.278764	0.616141	0.897650
Uttar Pradesh	-	0.570086	0.482474	-	0.293812	0.334209	-	0.642337
West Bengal	0.646203	0.660739	0.645031	-	0.332542	0.310069	0.618409	0.816682
Haryana	-	0.680300	0.610863	-	0.320899	0.367669	-	-
India	0.635704	0.620830	0.635181	0.213694	0.268524	0.313125	0.557888	0.806726

Table A_{6.4} : Final Demand Estimates of India for 1970

Sector	Final Demand (Rs.lakh)
1. Primary	2012884
2. Manufacturing Division 2	442392
3. Manufacturing Division 3	186173
4. Alcohol	18802
5. Cotton Textiles	192441
6. Paper and Paper Products	1106
7. Chemical Fertilizers	-
8. Heavy Chemicals	-
9. Chemicals (other than 311.1.1 and 311.2)	19908
10. Structural Clay Products	2950
11. Glass and Glass Products	2950
12. Pottery-China and Earthenware Products	2950
13. Cement	737
14. Basic Iron and Steel	4424
15. Iron and Steel (other than Basic)	4424
16. Non-Ferrous Metals	-
17. Others	779347
18. Energy	17327

CHAPTER 7

IMPACT OF ENERGY PRICE HIKE ON REGIONAL ECONOMIES

So far we were analysing the various aspects of regional variation in the fuel consumption and the fuel price was only indirectly taken note of via regional cost differentials. However, a consideration of price per se in the context of its impact on regional economies is not only important but is a desideratum as the energy prices are found to be increasing much faster than those of other commodities.

The first obvious effect of the energy price rise is the sympathetic rise in prices of other commodities. The second consequence can be a change in the relative output levels of different sectors leading to a compositional or structural change in the economy. Due to the variation in the pattern of existing fuel consumption in various regions as noted earlier and also the unequal relative price rise in different fuels, the impact of the energy price rise is not likely to be uniform over the various regions. Therefore it is important to examine the effects of energy price rise on the economy both at national and at regional level.

The input-output frame would be convenient to analyse the impact of the said price rise on the different sectors of the economy. For the analysis in such a frame, input-output tables are a primary requisite. The input-output tables for

Indian Union over a period of years are available and the analysis related to the structural change due to energy price hike is carried out for India as a whole and is presented in the Appendix 7.1. At the regional level it would be useful to assess how the hike in energy prices has affected the composition, particularly the output-mix over time and secondly to examine how the relative position of a region as regards the price of a particular industry group has changed as a result of the hike in the energy prices. The relative positions of a region vary because of different fuel mixes and also due to product-mix. To examine the changes over time, regional input-output tables are required for different time periods. As such a set of tables is not available, this aspect could not be examined. However for the year 1965, input-output tables for different regions on a comparable basis are available. In this chapter, an analysis of sectoral price changes in different regions due to energy price hike is undertaken. The methodology in the input-output frame and the results are discussed below.

7.1 Effect of Energy Price Hike on Prices of Other Sectors

7.1.1 Methodology of Analysis

In the input-output frame, the whole economy is divided into a number of sectors. An input coefficient (a_{ij}) represents the requirement of a consuming sector (i) per unit output of a producing sector (j) and an input column represents the technical requirements of all inputs to produce one rupee worth output of the producing sector. The income generated in the production process is output net of all inputs viz. the value added coefficient

which is $[1 - \sum_i a_{ij}]$ where 'i' represents the i^{th} input. The consistent prices for equilibrium are obtained by the following system of equations -

$$\sum_i a_{ij} P_i + V_j = P_j \quad \text{for all } j.$$

The changes in the equilibrium prices due to changes in the input prices are studied with the help of the above system of equations.

An increase in the price of any sector leads to one of the three following alternatives, viz.:

(1) All the price increase in one or more sectors is attributed to the producing sector, resulting in the reduction in the value added and prices of all other sectors remain unchanged.

(2) The entire price rise of a sector is transferred to the consuming sectors, maintaining its existing level of value added.

(3) The effect of price rise is shared between the producer and consumer sectors which reduces the value added to some extent and the remaining effect is attributed to the prices of other sectors. All the three alternatives can be studied with the above system of equations, which can be rewritten in the matrix form for the purpose of price evaluation as

$$V = P(I - A) \quad \dots (1)$$

or

$$V(I - A)^{-1} = P \quad \dots (2)$$

where V is a row vector of value added, P is a row vector of prices, A is the technological matrix and I is the identity

matrix of the same order as that of A. Using the standard input-output methods new prices can be determined.

Let us consider a three sector economy and write the system of prices as -

$$\left. \begin{aligned} a_{11}^* P_1 + a_{21}^* P_2 + a_{31}^* P_3 + V_1 &= P_1 \\ a_{12}^* P_1 + a_{22}^* P_2 + a_{32}^* P_3 + V_2 &= P_2 \\ a_{13}^* P_1 + a_{23}^* P_2 + a_{33}^* P_3 + V_3 &= P_3 \end{aligned} \right\} \dots \text{(I)}$$

where a_{ij}^* is the physical input coefficient from i^{th} sector to j^{th} one, P_1 , P_2 and P_3 are the prices of three sectors and V_1 , V_2 and V_3 are the value added coefficients.

If the price of the third sector for instance, changes from P_3 to $(1+r)P_3$, then the whole system undergoes a change as sector '3' enters as input in all other sectors directly or indirectly. The changes are either of the three alternatives, mentioned above. In the case of first alternative, the solution is easy as V_1 changes by $(r.P_3)$ and P_1 , P_2 remain unchanged. In the case of the second alternative, where value added remains unchanged and prices of other sectors undergo changes, the system has to be reformulated and new prices are to be obtained.

Let the new prices of the three sectors be f_1 , f_2 and f_3 . The system with these new prices becomes -

$$\left. \begin{aligned} a_{11}^* f_1 + a_{21}^* f_2 + a_{31}^* f_3 + V_1 &= f_1 \\ a_{12}^* f_1 + a_{22}^* f_2 + a_{32}^* f_3 + V_2 &= f_2 \\ a_{13}^* f_1 + a_{23}^* f_2 + a_{33}^* f_3 + V_3 &= f_3 \end{aligned} \right\} \dots \text{(II)}$$

Taking for instance, the price of the third sector as given exogenously as

$$f_3 = (1 + r)P_3$$

and hence the system gets reduced to two equations system as -

$$\left. \begin{aligned} a_{11}^* f_1 + a_{21}^* f_2 + V_1^N &= f_1 \\ a_{12}^* f_1 + a_{22}^* f_2 + V_2^N &= f_2 \end{aligned} \right\} \dots \text{(III)}$$

where $V_1^N = a_{31}^* f_3 + V_1$ and

$$V_2^N = a_{32}^* f_3 + V_2 .$$

The system (III) can now be solved for f_1 and f_2 as

$$\begin{bmatrix} 1 - a_{11}^* & -a_{21}^* \\ -a_{12}^* & 1 - a_{22}^* \end{bmatrix} \begin{bmatrix} f_1 \\ f_2 \end{bmatrix} = \begin{bmatrix} V_1^N \\ V_2^N \end{bmatrix}$$

or

$$[V_1^N \ V_2^N] [I - A^*]^{-1} = [f_1 \ f_2].$$

In the case of the third alternative, mentioned above, the estimation of V_1^N and V_2^N can be made with the prior knowledge about share between the producer and the consumer sector of the impact due to price changes and the system can be solved with the above equations for new prices.

If the prices of the original system are normalized such that each price is taken as unity, the price solution vector of f_1 and f_2 of the new system would give the new prices as ratios of the earlier prices.

7.1.2 Application of the Price Impact Model

Using a similar methodology Rangarajan et al¹ have studied changes in the prices of other sectors consequent on the changes

1 C. Rangarajan, Raaj Kumar Sah and K.S. Reddy, "Impact of Hike in Prices of Coal and Petroleum Products," Artha Vijnana, Vol. XXIII, No. 2, June 1981, pp. 176-181.

in the price of the energy sectors for the Indian economy as a whole under four different assumptions about the price restrictions on the various sectors viz. Coal, Electricity and Railways. The 66 x 66 Interindustry matrix of the Planning Commission, which refers to 1973-74 technical coefficient at 1971-72 prices, has been used for the said study and the price increases of Coal and Petroleum Products are those announced in July, August and September 1979. When no such restriction was imposed exogenously on any economic sector, they observed that all high fuel using industries showed a more than one per cent price increase. And these increases were observed to be the highest price increases when compared with those obtained under the certain price restrictions of the above-noted sectors.

Though this is the only study of its type dealing with the impact of energy price hike on the Indian economy, the results of the same cannot be accepted as they are for the following reasons. Since the authors use the input-output table of an earlier vintage price and use the current price hikes, the resulting increases found are over the base year prices rather than the current ones as the price corrections are not carried out.

The focus of our impact study is to understand the rate of energy price hike on the different regional economies. Such a regional study not only provides an understanding of the magnitudes of the price increases of the non-energy sectors under conditions of energy price hike, but also has a very large bearing on the locational policy implications.

To carry out the regional impact study, we need to have regional input-output tables. Such tables are available only for the year 1965 on a comparable basis for all the regions. Though the data are of old vintage, an analysis based on these tables would give us an indication of the differential impact of energy price hike on different regions.

The data are taken from the Artha Vijnana (1979)² which contains all regional input-output tables including the Indian Union. The tables have been uniformly constructed for 85 sectors and are evaluated at the 1965 producer prices. Because of the difficulties involved in handling such large sized tables, these are aggregated into 8 x 8 sectors. Since the energy sectors are of significant importance, out of these 8 sectors, four are devoted to energy and the rest of the economy is divided into four other sectors. The eight sectors are: Agriculture, Manufacturing Division 2, Manufacturing Division 3, Transport, Firewood, Coal, Petroleum Products and Electricity.

The reduced 8 x 8 input coefficient matrices for each region are presented in the Table A_{7.2} of this chapter.

The sectoral price impact due to energy price hike is studied, once with Petroleum Products alone as the exogenous sector and subsequently with all energy sectors as exogenous. On the basis of the number of endogenous sectors, the former model is termed as 7 sector model and the latter is called as the 4 sector one.

² P. Venkatramaiah, A.R. Kulkarni and Latika Argade, "Regional Input Output Tables for India, 1965," Artha Vijnana, Vol. XXI, No. 3, 4, September-December 1979.

The impact of energy price for both these models is studied for the following five time periods, viz. 1970, 1975, 1977, 1980 and 1981, for which actual energy price changes are utilized. The energy price changes over the period are calculated from the wholesale price index data³ and presented below.

Table 7.1 : Energy Sector's Price Index for 1970 to 1981

Year	Sector			
	Firewood	Coal	Petroleum Products	Electricity
1970	1.539	1.395	1.029	1.229
1975	2.726	2.381	3.612	1.887
1977	3.065	2.756	4.421	2.205
1980	3.963	4.679	5.432	2.874
1981	4.799	5.857	7.466	3.313

7.2 Differential Regional Price Impacts

7.2.1 Differential Price Impacts on 7 Sector Model

We discuss firstly the results of the 7 sector model, where the impact of rise in the price of Petroleum Products alone is considered. The results are presented in Table 7.2 to 7.6 in the form of percentage increase in the prices of all sectors for the five years due to the price rise in Petroleum Products, for each region. The Table 7.2 shows that for a rise of 2.9 per cent in the price of Petroleum Products; the consequent

³ Government of India, Ministry of Commerce and Industry, 'Wholesale Price Index Numbers, 1970-71 = 100', Office of the Economic Adviser, New Delhi.

Table 7.2 : Percentage Price Increase in Sectors Due to Price Hike in Petroleum Products, 1970
(Petroleum price : 1.029, 2.9 per cent increase)

State	Agri- culture	Manufac- turing Industries Div. 2	Manufac- turing Industries Div. 3	Transport	Firewood	Coal*	Electri- city
1. Andhra Pradesh	0.0144	0.0335	0.0524	0.1074	0.0029	0.0361	0.1084
2. Assam	0.0047	0.0363	0.0489	0.0794	0.0032	0.0398	0.3024
3. Bihar	0.0137	0.0258	0.0399	0.0656	0.0029	0.0317	0.0629
4. Gujarat	0.0116	0.0434	0.0476	0.0673	0.0031	0.0000	0.0456
5. Kerala	0.0040	0.0458	0.0516	0.1421	0.0053	0.0000	0.0360
6. Madhya Pradesh	0.0127	0.0331	0.0403	0.0824	0.0031	0.0328	0.0585
7. Tamil Nadu	0.0149	0.0484	0.0734	0.1297	0.0062	0.0389	0.0352
8. Maharashtra	0.0067	0.0113	0.0107	0.0080	0.0004	0.0255	0.0213
9. Karnataka	0.0025	0.0100	0.0048	0.0110	0.0004	0.0000	0.0389
10. Orissa	0.0053	0.0233	0.0227	0.0526	0.0020	0.0292	0.0205
11. Punjab	0.0189	0.0579	0.0765	0.1599	0.0076	0.0000	0.0159
12. Rajasthan	0.0135	0.0387	0.0453	0.0956	0.0032	0.0000	0.0910
13. Uttar Pradesh	0.0084	0.0295	0.0557	0.1006	0.0041	0.0000	0.0418
14. West Bengal	0.0060	0.0502	0.0562	0.1207	0.0054	0.0350	0.0332
15. Delhi	0.0109	0.0659	0.0796	0.1574	0.0196	0.0000	0.0557
All India	0.0119	0.0424	0.0521	0.1047	0.0042	0.0349	0.0472

* In case of Coal, zero per cent price increase is due to non-production of Coal in those regions.

Table 7.3 : Percentage Price Increase in Sectors Due to Price Hike in Petroleum Products, 1975
 [Price for Petroleum Products: 3.612 i.e. 261.2 Per Cent Increase]

State	Sector	Agri- culture	Manufac- turing Industries Div. 2	Manufac- turing Industries Div. 3	Trans- port	Fire- wood	Coal *	Electri- city
Andhra Pradesh		1.30	3.02	4.72	9.67	0.26	3.25	9.76
Assam		0.43	3.27	4.41	7.16	0.29	3.58	27.23
Bihar		1.23	2.32	3.60	5.91	0.26	2.86	5.66
Gujarat		1.05	3.91	4.29	6.06	0.27	0.00	4.11
Kerala		0.36	4.12	4.65	12.80	0.48	0.00	3.24
Madhya Pradesh		1.15	2.98	3.63	7.42	0.29	2.96	5.27
Tamil Nadu		1.34	4.36	6.61	11.68	0.56	3.50	3.17
Maharashtra		0.60	1.02	0.96	0.72	0.03	2.30	1.92
Karnataka		0.23	0.90	0.43	0.99	0.04	0.00	3.51
Orissa		0.48	2.10	2.04	4.74	0.18	2.63	1.85
Punjab		1.70	5.22	6.89	14.40	0.69	0.00	1.43
Rajasthan		1.22	3.48	4.08	8.61	0.29	0.00	8.19
Uttar Pradesh		0.76	2.66	5.02	9.06	0.37	0.00	3.76
West Bengal		0.54	4.53	5.06	10.87	0.49	3.16	2.99
Delhi		0.98	5.94	7.17	14.18	1.77	0.00	5.01
India		1.07	3.82	4.70	9.43	0.37	3.15	4.25

* See note to Table 7.2.

Table 7.4 : Percentage Price Increase in Sectors Due to Price Hike in Petroleum Products, 1977
(Price for Petroleum Products: 4.421 i.e. 342.1 Per Cent Increase)

State	Sector	Agri- culture	Manufac- turing Industries Div. 2	Manufac- turing Industries Div. 3	Trans- port	Fire- wood	Coal*	Electri- city
Andhra Pradesh		1.70	3.95	6.18	12.47	0.34	4.26	12.79
Assam		0.56	4.28	5.77	9.37	0.38	4.69	35.67
Bihar		1.62	3.04	4.71	7.74	0.34	3.74	7.42
Gujarat		1.37	5.12	5.62	7.94	0.36	0.00	5.38
Kerala		0.47	5.40	6.09	16.76	0.63	0.00	4.24
Madhya Pradesh		1.50	3.91	4.75	9.72	0.37	3.87	6.90
Tamil Nadu		1.75	5.71	8.66	15.36	0.73	4.59	4.15
Maharashtra		0.79	1.33	1.26	0.94	0.04	3.01	2.51
Karnataka		0.29	1.18	0.56	1.30	0.05	0.00	4.59
Orissa		0.62	2.75	2.67	6.20	0.24	3.45	2.42
Punjab		2.23	6.83	9.02	18.86	0.90	0.00	1.87
Rajasthan		1.60	4.56	5.35	11.28	0.38	0.00	10.73
Uttar Pradesh		0.99	3.48	6.58	11.87	0.48	0.00	4.93
West Bengal		0.70	5.93	6.63	14.24	0.64	4.14	3.92
Delhi		1.29	7.77	9.39	18.57	2.31	0.00	6.57
India		1.40	5.00	6.15	12.35	0.49	4.12	5.57

* See note to Table 7.2.

Table 7.5 : Percentage Price Increase in Sectors Due to Price Hike in Petroleum Products, 1980
 [Price for Petroleum Products: 5.432 i.e. 443.2 Per cent Increase]

Sector	Agri- culture	Manufac- turing Industries Div. 2	Manufac- turing Industries Div. 3	Trans- port	Fire- wood	Coal *	Electri- city
State							
Andhra Pradesh	2.20	5.12	8.00	16.41	0.44	5.52	16.57
Assam	0.72	5.55	7.48	12.14	0.49	6.08	46.21
Bihar	2.10	3.93	6.10	10.03	0.44	4.85	9.61
Gujarat	1.78	6.63	7.28	10.29	0.46	0.00	6.97
Kerala	0.60	7.00	7.88	21.71	0.82	0.00	5.50
Madhya Pradesh	1.95	5.06	6.16	12.59	0.48	5.02	8.93
Tamil Nadu	2.27	7.40	11.22	19.82	0.95	5.94	5.38
Maharashtra	1.02	1.72	1.64	1.22	0.06	3.89	3.25
Karnataka	0.38	1.53	0.73	1.68	0.06	0.00	5.95
Orissa	0.81	3.56	3.46	8.04	0.24	3.45	2.42
Punjab	2.89	8.85	11.69	24.44	1.17	0.00	2.43
Rajasthan	2.07	5.91	6.93	14.62	0.49	0.00	13.90
Uttar Pradesh	1.28	4.51	8.52	15.38	0.63	0.00	6.39
West Bengal	0.91	7.68	8.59	18.44	0.83	5.36	5.07
Delhi	1.67	10.07	12.16	24.05	3.00	0.00	8.51
India	1.82	6.47	7.97	16.00	0.64	5.34	7.22

* See note to Table 7.2.

Table 7.6 : Percentage Price Increase in Sectors Due to Price Hike in Petroleum Products, 1981
 [Price for Petroleum Products: 7.466 i.e. 646.6 Per Cent Increase]

State	Sector	Agri- culture	Manufac- turing Industries Div. 2	Manufac- turing Industries Div. 3	Trans- port	Fire- wood	Coal *	Electri- city
Andhra Pradesh		3.22	7.47	11.68	23.95	0.64	8.05	24.17
Assam		1.06	8.10	10.91	17.71	0.72	8.87	67.41
Bihar		3.06	5.74	8.90	14.63	0.64	7.07	14.02
Gujarat		2.59	9.67	10.62	15.01	0.68	0.00	10.18
Kerala		0.89	10.21	11.50	31.68	1.19	0.00	8.02
Madhya Pradesh		2.84	7.39	8.99	18.37	0.71	7.32	13.03
Tamil Nadu		3.31	10.80	16.37	28.92	1.38	8.67	7.85
Maharashtra		1.50	2.51	2.39	1.78	0.08	5.68	4.75
Karnataka		0.56	2.24	1.06	2.45	0.09	0.00	8.68
Orissa		1.18	5.20	5.05	11.73	0.44	6.52	4.57
Punjab		4.22	12.91	17.06	35.65	1.71	0.00	3.54
Rajasthan		3.02	8.62	10.11	21.33	0.71	0.00	20.28
Uttar Pradesh		1.87	6.58	12.44	22.44	0.91	0.00	9.32
West Bengal		1.33	11.20	12.54	26.91	1.22	7.82	7.40
Delhi		2.43	14.69	17.74	35.09	4.37	0.00	12.41
India		2.65	9.44	11.63	23.35	0.93	7.79	10.53

* See note to Table 7.2.

price rise in Agriculture sector of India as a whole is 0.0119 per cent and that in Andhra Pradesh is 0.0144 per cent. Further tables present the consequent price rise in different sectors for price rises of Petroleum Products by 261.2 per cent in 1975, 342.1 per cent in 1977, 443.2 per cent in 1980 and 646.6 per cent in 1981 respectively when compared with the 1965 Petroleum Price as base price.

To study the relative position of each region with reference to the differential impact of price rise in Petroleum Products over the time span, we calculate a new relative price index, which is a ratio of percentage price increase of a region to that of all India. Consider the following for illustration. For 1970, when Petroleum prices increased by 2.9 per cent, uniformly across the country, the all India Agriculture price increased by 0.0119 per cent, while the said price rise for Andhra Pradesh was 0.0144 per cent. Hence the relative index for Andhra Pradesh in Agriculture sector works out as $(0.0144/0.0119) \cdot 100$. However, in the present situation, when we have the same technological structure over the period and have only one exogenous sector, the relative price increase with all India as 100, turns out to be the same over the different time periods. The relevant relative price change indices for each of the States for different sectors are evaluated and presented in Table 7.7.

A value of the index, if less than 100, indicates relatively lower increase in a sector's price, while the same when greater than 100, suggests relatively higher rise in the sector's

Table 7.7 : Sectoral Price Change Indices at Regional Level (Based on 7 Sector Model)

State	Sector						
	Agri- culture	Manufac- turing Div. 2	Manufac- turing Div. 3	Transport	Firewood	Coal	Electricity
Andhra Pradesh	121	79	100	103	69	103	229
Assam	40	86	94	76	77	114	640
Bihar	115	61	77	63	69	91	133
Gujarat	98	103	91	64	72	-	97
Kerala	33	108	99	136	128	-	76
Madhya Pradesh	107	78	77	79	75	94	124
Tamil Nadu	125	114	141	124	148	111	75
Maharashtra	56	27	21	8	9	73	45
Karnataka	21	24	9	11	9	-	82
Orissa	45	55	43	50	38	65	34
Punjab	159	137	147	153	183	-	34
Rajasthan	114	91	87	91	77	-	193
Uttar Pradesh	70	70	107	96	98	-	89
West Bengal	50	119	108	115	130	100	70
Delhi	92	156	153	150	469	-	118
India	100	100	100	100	100	100	100

price. Looking at the Table 7.7, we find that for the Agriculture sector, Punjab shows the highest value of the price change index (159), indicating its highest use of Petroleum Products in Agriculture. The other States with relatively high price rise for Agriculture sector are Andhra Pradesh, Bihar, Madhya Pradesh, Tamil Nadu and Rajasthan. Kerala shows the lowest price rise (33) for the Agriculture sector. Comparing regional price change indices for the Manufacturing Division 2, it is observed that Gujarat, Kerala, Tamil Nadu, Punjab, West Bengal and Delhi have relatively larger price rise when compared with the country as a whole. Maharashtra and Karnataka have the lowest value on the said index, indicating their relative advantage with respect to the price rise. For the Manufacturing Division 3, Tamil Nadu, Punjab, West Bengal and Delhi have higher price rise than the average. Karnataka shows the lowest value on the relative price change index for the said Manufacturing Division 3.* The Coal sector does not show any significant variation in its relative price change index across regions. Assam, however, has the highest index, though it has very small production share in Coal. The price rise in Petroleum Products sector has a differential impact on Electricity Generation sector. The highest impact is observed in Assam (640), followed by Andhra Pradesh and Rajasthan. The States of Orissa

* Since the coverage of the Transport sector is not uniform at the regional level, the technologies referred to, do not reflect the real price impact of Petroleum price hike. Hence the results of the Transport sector are not discussed in the present analysis.

and Punjab show the lowest price rise in Electricity Generation sector in comparison with all India.

The above results, broadly show that coal-based States viz. Bihar, Madhya Pradesh, Orissa and also Karnataka are less affected by the price hike in Petroleum Products than the other States. On the other hand, in case of the following non-coal based States of Gujarat, Kerala, Tamil Nadu and Delhi, a significant impact of the said price hike is observed. The differential impact of price hike analysed above is to a large extent due to the changes in the product-mix of a given sector across regions.

7.2.2 Differential Price Impacts on 4 Sector Model

We now discuss the results of the four sector model where all energy sectors are made exogenous. As the prices of different fuels have not changed uniformly and as the fuel mix is different in different regions, the effect of energy price changes, has differential impact on the prices of other sectors, over a period of time, for different regions. As a consequence the relative position of a State may change over time. The results of the percentage price rise in different non-energy sectors, due to price hike in all the energy sectors are presented in Tables 7.8 to 7.12.

To study the differential impact of energy price hike on different regions over the time period, similar relative price change indices, with all India price rise as 100, have been calculated. It is observed that, though the basic input structure remains the same, due to differential price increase in the four

Table 7.8 : Percentage Price Increase in Economic Sectors Due to Price Hike of Energy, 1970

	<u>Firewood</u>	<u>Coal</u>	<u>Petroleum Products</u>	<u>Electricity</u>
Price Vector :	1.539	1.395	1.029	1.229
(Value in Percentage)				
State	Sector			
	Agri- culture	Manufa- cturing Div. 2	Manufa- cturing Div. 3	Trans- port
Andhra Pradesh	0.36	1.36	2.81	2.57
Assam	0.11	0.56	2.30	1.61
Bihar	0.29	1.45	5.04	3.32
Gujarat	0.40	1.97	1.80	2.04
Kerala	0.04	1.33	1.99	0.87
Madhya Pradesh	0.46	2.61	5.10	2.84
Tamil Nadu	0.28	1.28	1.42	1.05
Maharashtra	0.23	0.94	0.99	1.57
Karnataka	0.12	1.50	0.97	0.82
Orissa	0.21	3.81	3.20	1.60
Punjab	0.27	1.46	1.82	2.00
Rajasthan	0.32	1.63	2.83	2.23
Uttar Pradesh	0.24	1.19	3.57	2.30
West Bengal	0.11	1.85	2.70	1.82
Delhi	0.16	0.86	0.81	0.50
India	0.29	1.68	2.65	2.12

Table 7.9 : Percentage Price Increase in Economic Sectors Due to Price Hike of Energy, 1975

	<u>Firewood</u>	<u>Coal</u>	<u>Petroleum Products</u>	<u>Electricity</u>
Price Vector :	2.726	2.381	3.612	1.887
(Value in Percentage)				

	Sector			
State	-----	-----	-----	-----
	Agri- culture	Manufa- cturing Div. 2	Manufa- cturing Div. 3	Trans- port
	-----	-----	-----	-----
Andhra Pradesh	2.48	7.48	14.16	18.09
Assam	0.78	4.99	11.50	12.32
Bihar	2.20	7.22	20.82	17.16
Gujarat	2.37	10.62	10.45	12.98
Kerala	0.47	8.47	11.42	15.34
Madhya Pradesh	2.69	11.73	20.91	16.91
Tamil Nadu	2.30	8.60	11.33	14.85
Maharashtra	1.38	4.27	4.40	6.11
Karnataka	0.62	5.92	3.62	3.77
Orissa	1.18	14.46	13.12	10.14
Punjab	2.58	10.09	13.00	20.84
Rajasthan	2.29	8.99	13.75	16.07
Uttar Pradesh	1.57	6.67	16.77	16.64
West Bengal	0.90	10.80	14.18	16.78
Delhi	1.51	8.74	9.70	15.38
	-----	-----	-----	-----
India	2.02	9.45	13.65	16.36
	-----	-----	-----	-----

Table 7.10 : Percentage Price Increase in Economic Sectors Due to Price Hike of Energy, 1977

	<u>Firewood</u>	<u>Coal</u>	<u>Petroleum Products</u>	<u>Electricity</u>
Price Vector :	3.065	2.756	4.421	2.205
(Value in Percentage)				

	Sector			
State	-----	-----	-----	-----
	Agri- culture	Manufa- cturing Div. 2	Manufa- cturing Div. 3	Trans- port
	-----	-----	-----	-----
Andhra Pradesh	3.22	9.63	18.39	23.43
Assam	1.01	6.45	14.64	15.92
Bihar	2.86	9.34	26.76	22.19
Gujarat	3.05	13.72	13.56	16.80
Kerala	0.61	10.86	14.80	20.01
Madhya Pradesh	3.47	14.99	26.70	21.85
Tamil Nadu	3.04	11.34	14.79	19.36
Maharashtra	1.78	5.52	5.69	7.81
Karnataka	0.80	7.44	4.48	4.81
Orissa	1.52	17.82	16.89	13.13
Punjab	3.36	13.03	16.84	27.06
Rajasthan	2.97	11.62	17.76	20.80
Uttar Pradesh	2.03	8.59	21.17	21.47
West Bengal	1.17	14.02	18.29	21.85
Delhi	2.00	11.45	12.67	20.12
	-----	-----	-----	-----
India	2.62	12.23	17.65	21.22
	-----	-----	-----	-----

Table 7.11 : Percentage Price Increase in Economic Sectors Due to Price Hike of Energy, 1980

	<u>Firewood</u>	<u>Coal</u>	<u>Petroleum Products</u>	<u>Electricity</u>
Price Vector :	3.963	4.679	5.432	2.874
(Value in Percentage)				
	Sector			
State	Agri- culture	Manufa- cturing Div. 2	Manufa- cturing Div. 3	Trans- port
Andhra Pradesh	5.18	15.65	31.77	38.60
Assam	1.58	9.71	22.38	25.53
Bihar	4.53	16.22	51.05	39.22
Gujarat	4.78	22.47	22.23	28.09
Kerala	0.86	15.80	22.02	27.76
Madhya Pradesh	5.84	25.38	48.98	37.07
Tamil Nadu	4.42	16.73	22.14	27.91
Maharashtra	2.96	9.47	10.01	15.48
Karnataka	1.27	11.79	7.11	8.54
Orissa	2.50	27.41	31.96	21.79
Punjab	5.04	20.31	26.18	41.13
Rajasthan	4.77	19.54	30.66	34.00
Uttar Pradesh	3.15	13.47	31.89	33.78
West Bengal	1.81	22.12	30.94	33.46
Delhi	2.80	16.58	17.79	26.85
India	4.13	19.60	29.89	33.95

Table 7.12 : Percentage Price Increase in Economic Sectors Due to Price Hike of Energy, 1981

	<u>Firewood</u>	<u>Coal</u>	<u>Petroleum Products</u>	<u>Electricity</u>
Price Vector :	4.799	5.857	7.466	3.313
(Value in Percentage)				
	Sector			
State	Agri- culture	Manufa- cturing Div. 2	Manufa- cturing Div. 3	Trans- port
Andhra Pradesh	7.08	21.10	42.42	53.02
Assam	2.17	13.50	29.85	35.27
Bihar	6.23	21.70	67.74	52.76
Gujarat	6.48	30.15	29.97	38.32
Kerala	1.21	21.44	29.38	39.52
Madhya Pradesh	7.92	33.69	64.87	50.39
Tamil Nadu	6.01	22.58	30.33	39.47
Maharashtra	4.01	12.52	13.25	20.54
Karnataka	1.70	15.41	9.30	11.45
Orissa	3.38	35.95	42.28	29.67
Punjab	7.00	27.80	35.83	57.60
Rajasthan	6.54	26.35	40.89	46.77
Uttar Pradesh	4.27	18.11	42.38	46.48
West Bengal	2.50	29.72	41.56	46.45
Delhi	3.82	22.97	24.90	38.69
India	5.64	26.33	40.03	48.82

energy sectors, any given region shows different relative positions over the time period, when compared with all India. The sectorwise relative indices for each region for the five time points are presented in Table 7.13, and the results based on them are discussed below.

The results show that those States having Coal as the major source of energy viz. Bihar, Madhya Pradesh and Orissa, scored a relative advantage in their sectoral price increases, when Petroleum prices alone increased, during the period 1975 to 1977, as seen by the decline in their price change indices. After 1977, they showed again an upward trend, because of the price rise in Coal also. In Agriculture and Mining sector the price change indices at regional level change significantly from 1970 to 1975 and thereafter remain more or less the same. The major fuel used in this sector is Petroleum and to a lesser extent Electricity. Use of other fuels is negligible. Because of the massive hike of Petroleum prices in 1973, Tamil Nadu and Punjab, whose Agriculture price rise from 1965 to 1970 is less than All India price rise, show in 1975 a greater than all India price rise. The other States which show an increase in the relative price change index from 1970 to 1975 are Bihar, Kerala, West Bengal and Delhi, while Gujarat, Madhya Pradesh, Maharashtra, Karnataka and Orissa show a substantial decline. This must be because of larger Petroleum input relative to all India in the former group of States, while the Petroleum input in Agriculture is lower compared to all India in the latter group of States. The index for other States remain more or less the same.

Madhya Pradesh, Karnataka, Orissa and Maharashtra are the four States which seem to have improved their relative positions with respect to India in all the manufacturing sectors as seen from the declining movement of the price change indices over the time. Bihar and Uttar Pradesh are also found to have improved their position significantly in the Manufacturing Division 3 and marginally in Division 2. Assam, Gujarat and Rajasthan showed the improvement in their relative position in some sectors and deterioration in the remaining ones. On the other hand, Tamil Nadu, Punjab, West Bengal and Delhi are the four States whose relative position is seen to have deteriorated in the entire Manufacturing Division. The sectors in Andhra Pradesh and Kerala do not show any change in their relative positions due to price hike in the energy sectors.

7.3 Results of the Impact Analysis

Comparing the sectoral price change indices between the two models discussed above, the following observations may be made. While the price change indices of the same order in magnitude on both the models indicate that Petroleum Products are a major source of energy in a given region, the differential magnitude of the said indices indicate otherwise. The Agriculture sector shows that the price change indices are nearly the same in both the models as Petroleum Products are the major source of energy used in Agriculture. When the Petroleum sector alone is exogenous the price rise in the Manufacturing Division is larger than that when all energy sectors are exogenous, for the following regions: Assam, Kerala, Tamil Nadu, Punjab and

Delhi. The opposite situation is observed in the case of Bihar, Madhya Pradesh, Maharashtra, Karnataka and Orissa. Thus the price hike in energy, naturally affects the prices of various sectors differently depending upon its fuel use and the composition of fuel use. What is more significant is, because of differences in fuel mix amongst regions and differential variation in prices of different fuels, the price of a given sector's output varies differently across regions. The large hike in Petroleum prices has improved the comparative position of the Coal-based States like Orissa, Bihar and Madhya Pradesh and these States also happen to be less developed. Whether this favourable aspect has actually been taken advantage of is a different matter. The subsequent increases in Coal and other fuel prices have to an extent diminished the advantage gained initially as a result of Petroleum price hike. While pricing of Coal has to depend mainly on the costs of extraction of it, its impact on the industrial development of Coal producing States, which also happen to have a relatively larger consumption of it, should also be one of the important considerations in its pricing policy.

APPENDIX 7.1

As mentioned in the introduction of the Chapter 5, the consequence of energy price rise can be that the rate of growth of industries, with high energy intensity, is reduced, thus effecting a change in the output composition of the industrial sector. As the energy price rise is not the only reason for the change in the sectoral output levels, a direct comparison between the output compositions at different time periods is not of much relevance. Hence to examine the effect of energy price hike on the structure of the economy in terms of output composition, energy intensities of certain activities are studied over the period below.

The analysis is based on the four input-output tables viz. 1968-69,⁴ 1973-74,⁵ 1979-80⁶ and 1983-84;⁷ out of which the last table is a projected transaction matrix based on the 1979-80 Table. The original input-output tables are aggregated to seven sectors; of which four sectors relate to the major economic activities viz. Primary sector, Manufacturing

4 "Inter-industry transactions, 1968-69," National Accounts Statistics, 1970-71—1975-76, January 1978, Central Statistical Organization, Government of India, New Delhi, p. 123.

5 'National Accounts Statistics, 1970-71 to 1978-79,' Central Statistical Organization (C.S.O.), Government of India, 1981, p. 103.

6 'A Technical Note on the Sixth Plan of India (1980-85),' Planning Commission, Government of India, 1981.

7 Ibid.

Division 2, Manufacturing Division 3 and Others, and the remaining three sectors relate to the energy sector viz. Coal, Electricity and Petroleum Products. Since the transaction matrices are available in the monetary units, the energy intensities, obtained, will be in value terms, which do not reflect the "real" comparison between the energy intensities over the period, because of the price element involved. To overcome this difficulty, the sectoral energy intensities, expressed in value terms are converted to physical energy intensities expressed in TCR units as follows:

Energy consumption of a fuel in TCR units

$$= \frac{(\text{Energy consumption in money terms at given prices}) \times 100}{(\text{Price index of a fuel with 1970-71} = 100)} \cdot \frac{(\text{TCR equivalent per unit of a fuel})}{(\text{Price of a fuel per unit of it in 1970})}$$

While the prices and price indices for Coal and Electricity are directly available, a weighted price and price index are worked out for Petroleum Products.⁸ The price indices are also evaluated with 1970-71 = 100 as the base.⁹ The output figures are deflated with these price indices and the energy intensities are estimated in TCR units per thousand rupees of output at 1970-71 prices for each activity. These intensities, together with fuelwise consumption share at the sectoral level are

⁸ Chandhok, H.L., 'Wholesale Price Statistics - India 1947-78,' Vol. I, Economic and Scientific Research Foundation, New Delhi, India, 1978.

⁹ 'Wholesale Price Index Number,' Ministry of Commerce and Industry, Office of the Economic Advisers, Government of India, New Delhi.

presented in Table A7.1. Based on the above, the following observations may be made.

Table A7.1 : Sectoral Energy Intensities and Fuelwise Consumption Shares

Year	Energy Intensity TCR/000 Rs.	Coal % share	Petroleum Products % share	Electricity % share
<u>Agriculture and Mining</u>				
1968-69	0.052238	4.4	68.4	27.3
1973-74	0.153707	0.4	74.1	25.5
1979-80	0.157598	2.3	87.5	10.2
1983-84*	0.371514	1.5	87.8	10.7
<u>Manufacturing Division 2</u>				
1968-69	0.264324	31.3	22.7	46.0
1973-74	0.257398	26.4	31.2	42.4
1979-80	0.418378	15.3	50.7	34.0
1983-84*	0.456789	15.0	51.9	33.1
<u>Manufacturing Division 3</u>				
1968-69	0.853419	61.4	19.5	19.1
1973-74	0.660104	43.1	29.5	27.4
1979-80	0.650718	44.2	33.1	22.8
1983-84*	0.669790	42.9	32.3	24.8

Note : * The intensities are based on the projected transaction tables.

The primary sector indicates that the energy intensity is increasing considerably over the period 1968-69 to 1979-80. The projected value also indicates a high rate of growth in its energy intensity. The expansion of mining activity and the technological progress in the Agriculture sector are the possible

reasons for such increase in the energy intensity of the primary sector. The consumption share of each fuel over the period, indicates a clear trend that Electricity is being substituted by Petroleum Products. The Manufacturing Division 2, shows a steady growth in its energy intensity, indicating no significant change in the structure of the said sector. The consumption shares of both Coal and Electricity are declining and that of Petroleum Products is increasing.

The results obtained in case of Manufacturing Division 3, which contains the maximum share of HFU industries, are different from the ones, noted above. The energy intensity for this division seems to have declined from 1968-69 to 1979-80, which seems to substantiate the widespread belief that the rate of growth of HFU industries has gone down due to energy crisis. The composition of energy consumption also does not show any sharp increase in the consumption of Petroleum Products as in the case of the other two sectors. While Coal shows a marginal decline, Electricity shows a marginal increase in its consumption share.

One also feels from the above Table A₇.1, that the technological substitutions between fuels have not taken place in the desired direction in the economy as a whole. Secondly, the relative output levels have altered only in case of HFU industries in the economy.

Table A7.2 : regional (Energy Specific) Input-Output Coefficient Matrices

Sector	Sector	1	2	3	4	5	6	7	8
<u>State : Andhra Pradesh</u> ✓									
1. Agriculture and other primary sectors		0.113330	0.420456	0.073252	-	0.000105	-	0.621831	-
2. Manufacturing Div. 2		0.009976	0.116700	0.050691	0.015745	0.003057	-	-	-
3. Manufacturing Div. 3		0.016276	0.015576	0.181913	0.132304	0.001525	0.052415	-	-
4. Others*		0.082612	0.176525	0.284797	0.210808	0.025156	0.064449	-	0.256774
5. Firewood		0.000380	0.005289	0.001026	-	0.001652	0.022291	0.057438	-
6. Coal		-	0.003355	0.022664	0.037941	-	-	-	0.110417
7. Petroleum Products		0.000906	0.001024	0.002146	0.026085	-	0.008247	0.000526	0.022998
8. Electricity		0.001146	0.005775	0.022603	0.002626	-	0.022675	0.003267	0.093689
<u>State : Assam</u> ✓									
1. Agriculture and other primary sectors		0.084066	0.580340	0.011644	-	0.000101	-	0.621840	-
2. Manufacturing Div. 2		0.006772	0.055000	0.010700	0.017647	0.002850	-	-	-
3. Manufacturing Div. 3		0.009638	0.005800	0.253983	0.100646	0.001400	0.050837	-	-
4. Others*		0.039910	0.122158	0.289598	0.173883	0.038238	0.056500	0.079470	0.423593
5. Firewood		0.000007	0.001712	0.015447	-	0.000715	0.023272	-	-
6. Coal		-	0.002948	0.001416	0.026214	-	-	-	-
7. Petroleum Products		0.000098	0.007300	0.002914	0.020350	-	0.008247	0.000526	0.090226
8. Electricity		0.000564	0.000942	0.014906	-	-	0.029121	0.004196	0.023296
<u>State : Bihar</u> ✓									
1. Agriculture and other primary sectors		0.142531	0.362719	0.028279	-	0.000239	-	0.621924	0.000321
2. Manufacturing Div. 2		0.005034	0.128300	0.008091	0.026128	0.001271	-	-	0.000094
3. Manufacturing Div. 3		0.003132	0.023940	0.172121	0.153840	0.001265	0.052825	-	-
4. Others*		0.058480	0.183423	0.319609	0.189984	0.042722	0.060854	0.022442	0.238623
5. Firewood		0.000223	0.001388	0.001056	-	0.001012	0.022242	-	-
6. Coal		-	0.005393	0.069260	0.038833	-	-	-	0.050169
7. Petroleum Products		0.002629	0.001360	0.002932	0.015266	-	0.008247	0.000526	0.007689
8. Electricity		0.000641	0.005772	0.012660	0.013033	-	0.025780	0.003714	0.371145

* This sector contains the transport sector.

(continued)

Table A7.2 : (continued)

Sector	Sector	1	2	3	4	5	6	7	8
<u>State : Gujarat</u> ✓									
1. Agriculture and other primary sectors		0.162085	0.119554	0.026320	-	0.000033	-	0.621945	0.000167
2. Manufacturing Div. 2		0.022679	0.257600	0.104233	0.023144	0.002206	-	-	0.000004
3. Manufacturing Div. 3		0.010649	0.078602	0.189334	0.173555	0.000498	-	-	-
4. Others*		0.073049	0.274230	0.271905	0.231729	0.043417	-	0.080335	0.270961
5. Firewood		0.001700	0.004349	0.001712	-	0.001940	-	-	0.000025
6. Coal		-	0.005897	0.008171	0.027191	-	-	-	0.145042
7. Petroleum Products		0.001132	0.002798	0.005158	0.014573	-	-	0.000526	0.008319
8. Electricity		0.001090	0.010470	0.011278	0.003936	-	-	0.003232	0.071659
<u>State : Kerala</u> ✓									
1. Agriculture and other primary sectors		0.039265	0.286710	0.066152	-	0.002829	-	-	-
2. Manufacturing Div. 2		0.002845	0.161300	0.080143	0.024844	0.000087	-	-	-
3. Manufacturing Div. 3		0.003070	0.022858	0.172674	0.126116	0.010940	-	-	-
4. Others*		0.020850	0.211678	0.233802	0.217339	0.033430	-	-	0.190413
5. Firewood		0.000002	0.010167	0.009407	-	0.001163	-	-	0.000036
6. Coal		-	0.002823	0.004433	0.007300	-	-	-	-
7. Petroleum Products		0.000191	0.001942	0.001539	0.035708	-	-	-	0.000553
8. Electricity		0.000262	0.009122	0.028298	0.000252	-	-	-	0.203046
<u>State: Madhya Pradesh</u> ✓									
1. Agriculture and other primary sectors		0.252661	0.265961	0.044119	-	0.000535	-	-	0.001334
2. Manufacturing Div. 2		0.012836	0.216400	0.053464	0.015108	0.001111	-	-	-
3. Manufacturing Div. 3		0.007933	0.070087	0.104415	0.116599	0.001825	0.047175	-	-
4. Others*		0.091826	0.186161	0.260245	0.205915	0.036977	0.067683	-	0.269638
5. Firewood		0.000006	0.009108	0.012064	-	0.000488	0.023103	-	-
6. Coal		-	0.007731	0.066696	0.035345	-	-	-	0.150850
7. Petroleum Products		0.000416	0.001213	0.003148	0.020218	-	0.008247	-	0.010102
8. Electricity		0.000309	0.010239	0.016517	0.007341	-	0.023518	-	0.033895

(continued)

Table A7.2 : (continued)

Sector	Sector	1	2	3	4	5	6	7	8
<u>State : Tamil Nadu</u> ✓									
1. Agriculture and other primary sectors		0.141893	0.170648	0.031513	-	0.004509	-	-	-
2. Manufacturing Div. 2		0.016529	0.277400	0.043357	0.024768	0.005183	-	-	-
3. Manufacturing Div. 3		0.016915	0.025038	0.243483	0.143625	0.001830	0.043096	-	-
4. Others*		0.052894	0.203148	0.294051	0.230447	0.044142	0.070826	-	0.156612
5. Firewood		0.000051	0.004191	0.002358	-	0.002139	0.022491	-	-
6. Coal		-	0.000861	0.005601	0.011996	-	-	-	0.078828
7. Petroleum Products		0.001255	0.001262	0.004853	0.030204	-	0.008247	-	0.001983
8. Electricity		0.005835	0.015952	0.014763	0.000454	-	0.070826	-	0.172095
<u>State : Maharashtra</u> ✓									
1. Agriculture and other primary sectors		0.202934	0.136540	0.018651	-	0.000493	-	0.372552	0.000524
2. Manufacturing Div. 2		0.011077	0.188100	0.051675	0.019139	0.001426	-	-	-
3. Manufacturing Div. 3		0.012404	0.049884	0.259538	0.161950	0.000485	0.040905	-	-
4. Others*		0.078662	0.247102	0.281403	0.215506	0.043392	0.072977	0.332549	0.218689
5. Firewood		0.000225	0.001771	0.001260	-	0.000697	0.023323	-	0.000003
6. Coal		-	0.000289	0.000583	0.026598	-	-	-	0.046253
7. Petroleum Products		0.001529	0.001916	0.001664	0.001255	-	0.008247	0.000251	0.004812
8. Electricity		0.000885	0.007898	0.006346	-	-	0.025082	0.009349	0.206891
<u>State : Karnataka</u> ✓									
1. Agriculture and other primary sectors		0.137330	0.214296	0.035014	-	0.001581	-	-	0.000007
2. Manufacturing Div. 2		0.008105	0.200900	0.027819	0.015622	0.003756	-	-	-
3. Manufacturing Div. 3		0.012184	0.034683	0.189344	0.162571	0.008791	-	-	-
4. Others*		0.059470	0.210234	0.254608	0.215813	0.030435	-	-	0.205885
5. Firewood		0.000088	0.011559	0.008778	-	0.000188	-	-	-
6. Coal		-	0.003945	0.000725	0.011030	-	-	-	-
7. Petroleum Products		0.000457	0.001617	0.000219	0.002645	-	-	-	0.008320
8. Electricity		0.000933	0.008066	0.001336	0.000685	-	-	-	0.322168

(continued)

Table A.2: (continued)

Sector	Sector	1	2	3	4	5	6	7	8
<u>State : Orissa</u> ✓									
1. Agriculture and other primary sectors		0.150065	0.230026	0.054925	-	0.000661	-	-	-
2. Manufacturing Div. 2		0.008351	0.100600	0.009275	0.018644	0.003194	-	-	-
3. Manufacturing Div. 3		0.006320	0.039908	0.099346	0.093310	0.002662	0.047257	-	-
4. Others*		0.072091	0.287846	0.250660	0.129490	0.035273	0.071760	-	0.264831
5. Firewood		0.000146	0.047882	0.000286	-	0.000039	0.023766	-	-
6. Coal		-	0.003992	0.052089	0.020764	-	-	-	-
7. Petroleum Products		0.000132	0.001192	0.001681	0.014649	-	0.008247	-	0.001030
8. Electricity		0.000110	0.001854	0.015692	0.007179	-	0.020734	-	0.175166
<u>State : Punjab</u> ✓									
1. Agriculture and other primary sectors		0.173055	0.323445	0.026396	-	0.001746	-	-	0.000015
2. Manufacturing Div. 2		0.012205	0.165100	0.025822	0.033388	0.002648	-	-	-
3. Manufacturing Div. 3		0.012181	0.035387	0.289382	0.158360	0.001361	-	-	-
4. Others*		0.069098	0.233453	0.305867	0.262479	0.045888	-	-	0.079213
5. Firewood		0.000066	0.004576	0.003697	-	0.003092	-	-	-
6. Coal		-	0.005379	0.005025	0.026084	-	-	-	-
7. Petroleum Products		0.001012	0.000713	0.001127	0.035817	-	-	-	0.000014
8. Electricity		0.001540	0.006147	0.010246	0.000209	-	-	-	0.199599
<u>State : Rajasthan</u> ✓									
1. Agriculture and other primary sectors		0.0245290	0.255335	0.030540	-	0.003090	-	-	0.000041
2. Manufacturing Div. 2		0.009921	0.260700	0.040373	0.022592	0.001715	-	-	-
3. Manufacturing Div. 3		0.007267	0.020487	0.211358	0.129990	0.003761	-	-	-
4. Others*		0.080565	0.197404	0.268335	0.212154	0.030290	-	-	0.245241
5. Firewood		0.000200	0.001909	0.004180	-	0.001966	-	-	0.000053
6. Coal		-	0.008956	0.023082	0.031291	-	-	-	0.065882
7. Petroleum Products		0.000596	0.001613	0.002228	0.023583	-	-	-	0.021600
8. Electricity		0.000654	0.006996	0.018142	0.002124	-	-	-	0.053453

(continued)

Table A7.2 : (continued)

Sector	Sector	1	2	3	4	5	6	7	8
<u>State : Uttar Pradesh</u> ✓									
1. Agriculture and other primary sectors		0.163940	0.347163	0.026773	-	0.001043	-	-	0.000374
2. Manufacturing Div. 2		0.013288	0.157700	0.026645	0.027121	0.001878	-	-	-
3. Manufacturing Div. 3		0.006773	0.029255	0.259549	0.152056	0.002372	-	-	0.000002
4. Others*		0.053267	0.171466	0.292493	0.234847	0.038703	-	-	0.303500
5. Firewood		0.000005	0.002958	0.028028	-	0.000637	-	-	0.000014
6. Coal		-	0.002279	0.001319	0.026613	-	-	-	0.072262
7. Petroleum Products		0.000286	0.000945	0.003477	0.023309	-	-	-	0.002639
8. Electricity		0.001649	0.007434	0.015775	0.002725	-	-	-	0.086256
<u>State : West Bengal</u> ✓									
1. Agriculture and other primary sectors		0.085547	0.110577	0.027431	-	0.000368	-	-	0.002924
2. Manufacturing Div. 2		0.009139	0.365100	0.029674	0.014634	0.001025	-	-	-
3. Manufacturing Div. 3		0.007246	0.032676	0.257288	0.122850	0.001673	0.049547	-	0.000137
4. Others*		0.034356	0.192026	0.264781	0.191366	0.043917	0.060673	-	0.153470
5. Firewood		0.000017	0.003835	0.004349	-	0.001373	0.024168	-	-
6. Coal		-	0.005083	0.024193	0.021058	-	-	-	0.143724
7. Petroleum Products		0.000154	0.001924	0.002379	0.030660	-	0.008247	-	0.001158
8. Electricity		0.000050	0.013574	0.011570	0.008511	-	0.027601	-	0.188205

(continued)

Table A7.2 : (continued)

Sector	Sector	1	2	3	4	5	6	7	8
<u>State : Delhi</u> ✓									
1. Agriculture and other primary sectors		0.075576	0.129636	0.025801	-	-	-	-	0.000734
2. Manufacturing Div. 2		0.007966	0.345300	0.031810	0.022532	0.005573	-	-	-
3. Manufacturing Div. 3		0.004265	0.051650	0.268255	0.228549	0.005625	-	-	0.000002
4. Others*		0.024260	0.227689	0.309682	0.308281	0.118751	-	-	0.205685
5. Firewood		0.000015	0.000480	0.002095	-	0.005469	-	-	0.000713
6. Coal		-	0.004184	0.002903	0.001369	-	-	-	0.075706
7. Petroleum Products		0.001763	0.000450	0.002297	0.030756	-	-	-	0.005268
8. Electricity		0.005020	0.008411	0.007435	-	-	-	-	0.143499
<u>All India</u> ✓									
1. Agriculture and other primary sectors		0.145557	0.209961	0.031169	-	0.000745	-	0.461020	0.000847
2. Manufacturing Div. 2		0.010752	0.226900	0.037532	0.021702	0.002051	-	-	0.000005
3. Manufacturing Div. 3		0.011449	0.041475	0.234122	0.142258	0.002581	0.045136	-	0.000024
4. Others*		0.070025	0.207903	0.267052	0.215221	0.037563	0.067336	0.241954	0.189572
5. Firewood		0.000266	0.004340	0.003804	-	0.000788	0.020750	-	0.000031
6. Coal		-	0.004399	0.020482	0.027554	-	-	-	0.081749
7. Petroleum Products		0.000590	0.001925	0.002939	0.025069	-	0.008305	0.000349	0.005401
8. Electricity		0.001365	0.011897	0.015988	0.003813	-	0.028474	0.008304	0.187473

CHAPTER 8

SUMMARY AND CONCLUSIONS

The awareness of the exhaustibility of natural resources that gained ground during the sixties led to serious efforts for conservation of these resources as far as possible. In the case of Energy, the awareness was translated firstly by attempting to save it by more efficient utilization and secondly by finding new non-conventional energy resources. The latter attempt is still in its infant stage and so far very little has been achieved in rendering any non-conventional energy source as a new commercial source of energy. But serious efforts are being made towards the energy saving aspect by technological renovations and improvements. As India is a very vast country and different supply and demand situations across the region in the case of energy exist, this study has focussed the attention on the regional dimension viz. the regional variability in the consumption. The present study has been taken up to understand the regional variability in fuel consumption and to explore the scope for energy saving.

8.1 Data Base of the Study

The study is based on the information on the large scale manufacturing industries in India for 1970. The data have been compiled from the reports of the Annual Survey of Industries. 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 these reports. There are 24 regions (i.e. States including Union Territories) for the year under study. The study has been carried out in value terms as also in energy units. The particular energy unit, chosen for the present study, is Tonne Coal Replacement (TCR).

8.2 Regional Fuel Consumption and Inter-Fuel Substitutability

It has been shown that the variation in fuel consumption of the industrial sector between regions depends, among others, on the factors like development level of a region, availability of fuels and the industry-mix. Presenting a broad picture of fuel consumption regionwise, the regional variation in fuel consumption has been confirmed by statistical tests. It is found that this variation arises mainly because of the differential pattern of availability and requirement. The impact of these factors on the regional consumption variation has been studied with the help of the six economic variables viz. production of fuels, prices of fuels, relative prices of different fuels, level of industrialization at the regional level, industry-mix of a region, and level of mechanization of a region; by using the multiple regression technique. It has been observed that the absolute fuel consumption depends on its production and price. The fuel consumption further has been found to depend on the share of industrial output. The share of heavy fuel using industries and level of mechanization have

been found to be statistically insignificant, which as argued, can be due to a statistical lacuna of comparing absolute figures with the relative one. The relation between relative consumption of fuels and their relative prices, which under certain assumptions has provided the estimates of elasticity of substitution between fuels. At the aggregate industrial level, the elasticity of substitution between a single fuel against all other fuels has shown that Coal has the highest elasticity of substitution (2.99) which is followed by Electricity (1.70) and Other Fuel Oils (1.15). For the same, the inter-fuel elasticity of substitution has indicated that the elasticity of substitution between Other Fuel Oils and Coal is the highest (3.68), followed by that between Electricity and Other Fuel Oils (2.07) and the least value of elasticity of substitution (1.48) is observed between Coal and Electricity. However, the variation in the industry-mix across regions has been a limitation in respect of these results. The results carried out at the individual industry level have indicated a similar trend, which also suffers from the limitation of product-mix. Hence, while the exact magnitudes of these elasticities cannot be accepted at their face value, the trends in these elasticities, it is hoped, will remain unaffected. Even so it has been broadly concluded that the highest substitutability exists between Other Fuel Oils and Coal. A moderate inter-fuel substitution has also been observed between Electricity and Other Fuel Oils. The substitution between Coal and Electricity has been found to be the lowest.

8.3 Regional Energy Efficiency on Physical Basis

For understanding the energy efficiency of a region, a model, which isolates the main factors influencing it viz. the energy intensity of a region and its structure or the level of industrialization, has been applied. The results regarding the intensity effect have indicated that Madhya Pradesh, Bihar, Uttar Pradesh and Orissa have been using a significantly high proportion energy to produce the same industrial income as that of all India. On the other hand, Maharashtra, Karnataka and Kerala have been found to be energy efficient States. The industry-mix naturally affects the energy intensity of a region. Hence it has been found desirable to assess the region for its energy efficiency at the individual industry level. Taking into consideration the objective of the study, the industries, which consume more than average energy per unit of its output, have been considered and they are labelled as HFU (heavy fuel using) industries. The results have shown that even at the individual industry level, Bihar, Orissa and Uttar Pradesh turn out to be energy inefficient.

For assessing the performance of a region for the energy use, the regions and the industries have been classified into a four-fold grouping on the basis of the intensity and structure effects (isolated by the model). It has been observed that about one-third value added of the total HFU industry group comes from the energy efficient regions. On the other hand, about 43 per cent income from the same group has been found to have generated from the energy inefficient group. Alcohol

(53.96 per cent), Chemical Fertilizers (74.80 per cent), Heavy Chemicals (59.35 per cent), Glass and Glass Products (78.56 per cent), Cement (66.94 per cent) and Iron and Steel (other than Basic) (76.30 per cent) are noted to be the industries which have more than half the share of their income generated by the energy efficient regions. On the other hand, Textiles (72.19 per cent) and Structural Clay Products (53.89 per cent) are noted to have their significant income generated from energy inefficient regions.

8.4 Minimum Energy Cost Locations for Industries

While physical energy saving is an important factor, a costwise consideration of energy consumption is equally important. It is felt that a region chooses a fuel technology such that it minimizes the energy cost to produce the same output, in comparison with any other region's fuel technology and fuel prices. The model developed to study this aspect has provided the actual and hypothetical costs (based on a certain fuel technology with other region's fuel prices). The comparisons of minimum costs on both considerations have indicated that the existing minimum cost is largely due to more efficient technology rather than the price advantage. In other words, it has been found that the variation in regional fuel technologies is relatively more important a factor than the regional price variation in explaining the variation in energy costs.

Before concluding about the promotion of industries in different regions on the basis of physical and cost efficiency of energy use, an exercise to obtain optimal allocations of

industries with the objective of minimum energy consumption, based on the Linear Programming technique has been carried out. The solution of the L.P. model has provided the optimal locations for each industry along with their production levels. The model by and large has picked up those locations for which the energy is minimum for a given industry as obtained by the cost exercise, discussed earlier, with some exceptions which are due to the constraints imposed in the model for the minimum industrial income level of a region. Thus broadly this model has advocated Andhra Pradesh for Alcohol industry, Punjab and Orissa for Textiles industry, Maharashtra for Paper industry, Tamil Nadu for Chemical Fertilizers industry, West Bengal for Heavy Chemicals, West Bengal and Bihar for Structural Clay Products, Haryana for Glass and Glass Products, West Bengal for Pottery—China—Earthenware industry and Maharashtra and Rajasthan for Non-Ferrous Metal industry.

The solution of the L.P. model has provided the minimum energy cost to satisfy the inter-industry demand of 1970, which has amounted to Rs. 119803 lakh. The actual cost for the same with existing allocation of industries has been worked out as Rs. 155667 lakh. This has been found to result into energy saving to the tune of Rs. 35864 lakh, which is equivalent to 23 per cent saving of energy for inter-industry use alone. It has been noted that it is not feasible or desirable to allocate any industry in only one region to minimize the energy cost. In view of this, the above results, it has been noted, need not be accepted per se, but they certainly indicate that there is

sufficient scope for energy saving in the Indian industrial sector by shifting the industrial locations.

8.5 Impact of Energy Price Hike

It has been shown that the large hike in Petroleum Products during the recent years, not only has a significant impact on the prices of the other sectors' output in the economy, but it has also led to compositional or structural change in the same. This impact has been analysed in the input-output frame. The impact of the energy price hike on the structure of the economy in terms of output composition has been studied with the help of energy intensities of economic activities over the period (1968-1983). The results have shown that the relative output levels have altered only in the case of HFU industries in the economy. At the regional level also it would have been useful to assess how the hike in energy prices has affected the composition, particularly the output-mix over time and secondly to examine how the relative position of a region as regards the price of a particular industry group has changed as a result of the hike in the energy prices. To examine the changes over time, regional input-output tables for different time periods was a prerequisite which are not available. Hence only the impact of the energy price hike on the regional prices of other sectors output has been studied. The results have shown that the energy price increase has affected the regional prices of other economic sectors differently. As a consequence it has been found that the relative advantage of a region for a given industry has changed over the

period. The large hike in Petroleum prices has been found to have improved the comparative position of the Coal based States like Orissa, Bihar and Madhya Pradesh and these States, it has been noted, happen to be less developed also. The subsequent increases in Coal and other fuel prices have to an extent been found to have diminished the advantage gained initially as a result of Petroleum price hike. While pricing of Coal has to depend mainly on the costs of its extraction it has been argued, that the impact of it on the industrial development of Coal producing States, which also happen to have a relatively larger consumption of it, should also be one of the important considerations in its pricing policy.

Table A-1 : Regionwise Prices of Each Fuel Per TCR Unit (1970, Total Industrial Sector)

State	Fuel	Coal	Coke	Coal gas	Firewood	Charcoal	Aviation and Motor Spirit	Diesel Oil	Other fuel oils	Lubricating oils	Industrial and Power Alcohol	Electricity
Andhra Pradesh		53.90	106.44	1361.45	65.15	183.14	228.32	91.42	156.87	1153.01	-	128.57
Assam		53.49	109.49	neg.	22.58	222.12	239.74	71.26	156.87	1281.12	-	185.71
Bihar		60.78	125.16	108.43	52.37	228.81	222.61	84.70	156.87	1080.60	1993.75	128.57
Gujarat		82.03	164.46	939.76	84.14	234.43	224.51	87.39	122.00	1019.33	469.12	171.43
Jammu and Kashmir		107.57	323.08	-	157.06	145.44	213.10	77.98	580.99	1643.18	-	142.85
Kerala		110.73	192.64	-	43.66	161.79	235.93	80.67	139.44	1030.47	390.93	114.28
Madhya Pradesh		45.80	148.54	-	59.26	250.55	228.32	108.90	162.68	1108.45	-	157.14
Tamil Nadu		46.50	182.24	325.30	64.20	218.42	215.00	80.67	139.44	1208.71	1387.80	142.85
Maharashtra		53.23	168.26	361.45	88.26	237.29	218.81	73.95	139.44	1075.02	684.12	142.85
Karnataka		85.20	153.41	-	45.15	148.08	230.22	95.45	162.68	1208.71	5531.66	100.00
Orissa		68.97	48.21	301.20	47.94	135.40	226.42	73.95	185.92	1158.58	4065.68	100.00
Punjab		95.94	158.80	-	120.04	353.55	251.15	73.95	209.16	1208.71	-	57.14
Rajasthan		75.77	126.74	-	77.69	299.96	239.74	68.57	156.87	1069.46	-	200.00
Uttar Pradesh		67.91	135.78	385.54	86.47	226.78	232.12	96.80	174.30	1097.30	664.58	128.57
West Bengal		44.92	100.65	277.11	52.85	193.27	209.29	69.91	145.25	907.93	918.68	171.43
Andaman and Nicobar Islands		200.00	189.64	-	147.55	263.43	190.27	164.02	673.95	1331.25	-	471.43
Delhi		78.05	154.20	602.41	135.37	307.25	222.61	71.25	174.30	1036.04	-	214.29
Himachal Pradesh		90.69	151.84	-	72.46	268.49	209.29	111.59	226.59	1164.15	-	185.71
Tripura		115.00	-	-	33.65	-	237.83	99.49	290.50	1359.10	-	271.43
Pondicherry		88.26	-	-	88.26	-	215.00	107.56	342.78	1230.99	-	128.57
Goa, Daman and Diu		-	-	-	44.15	98.17	239.74	60.50	151.06	1481.65	-	200.00
Manipur		-	-	-	-	-	-	29.17	580.99	1392.52	-	300.00
Haryana		91.37	140.59	1192.77	83.88	319.96	209.29	67.22	197.54	1253.27	547.30	171.43
Chandigarh		99.68	176.99	-	175.44	581.74	256.86	104.87	168.48	1247.70	-	157.14
India		59.44	126.17	5.24	59.95	164.17	220.49	79.68	142.83	1065.06	732.59	135.42

Table A-2 : Relative Prices of All Fuels With Reference to Coal Price (Prices in TCR Unit)

State	Fuel	Coke	Coal gas	Firewood	Charcoal	Aviation and Motor Spirit	Diesel Oil	Other Fuel Oils	Lubricating Oils	Power Alcohol	Electricity
Andhra Pradesh		1.97	25.56	1.21	3.40	4.24	1.70	2.91	21.39	-	2.39
Assam		2.05	0.00	0.42	4.15	4.48	1.33	2.93	23.95	-	3.47
Bihar		2.06	1.78	0.86	3.76	3.66	1.39	2.58	17.78	32.80	2.12
Gujarat		2.00	11.46	1.03	2.86	2.74	1.07	1.49	12.42	5.72	2.09
Jammu and Kashmir		3.00	-	1.46	1.35	1.98	0.72	5.40	15.27	-	1.33
Kerala		1.74	-	0.39	1.46	2.13	0.73	1.26	9.31	3.53	1.03
Madhya Pradesh		3.24	-	1.29	5.47	4.99	2.38	3.55	24.20	-	3.43
Tamil Nadu		3.92	7.00	1.38	4.70	4.62	1.73	3.00	25.99	29.85	3.07
Maharashtra		3.16	6.79	1.66	4.46	4.11	1.39	2.62	20.20	12.85	2.68
Karnataka		1.80	-	0.53	1.74	2.70	1.12	1.91	14.19	64.93	1.17
Orissa		0.70	4.37	0.70	1.96	3.28	1.07	2.70	16.80	58.95	1.45
Punjab		1.66	-	1.25	3.69	2.62	0.77	2.18	12.60	-	0.60
Rajasthan		1.67	-	1.03	3.96	3.16	0.90	2.07	14.11	-	2.64
Uttar Pradesh		2.00	5.68	1.27	3.34	3.42	1.43	2.57	16.16	9.79	1.89
West Bengal		2.24	6.17	1.18	4.30	4.66	1.56	3.23	20.21	20.45	3.82
Andaman and Nicobar Islands		0.95	-	0.74	1.32	0.95	0.82	3.37	6.66	-	2.36
Delhi		1.98	7.72	1.73	3.94	2.85	0.91	2.23	13.27	-	2.75
Himachal Pradesh		1.67	-	0.80	2.96	2.31	1.23	2.50	12.84	-	2.05
Tripura		-	-	0.29	-	2.07	0.87	2.53	11.82	-	2.36
Pondicherry		-	-	1.00	-	2.44	1.22	3.88	13.95	-	1.46
Goa, Daman and Diu*		-	-	-	-	-	-	-	-	-	-
Manipur*		-	-	-	-	-	-	-	-	-	-
Haryana		1.54	13.05	0.92	3.50	2.29	0.74	2.16	13.72	5.99	1.88
Chandigarh		1.78	-	1.76	5.84	2.58	1.05	1.69	12.52	-	1.58

* These two States do not use coal, hence no relative prices are evaluated.

Table A-3.1 : State x Industry Price of Coal (Rs./M. Tonne)

Industry	211	231	271	311.1.1	311.1.3 *	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511
State																
Andhra Pradesh	72.70	55.93	87.14	-	-	59.73	-	-	-	-	57.82	66.43	88.70	73.03	-	48.60
Assam	-	80.43	-	-	-	-	-	-	-	-	-	-	114.29	60.77	-	-
Bihar	-	68.10	-	41.09	-	46.85	-	40.00	44.22	31.28	-	52.59	70.80	36.58	49.15	39.66
Gujarat	-	91.42	93.16	45.45	-	81.34	85.50	-	71.12	-	99.99	89.34	115.79	94.98	-	71.12
Kerala	-	91.50	-	-	-	-	-	-	108.33	-	-	-	-	-	-	-
Madhya Pradesh	75.24	73.34	38.64	-	-	-	-	-	50.37	-	67.93	51.86	60.03	56.00	-	36.15
Tamil Nadu	-	81.92	91.22	94.47	-	103.95	-	-	87.70	-	-	95.10	100.60	160.62	-	34.10
Maharashtra	-	72.47	52.56	94.26	-	76.87	62.50	-	57.81	52.13	-	-	65.08	87.65	112.03	46.59
Karnataka	-	84.56	94.25	-	-	-	-	-	107.83	-	-	80.17	105.72	119.85	-	-
Orissa	-	52.64	47.93	-	-	-	-	-	70.19	-	-	-	81.52	65.45	-	25.53
Punjab	-	95.47	-	-	-	-	-	-	-	-	-	-	96.14	107.63	-	106.00
Rajasthan	-	92.14	-	-	-	-	-	-	-	-	-	77.30	-	123.29	112.50	145.07
Uttar Pradesh	82.91	77.44	78.92	-	-	61.84	-	-	-	83.64	88.45	-	82.49	73.34	-	65.98
West Bengal	-	54.97	47.21	-	-	59.34	47.12	56.34	46.42	51.63	58.78	-	44.53	62.57	80.68	41.62
Delhi	-	84.61	-	-	-	-	-	-	-	98.50	89.34	-	107.73	95.89	-	-
Haryana	90.83	92.36	80.93	-	-	-	-	-	-	90.10	86.31	-	73.16	108.11	-	-

* Coal is not used in this industry.

Table A-3.2 : State x Industry Price of Electricity (Rs./KWH)

Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511
State																
Andhra Pradesh	0.24	0.13	0.08	0.07	-	0.10	0.13	-	-	-	0.20	0.07	0.23	0.24	-	-
Assam	-	0.11	-	-	-	-	-	-	-	-	-	-	0.17	0.25	-	0.20
Bihar	-	0.13	-	0.05	-	0.14	-	0.13	-	0.27	-	0.11	0.07	0.11	0.11	0.38
Gujarat	-	0.12	0.12	0.09	-	0.12	0.11	-	0.17	-	0.16	0.11	0.17	0.16	0.09	0.16
Kerala	-	0.12	-	-	0.29	0.06	-	-	0.17	-	-	-	-	-	-	0.33
Madhya Pradesh	0.16	0.12	0.14	-	-	-	-	-	0.16	-	0.18	0.10	0.10	0.14	-	-
Tamil Nadu	-	1.06	0.09	0.09	0.34	0.05	0.15	-	0.14	-	-	0.07	0.14	0.14	0.11	0.27
Maharashtra	-	0.09	0.10	0.08	0.20	0.09	0.09	0.15	0.10	0.10	-	-	0.12	0.07	0.12	0.14
Karnataka	-	0.08	0.07	-	0.19	-	-	-	0.15	-	-	0.07	0.04	0.14	0.15	0.11
Orissa	-	0.15	0.10	-	-	-	-	-	0.14	-	-	-	0.11	0.05	-	0.24
Punjab	-	0.09	-	-	-	-	-	-	-	-	-	-	0.12	0.11	-	0.20
Rajasthan	-	0.12	-	-	-	-	-	-	-	-	-	0.11	-	0.18	0.15	0.17
Uttar Pradesh	0.18	0.13	0.11	-	-	0.06	-	-	-	0.14	0.19	-	0.11	0.17	-	0.86
West Bengal	-	0.13	0.12	-	-	0.07	0.13	0.09	0.15	0.13	0.16	-	0.09	0.12	0.09	0.20
Delhi	-	0.16	-	-	-	-	-	-	-	0.16	0.19	-	0.17	0.18	-	-
Haryana	0.15	0.12	0.11	-	-	-	-	-	-	0.08	0.14	-	0.15	0.09	-	-

Table A-3.3 : State x Industry Price of Other Fuel Oils (Rs./Litre)

Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511
State																
Andhra Pradesh	-	0.32	0.27	0.23	-	0.24	-	-	-	-	-	0.59	0.24	0.28	-	0.24
Assam	-	-	-	-	-	-	-	-	-	-	-	-	0.35	0.40	-	-
Bihar	-	-	-	0.33	-	-	-	0.33	0.27	0.50	-	0.63	0.27	0.29	0.27	0.28
Gujarat	-	0.25	0.51	0.60	-	0.21	0.24	-	0.25	-	0.22	0.21	0.26	0.28	0.28	0.17
Kerala	-	0.24	-	-	-	0.28	-	-	0.28	-	-	-	-	-	-	0.54
Madhya Pradesh	-	0.58	0.25	-	-	-	-	-	0.30	-	0.30	0.29	0.31	0.29	-	0.37
Tamil Nadu	-	0.24	0.27	0.23	-	0.25	0.51	-	0.23	-	-	0.23	0.27	0.27	0.26	0.17
Maharashtra	-	0.24	0.28	0.22	0.29	0.25	0.22	0.32	0.25	0.23	-	-	0.24	0.22	0.24	0.26
Karnataka	-	0.27	0.27	-	-	-	-	-	0.34	-	-	0.37	0.29	0.48	0.26	-
Orissa	-	0.86	0.23	-	-	-	-	-	0.26	-	-	-	0.37	0.27	-	0.20
Punjab	-	0.47	-	-	-	-	-	-	-	-	-	-	0.46	0.37	-	-
Rajasthan	-	0.59	-	-	-	-	-	-	-	-	-	0.27	-	0.60	0.42	1.00
Uttar Pradesh	0.31	0.48	0.29	-	-	0.41	-	-	-	0.31	0.45	-	0.29	0.35	-	-
West Bengal	-	0.40	0.25	-	-	0.26	0.24	-	0.57	0.22	0.36	-	0.25	0.25	0.26	0.19
Delhi	-	0.56	-	-	-	-	-	-	-	0.27	0.67	-	0.30	0.30	-	-
Haryana	-	0.64	0.30	-	-	-	-	-	-	0.31	0.91	-	0.37	0.28	-	-

Table A-4.1 : State x Industry Consumption Share of Coal (Value of Consumption)

Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511
State					*											
Andhra Pradesh	55.79	13.34	47.36	-	-	8.88	-	-	-	-	83.58	65.36	2.47	0.62	-	94.99
Assam	-	16.26	-	-	-	-	-	-	-	-	-	-	7.38	5.42	-	-
Bihar	-	43.96	-	77.37	-	3.93	-	3.82	55.27	80.68	-	58.11	63.18	17.91	45.06	7.03
Gujarat	-	30.39	35.08	-	-	19.54	21.80	-	57.84	-	51.56	50.09	1.01	0.75	-	61.09
Kerala	-	0.63	-	-	-	-	-	-	2.03	-	-	-	-	-	-	-
Madhya Pradesh	80.04	28.41	45.81	-	-	-	-	-	58.40	-	54.00	61.73	19.50	1.94	-	98.81
Tamil Nadu	-	0.76	33.12	0.60	-	0.77	-	-	6.72	-	-	63.48	0.83	0.26	-	94.46
Maharashtra	-	9.55	16.80	0.09	-	2.15	-	-	28.74	1.11	-	-	0.88	0.51	0.25	93.05
Karnataka	-	8.97	53.08	-	-	-	-	-	9.15	-	-	69.25	10.66	3.17	-	-
Orissa	-	39.18	52.82	-	-	-	-	-	52.49	-	-	-	76.64	0.66	-	75.49
Punjab	-	37.97	-	-	-	-	-	-	-	-	-	-	35.59	9.65	-	72.26
Rajasthan	-	32.36	-	-	-	-	-	-	-	-	-	82.53	-	2.89	0.79	65.24
Uttar Pradesh	84.01	28.21	53.21	-	-	34.29	-	-	-	62.06	75.87	-	12.05	17.36	-	98.42
West Bengal	-	17.03	51.60	-	-	16.53	11.27	0.78	74.12	26.13	23.56	-	12.68	5.83	0.98	92.86
Delhi	-	54.17	-	-	-	-	-	-	-	67.36	83.60	-	4.13	15.40	-	-
Haryana	81.48	31.91	81.57	-	-	-	-	-	-	1.80	80.46	-	10.18	0.19	-	-

* Coal has not been used in this industry.

Table A-4.2 : State x Industry Consumption Share of Electricity (on the Value Basis)

Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511 *
State																
Andhra Pradesh	38.95	79.37	43.31	59.31	-	79.11	93.44	-	-	-	12.89	31.38	63.66	56.17	-	-
Assam	-	74.76	-	-	-	-	-	-	-	-	-	-	49.85	42.36	-	-
Bihar	-	45.65	40.09	2.41	-	94.36	-	86.51	21.30	5.26	-	38.25	9.71	65.52	16.33	-
Gujarat	-	61.40	-	89.46	-	13.28	43.25	-	6.09	-	15.78	20.58	50.28	31.31	48.04	-
Kerala	-	83.34	-	-	100.00	58.70	-	-	12.83	-	-	-	-	-	-	-
Madhya Pradesh	11.23	65.54	42.99	-	-	-	-	-	15.57	-	18.57	32.56	62.77	69.52	-	-
Tamil Nadu	-	97.67	42.74	67.62	86.49	72.60	93.55	-	11.82	-	-	21.35	58.37	59.57	87.89	-
Maharashtra	-	51.16	57.17	70.76	51.84	60.61	56.89	25.33	17.95	20.66	-	-	63.33	58.48	51.50	-
Karnataka	-	52.96	32.27	-	100.00	-	-	-	7.91	-	-	27.26	46.50	37.00	73.63	-
Orissa	-	54.89	39.88	-	-	-	-	-	14.02	-	-	-	15.11	89.85	-	-
Punjab	-	46.80	-	-	-	-	-	-	-	-	-	-	31.18	45.54	-	-
Rajasthan	-	58.66	-	-	-	-	-	-	-	-	-	13.76	-	7.72	73.26	-
Uttar Pradesh	6.08	64.82	39.32	-	-	50.56	-	-	-	8.03	19.26	-	63.35	29.91	-	-
West Bengal	-	74.34	43.08	-	-	77.68	75.76	97.59	21.58	15.61	25.47	-	50.01	31.70	57.80	-
Delhi	-	41.23	-	-	-	-	-	-	-	7.11	12.42	-	28.62	9.29	-	-
Haryana	12.96	59.71	14.71	-	-	-	-	-	-	26.76	17.18	-	54.92	42.93	-	-

* As the use of electricity in the production of electricity is negligible, the consumption share of it has not been reported.

Table A-4.3 : State x Industry Consumption of Other Fuel Oils (on Value Basis)

State	Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511
Andhra Pradesh		3.16	1.19	3.91	36.75	-	10.41	-	-	-	-	-	0.06	30.91	21.80	-	2.86
Assam		-	-	-	-	-	-	-	-	-	†	-	-	37.54	10.34	-	-
Bihar		-	-	-	0.01	-	-	-	0.01	20.03	0.46	-	0.02	7.01	3.94	34.08	72.20
Gujarat		-	4.49	22.26	7.33	-	47.10	32.96	-	16.70	-	27.66	20.72	39.40	18.44	32.40	36.42
Kerala		-	9.09	-	-	-	40.97	-	-	3.64	-	-	-	-	-	-	7.88
Madhya Pradesh		-	0.46	7.30	-	-	-	-	-	3.84	-	23.76	2.73	0.55	15.99	-	0.17
Tamil Nadu		-	1.05	20.98	25.07	-	24.09	1.63	-	78.11	-	-	13.06	34.59	21.47	3.90	4.71
Maharashtra		-	32.21	15.88	27.48	27.09	33.50	37.73	19.25	25.38	64.66	-	-	28.55	21.05	31.13	0.48
Karnataka		-	31.50	10.52	-	-	-	-	-	2.49	-	-	0.27	6.72	2.38	24.56	-
Orissa		-	0.18	3.33	-	-	-	-	-	12.23	-	-	-	4.48	1.39	-	1.95
Punjab		-	1.43	-	-	-	-	-	-	-	-	-	-	19.92	6.67	-	-
Rajasthan		-	0.66	-	-	-	-	-	-	-	-	-	0.67	-	0.96	11.03	0.01
Uttar Pradesh		6.99	1.03	3.56	-	-	7.95	-	-	-	14.53	1.16	-	13.31	12.55	-	-
West Bengal		-	0.42	1.57	-	-	3.10	6.37	-	0.28	50.63	18.91	-	12.92	8.04	25.68	2.59
Delhi		-	0.71	-	-	-	-	-	-	-	22.38	0.25	-	43.44	10.51	-	-
Haryana		-	1.28	0.54	-	-	-	-	-	-	48.68	0.49	-	30.84	33.79	-	-

Table A-5.1 : State x Industry Consumption Share of Coal (on Quantity Basis)

Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511
State					*											
Andhra Pradesh	87.26	34.33	54.49	-	-	19.36	-	-	-	-	94.83	74.64	6.09	2.24	-	98.09
Assam	-	28.02	-	-	-	-	-	-	-	-	-	-	13.75	13.33	-	-
Bihar	-	70.86	-	94.00	-	12.46	-	17.57	83.19	93.23	-	80.36	75.01	47.13	72.20	21.99
Gujarat	-	44.85	54.81	0.01	-	29.55	33.21	-	70.02	-	62.57	66.04	1.74	1.58	-	69.19
Kerala	-	1.15	-	-	-	-	-	-	1.14	-	-	-	-	-	-	-
Madhya Pradesh	90.24	49.60	81.80	-	-	-	-	-	75.92	-	77.44	82.63	38.26	6.55	-	99.74
Tamil Nadu	-	11.17	43.95	0.81	-	0.64	-	-	10.11	-	-	67.33	1.48	0.32	-	98.22
Maharashtra	-	16.51	36.58	0.11	-	3.71	0.01	-	42.91	2.90	-	-	2.19	0.71	0.39	95.32
Karnataka	-	12.80	57.77	-	-	-	-	-	4.34	-	-	74.81	8.65	4.99	-	-
Orissa	-	73.80	77.12	-	-	-	-	-	64.44	-	-	-	87.52	0.77	-	92.92
Punjab	-	49.06	-	-	-	-	-	-	-	-	-	-	51.88	13.40	-	65.39
Rajasthan	-	48.75	-	-	-	-	-	-	-	-	-	91.08	-	4.40	1.43	51.75
Uttar Pradesh	92.87	50.23	70.24	-	-	45.05	-	-	-	75.25	91.49	-	21.58	35.95	-	99.58
West Bengal	-	40.42	79.59	-	-	26.03	32.93	1.76	92.94	50.22	46.66	-	32.82	12.46	1.84	96.63
Delhi	-	76.85	-	-	-	-	-	-	-	79.40	93.82	-	7.02	27.39	-	-
Haryana	91.29	48.42	90.83	-	-	-	-	-	-	3.23	91.39	-	25.42	0.29	-	-

* Coal has not been used in this industry.

Table A-5.2 : State x Industry Consumption Share of Electricity (on the Quantity Basis)

State	Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511 *
Andhra Pradesh		12.74	62.78	40.33	69.66	-	69.85	96.40	-	-	-	2.99	24.13	42.76	43.60	-	-
Assam		-	68.67	-	-	-	-	-	-	-	-	-	-	44.01	17.53	-	-
Bihar		-	26.33	-	1.85	-	84.10	-	76.52	7.07	0.49	-	18.35	8.09	41.55	8.40	-
Gujarat		-	50.00	33.37	95.84	-	9.87	34.88	-	2.10	-	8.33	14.22	42.29	27.24	59.08	-
Kerala		-	77.38	-	-	79.20	73.13	-	-	3.29	-	-	-	-	-	-	-
Madhya Pradesh		4.07	48.85	14.37	-	-	-	-	-	4.58	-	7.22	15.41	51.55	63.48	-	-
Tamil Nadu		-	78.19	38.46	68.86	50.72	83.90	94.92	-	8.02	-	-	21.70	52.50	57.87	87.98	-
Maharashtra		-	49.77	45.55	73.15	45.06	62.72	59.45	13.13	11.28	19.14	-	-	59.54	67.65	53.77	-
Karnataka		-	59.57	33.43	-	100.00	-	-	-	1.89	-	-	23.70	65.17	34.96	66.82	-
Orissa		-	25.32	19.87	-	-	-	-	-	5.96	-	-	-	9.05	94.15	-	-
Punjab		-	45.78	-	-	-	-	-	-	-	-	-	-	24.22	43.74	-	-
Rajasthan		-	46.37	-	-	-	-	-	-	-	-	-	7.42	-	5.65	70.45	-
Uttar Pradesh		2.19	47.42	26.73	-	-	49.32	-	-	-	4.04	7.43	-	57.46	18.40	-	-
West Bengal		-	53.24	18.11	-	-	70.13	56.71	98.07	6.00	8.48	13.22	-	44.40	24.24	64.27	-
Delhi		-	22.25	-	-	-	-	-	-	-	3.69	4.68	-	22.16	6.01	-	-
Haryana		6.13	48.11	8.32	-	-	-	-	-	-	36.21	8.20	-	45.72	50.43	-	-

* As the use of electricity in the production of electricity is negligible, the consumption share of it has not been reported.

Table A-5.3 : State x Industry Consumption of Other Fuel Oils (on Quantity Basis)

Industry	211	231	271	311.1.1	311.1.3	311.2	311(R)	329	331	332	333	334	341.1	341(R)	342	511
Andhra Pradesh	-	0.91	2.49	29.62	-	9.80	-	-	-	-	-	0.01	48.76	34.98	-	1.01
Assam	-	-	-	-	-	-	-	-	-	-	-	-	39.12	6.59	-	-
Bihar	-	-	-	-	-	-	-	0.01	8.44	0.06	-	-	3.78	2.27	17.20	54.75
Gujarat	-	4.17	10.89	2.93	-	47.14	31.09	-	9.86	-	26.37	18.08	51.39	22.64	31.10	29.63
Kerala	-	10.70	-	-	-	26.59	-	-	1.36	-	-	-	-	-	-	5.09
Madhya Pradesh	0.15	0.18	3.51	-	-	-	-	-	1.42	-	13.22	1.13	0.36	17.96	-	0.03
Tamil Nadu	-	9.12	16.23	24.55	-	14.44	1.18	-	76.53	-	-	9.82	39.83	27.32	4.05	1.66
Maharashtra	-	29.55	11.26	25.92	39.56	31.20	37.89	11.60	15.23	64.77	-	-	33.81	19.90	38.56	0.15
Karnataka	-	24.54	6.90	-	-	-	-	-	0.64	-	-	0.11	3.40	1.61	31.70	-
Orissa	-	0.04	1.78	-	-	-	-	-	6.92	-	-	-	1.94	0.68	-	0.53
Punjab	-	0.65	-	-	-	-	-	-	-	-	-	-	10.50	4.63	-	-
Rajasthan	-	0.27	-	-	-	-	-	-	-	-	-	0.36	-	0.52	9.18	-
Uttar Pradesh	3.61	0.51	2.18	-	-	2.74	-	-	-	8.16	0.47	-	11.58	9.32	-	-
West Bengal	-	0.23	0.78	-	-	1.93	6.34	-	0.05	38.74	10.67	-	10.30	7.38	25.86	1.00
Delhi	-	0.26	-	-	-	-	-	-	-	16.47	0.06	-	46.25	10.12	-	-
Haryana	-	0.48	0.28	-	-	-	-	-	-	44.38	0.09	-	25.95	32.65	-	-

Table A-6 : Gross Output State x HFU Industries (1970 A.S.I., '000 Rs.)

State	Andhra Pradesh	Assam	Bihar	Gujarat	Kerala	Madhya Pradesh	Tamil Nadu	Maha-rashtra	Karna-taka	Orissa	Punjab	Raja-sthan	Uttar Pradesh	West Bengal	Delhi	Haryana
211	9,100	-	-	-	-	6,212	-	-	-	-	-	-	31,796	-	-	10,667
231	396,394	13,261	42,655	3597,745	189,429	855,000	2564,851	5045,536	520,978	99,584	409,344	379,208	1054,557	3171,022	309,451	299,856
271	67,705	-	-	58,838	-	159,386	100,305	396,220	136,696	201,936	-	-	69,433	339,683	-	100,985
311.1.1	214,256	-	174,049	308,420	-	-	102,152	257,200	-	-	-	-	-	-	-	-
311.2	14,493	-	12,392	355,142	99,107	-	142,675	776,797	-	-	-	-	74,489	94,518	-	-
311(R)	2,461	-	-	271,557	25,729	-	48,247	1273,053	7,289	-	-	-	228,960	215,524	-	-
331	-	-	63,123	19,474	31,467	13,169	48,079	41,488	34,725	8,071	-	-	-	19,153	-	-
332	-	-	5,486	-	-	-	-	140,252	-	-	-	-	80,785	91,388	2,078	34,296
333	2,053	-	-	20,370	-	1,963	-	-	-	-	-	-	1,377	18,023	3,165	11,034
334	156,598	-	217,245	213,407	-	264,976	338,768	-	169,517	-	-	173,597	-	-	-	-
341.1	30,745	4,294	1461,953	94,922	34,422	1326,514	157,403	391,759	160,793	1057,211	118,305	-	161,756	1607,451	40,416	27,294
341(R)	22,639	2,965	152,715	137,323	-	18,316	180,586	688,464	11,099	90,593	22,337	2,929	104,450	393,037	4,845	119,091
342	-	-	213,009	5,556	-	-	102,766	577,520	183,037	-	-	41,665	-	445,073	-	-
511	373,875	53,019	334,101	530,997	174,238	333,248	924,962	1307,853	481,595	127,198	219,277	178,804	659,983	897,290	-	-
Total	1290,319	73,539	2676,728	5613,751	554,392	2978,784	4710,794	10896,142	1705,729	1584,593	769,263	776,203	2467,586	7292,162	359,955	603,223

Tabla A-7 : Value Added State x HFU Industries (1970 A.S.I., '000 Rs.)

State	Andhra Pradesh	Assam	Bihar	Gujarat	Kerala	Madhya Pradesh	Tamil Nadu	Maha-rashtra	Karna-taka	Orissa	Punjab	Raja-sthan	Uttar Pradesh	West Bengal	Delhi	Haryana
211	7,054	-	-	-	-	2,338	-	-	-	-	-	-	9,971	-	-	2,296
231	85,150	1,476	12,447	1019,699	41,958	195,824	605,079	1654,434	113,477	24,167	96,265	83,744	261,496	936,291	86,125	55,255
271	10,324	-	-	12,435	-	95,144	30,393	131,828	44,739	62,348	-	-	16,465	112,798	-	35,249
311.1.1	53,812	-	22,086	118,608	-	-	8,036	27,952	-	-	-	-	-	-	-	-
311.2	2,974	-	3,658	113,271	37,071	-	44,667	263,501	-	-	-	-	18,453	22,829	-	-
311(R)	2,756	-	-	97,628	4,040	-	14,624	431,715	605	-	-	-	55,126	60,848	-	-
331	-	-	20,677	9,658	17,114	5,099	13,164	19,584	18,108	2,015	-	-	-	7,776	-	-
332	-	-	1,921	-	-	-	-	48,765	-	-	-	-	22,385	31,689	543	10,580
333	566	-	-	7,326	-	869	-	-	-	-	-	-	(-169)	12,210	1,091	4,260
334	42,416	-	36,280	42,788	-	72,679	72,497	-	42,594	-	-	34,625	-	-	-	-
341.1	4,579	538	458,944	18,858	5,657	194,269	38,571	86,046	12,353	167,666	19,484	-	40,896	293,025	5,111	4,341
341(R)	585	1,682	10,520	41,327	-	5,508	69,913	220,352	7,392	24,125	7,876	977	27,713	95,522	1,230	29,291
342	-	-	105,328	1,335	-	-	34,675	90,316	72,551	-	-	8,412	-	121,268	-	-
511	200,883	16,613	112,012	214,703	128,067	153,395	436,873	506,423	316,176	56,831	139,603	107,722	229,921	267,745	-	-
All HFU	411,099	20,309	824,620	1697,636	233,907	725,125	1368,492	3496,039	627,995	337,152	263,228	235,480	682,257	1972,539	94,100	141,272
All Industries	1088,235	404,699	1700,134	2385,658	734,445	1003,855	2808,036	7569,559	1632,265	504,923	526,451	539,413	1928,491	4014,599	425,909	605,685
Percentage of HFU in All Industries (With Textile)	37.78	5.02	48.50	71.16	31.85	72.23	48.73	46.18	38.47	66.77	50.00	43.65	35.38	49.13	22.09	23.32
Without Textile (Percentage)	29.95	4.65	47.77	28.42	26.14	52.73	27.19	24.33	31.52	61.99	31.71	28.13	21.82	25.81	1.87	14.20

Table A-8.1 : Fuel Consumption: State x HFU Industries in Value Terms for 1970, ('000 Rs.)

State	Andhra Pradesh	Assam	Bihar	Gujarat	Kerala	Madhya Pradesh	Tamil Nadu	Maha-rashtra	Karna-taka	Orissa	Punjab	Raja-sthan	Uttar Pradesh	West Bengal	Delhi	Haryana
211	505	-	-	-	-	484	-	-	-	-	-	-	5,612	-	-	541
231	14,321	418	1,367	197,269	6,651	38,965	90,543	269,977	18,045	3,374	13,054	15,511	49,457	107,463	18,684	10,048
271	9,216	-	-	11,150	-	10,359	10,109	18,736	18,469	22,399	-	-	9,362	31,833	-	9,902
311.1.1	17,669	-	23,327	32,358	-	-	7,673	28,746	-	-	-	-	-	-	-	-
311.2	2,969	-	3,890	60,106	8,424	-	27,823	68,029	-	-	-	-	13,118	7,368	-	-
311(R)	326	-	-	14,436	10	-	1,324	86,387	5	-	-	-	37,447	12,685	-	-
331	-	-	9,702	4,036	6,457	2,278	9,777	6,347	6,651	1,995	-	-	-	2,866	-	-
332	-	-	665	-	-	-	-	20,076	-	-	-	-	18,596	12,409	478	4,391
333	481	-	-	4,866	-	468	-	-	-	-	-	-	431	4,960	807	2,038
334	34,396	-	49,256	70,068	-	54,361	92,805	-	44,925	-	-	45,774	-	-	-	-
341.1	2,084	325	289,526	3,381	1,068	77,586	6,146	19,955	50,826	234,602	5,183	-	14,826	87,215	1,905	1,812
341(R)	2,152	230	22,744	7,550	-	2,553	12,030	45,837	1,005	17,453	1,929	312	5,330	29,736	416	2,088
342	-	-	13,617	179	-	-	6,997	11,338	18,463	-	-	1,152	-	11,501	-	-
511	59,931	5,860	43,829	135,506	167	59,975	106,621	137,243	841	14,950	1,525	6,033	198,395	191,738	-	-
All HFU Industries	144,050	6,833	465,204	541,505	23,377	247,029	371,848	713,393	159,230	294,773	21,691	68,782	352,574	504,896	22,290	30,820
All Industries	1088,235	404,699	1700,134	2385,658	734,445	1003,855	2808,036	7569,559	1632,265	504,923	526,451	539,413	1928,491	4014,599	425,909	605,685

Table A-8.2 : Fuel Consumption (State x HFU Industry) in Physical Units for 1970 (TCR Units)

State	Andhra Pradesh	Assam	Bihar	Gujarat	Kerala	Madhya Pradesh	Tamil Nadu	Maha-rashtra	Karna-taka	Orissa	Punjab	Raja-sthan	Uttar Pradesh	West Bengal	Delhi	Haryana
211	835	-	-	-	-	5,671	-	-	-	-	-	-	61,211	-	-	5,307
231	98,898	2,974	12,455	1444,426	39,927	277,700	606,394	2015,147	143,772	33,698	104,368	111,032	356,891	817,927	128,209	71,201
271	90,610	-	-	75,480	-	149,560	82,362	157,539	175,292	319,294	-	-	89,814	437,029	-	106,545
311.1.1	146,048	-	467,226	220,562	-	-	53,645	223,573	-	-	-	-	-	-	-	-
311.2	22,575	-	22,784	411,780	77,736	-	318,503	472,649	-	-	-	-	161,154	78,799	-	-
311(R)	1,660	-	-	103,734	28	-	6,099	565,633	18	-	-	-	399,427	189,134	-	-
331	-	-	141,994	45,990	105,435	34,622	72,534	73,085	129,562	22,109	-	-	-	49,118	-	-
332	-	-	17,901	-	-	-	-	134,794	-	-	-	-	179,525	124,118	4,117	24,384
333	7,332	-	-	39,738	-	4,752	-	-	-	-	-	-	4,041	42,258	8,029	20,779
334	452,325	-	672,547	670,302	-	731,387	912,028	-	516,964	-	-	535,728	-	-	-	-
341.1	9,441	21,426	3295,799	16,410	13,482	657,413	33,676	116,989	581,772	2513,648	36,748	-	99,772	730,883	10,316	9,573
341(R)	7,940	1,357	215,015	35,261	-	13,362	61,022	353,797	5,349	227,294	11,921	1,660	34,890	220,002	2,398	12,973
342	-	-	168,837	1,163	-	-	43,582	61,926	92,469	-	-	5,606	-	73,531	-	-
511	1189,909	3565,217	353,304	1343,844	812	1865,944	2979,427	1503,960	520	475,290	15,713	69,592	2966,773	4339,317	-	-
Total	2027,583	3590,974	5410,256	4408,690	237,420	3740,411	5169,272	5679,092	1645,718	3591,333	168,750	723,618	4353,498	7126,316	153,069	250,762

Table A-9 : Energy Input Coefficients (Value Terms), 1970

	Coal	Petroleum Products	Electri- City	Other Fuels
<u>Industry 211</u>				
Andhra Pradesh	0.005824	0.000550	0.004066	-
Madhya Pradesh	0.001977	0.006761	0.008693	-
Uttar Pradesh	0.148226	0.015411	0.010725	0.002076
Haryana	0.041249	0.000562	0.006562	0.002249
<u>Industry 231</u>				
Andhra Pradesh	0.004791	0.002104	0.028510	0.000518
Assam	0.005052	0.001810	0.023226	0.000980
Bihar	0.014090	0.002461	0.014629	0.000868
Gujarat	0.016461	0.004151	0.033260	0.000300
Kerala	0.000222	0.004466	0.029151	0.001140
Madhya Pradesh	0.011816	0.002089	0.027262	0.010429
Tamil Nadu	0.002164	0.004164	0.027976	0.001331
Maharashtra	0.004797	0.018760	0.025713	0.000990
Karnataka	0.002987	0.011955	0.017636	0.000721
Orissa	0.013145	0.001717	0.018417	0.000271
Punjab	0.011941	0.003284	0.014716	0.001505
Rajasthan	0.013154	0.003280	0.023844	0.000372
Uttar Pradesh	0.013165	0.002492	0.030247	0.000756
West Bengal	0.005731	0.002421	0.025017	0.000481
Delhi	0.026941	0.000378	0.020504	0.001913
Haryana	0.010618	0.002152	0.019866	0.000645

(continued)

Table A-9 : (continued)

	Coal	Petroleum Products	Electri- city	Other Fuels
<u>Industry 271</u>				
Andhra Pradesh	0.064072	0.010014	0.058592	0.002599
Gujarat	0.065502	0.044818	0.074850	0.001530
Madhya Pradesh	0.029658	0.007121	0.027832	0.000125
Tamil Nadu	0.032916	0.022139	0.042476	0.001844
Maharashtra	0.007645	0.010246	0.026018	0.001603
Karnataka	0.069819	0.017396	0.042452	0.001866
Orissa	0.058439	0.006244	0.044123	0.001837
Uttar Pradesh	0.071709	0.009304	0.052986	0.000763
West Bengal	0.048339	0.003165	0.040364	0.001820
Haryana	0.077556	0.002773	0.013982	0.000773
<u>Industry 311.1.1</u>				
Andhra Pradesh	-	0.030239	0.044409	0.000233
Bihar	0.103695	0.021913	0.003235	0.005182
Gujarat	0.000003	0.009766	0.089002	0.000717
Tamil Nadu	0.000401	0.020548	0.045491	0.000832
Maharashtra	0.000089	0.029557	0.072706	0.000397
<u>Industry 311.2</u>				
Andhra Pradesh	0.018009	0.023529	0.160422	0.000828
Bihar	0.010733	0.000565	0.257828	0.004116
Gujarat	0.027865	0.080615	0.018942	0.015200
Kerala	-	0.034398	0.049038	0.000101
Tamil Nadu	0.001493	0.047640	0.141132	0.004122
Maharashtra	0.001735	0.027969	0.049000	0.002141
Uttar Pradesh	0.060277	0.016338	0.088872	0.010284
West Bengal	0.012876	0.003269	0.060496	0.001238

(continued)

Table A-9 : (continued)

	Coal	Petroleum Products	Electri- city	Other Fuels
<u>Industry 311 (R)</u>				
Andhra Pradesh	-	0.003657	0.121495	0.004876
Gujarat	0.010849	0.016987	0.021524	0.000409
Tamil Nadu	-	0.001531	0.040964	0.001293
Maharashtra	0.000002	0.024741	0.033740	0.000825
West Bengal	0.006417	0.006333	0.043146	0.001053
<u>Industry 331</u>				
Bihar	0.082760	0.033648	0.031890	0.001442
Gujarat	0.117593	0.039026	0.012375	0.034303
Kerala	0.004131	0.011378	0.026091	0.161820
Madhya Pradesh	0.100539	0.014655	0.026805	0.030147
Tamil Nadu	0.013374	0.159176	0.023524	0.002870
Maharashtra	0.043699	0.063464	0.027285	0.017595
Karnataka	0.017451	0.010367	0.015090	0.147905
Orissa	0.123903	0.034569	0.033081	0.044480
West Bengal	0.110635	0.006318	0.032214	0.000104
<u>Industry 332</u>				
Bihar	0.095151	0.009479	0.006198	0.007109
Maharashtra	0.001455	0.097952	0.026952	0.004107
Uttar Pradesh	0.139877	0.056137	0.018097	0.011277
West Bengal	0.035213	0.076827	0.021031	0.001664
Delhi	0.154957	0.058710	0.016362	-
Haryana	0.002070	0.082051	0.030820	0.000233

(continued)

Table A-9 : (continued)

	Coal	Petroleum Products	Electri- city	Other Fuels
<u>Industry 333</u>				
Andhra Pradesh	0.195811	0.001461	0.030200	0.006820
Gujarat	0.122042	0.072705	0.037359	0.004614
Madhya Pradesh	0.127357	0.061641	0.043811	0.003057
Uttar Pradesh	0.237473	0.012346	0.060276	0.002905
West Bengal	0.035447	0.032449	0.038322	0.044225
Delhi	0.212638	0.004739	0.031596	0.005372
Haryana	0.148541	0.004169	0.031720	0.000181
<u>Industry 334</u>				
Andhra Pradesh	0.143227	0.006578	0.068756	0.000581
Bihar	0.130848	0.007213	0.086124	0.000990
Gujarat	0.185336	0.076417	0.068011	0.000641
Madhya Pradesh	0.118290	0.009922	0.062591	0.001023
Tamil Nadu	0.172381	0.040069	0.057966	0.001131
Karnataka	0.182908	0.008483	0.072010	0.000719
Rajasthan	0.217262	0.008111	0.036228	0.001647
<u>Industry 341.1</u>				
Andhra Pradesh	0.001659	0.021109	0.042739	0.001626
Assam	0.005589	0.031207	0.037727	0.001164
Bihar	0.119715	0.019416	0.018393	0.031948
Gujarat	0.000348	0.015433	0.017246	0.001276
Madhya Pradesh	0.011382	0.010064	0.036643	0.000288
Tamil Nadu	0.000318	0.013926	0.022350	0.001697
Maharashtra	0.000426	0.015879	0.030669	0.001455
Karnataka	0.033105	0.054511	0.144360	0.078467
Orissa	0.169635	0.017751	0.033439	0.000505
Punjab	0.015494	0.012257	0.013575	0.002215
Uttar Pradesh	0.010980	0.016704	0.057735	0.005712
West Bengal	0.006642	0.013047	0.026203	0.006509
Delhi	0.001930	0.021972	0.013386	0.009476
Haryana	0.006522	0.020957	0.035173	0.001392

(continued)

Table A-9 : (continued)

	Coal	Petroleum Products	Electri- city	Other Fuels
<u>Industry 341(R)</u>				
Andhra Pradesh	0.000574	0.030743	0.051681	0.009073
Assam	0.003710	0.018888	0.029005	0.016863
Bihar	0.024713	0.009161	0.090410	0.013698
Gujarat	0.000386	0.012401	0.016152	0.022640
Madhya Pradesh	0.002675	0.025824	0.095872	0.013541
Tamil Nadu	0.000172	0.017676	0.039627	0.009043
Maharashtra	0.000320	0.016424	0.036673	0.009295
Karnataka	0.002883	0.007658	0.033607	0.046671
Orissa	0.001269	0.003312	0.173082	0.014979
Punjab	0.007700	0.012266	0.036352	0.023503
Rajasthan	0.003073	0.003413	0.008194	0.091499
Uttar Pradesh	0.008808	0.010274	0.015175	0.016477
West Bengal	0.004366	0.009224	0.023733	0.037551
Delhi	0.013003	0.011765	0.007843	0.051807
Haryana	0.000034	0.007801	0.007415	0.002024
<u>Industry 342</u>				
Bihar	0.028130	0.022844	0.010197	0.001258
Gujarat	-	0.011339	0.015479	0.005398
Tamil Nadu	-	0.006617	0.059397	0.001566
Maharashtra	0.000047	0.007678	0.009484	0.001206
Karnataka	-	0.025591	0.072341	0.000312
Rajasthan	0.000216	0.004824	0.019921	0.002232
West Bengal	0.000245	0.009151	0.014407	0.001122

(continued)

Table A-9 : (continued)

	Coal	Petroleum Products	Electri- city	Other Fuels
<u>Industry 511</u>				
Andhra Pradesh	0.151722	0.007994	-	-
Assam	-	0.088987	0.000038	0.020162
Bihar	0.009222	0.121819	0.000018	0.000120
Gujarat	0.124530	0.077786	0.000802	0.000740
Kerala	-	0.000913	0.000023	0.000011
Madhya Pradesh	0.201889	0.002076	-	0.000360
Tamil Nadu	0.107883	0.005450	0.000003	0.000877
Maharashtra	0.051066	0.002864	0.000267	0.000684
Karnataka	-	0.000243	0.000002	0.000042
Orissa	0.088649	0.027800	0.000991	-
Punjab	0.004966	0.001688	0.000005	0.000215
Rajasthan	0.029222	0.015313	0.000006	0.000252
Uttar Pradesh	0.295349	0.004011	0.000512	0.000234
West Bengal	0.194481	0.014545	0.000135	0.000276

Table A-10 : Regional Energy Coefficients, 1970

(TCRs per Rs.1,000 output)				
State	Coal	Petroleum Products	Electricity	Other Fuels
<u>Industry 211</u>				
Andhra Pradesh	0.080110	-	0.011692	-
Madhya Pradesh	0.823728	0.051922	0.037186	-
Uttar Pradesh	1.787835	0.080745	0.042093	0.014468
Haryana	0.454111	0.000337	0.030515	0.012449
<u>Industry 231</u>				
Andhra Pradesh	0.085662	0.004804	0.156619	0.002404
Assam	0.062816	0.003462	0.153978	0.003963
Bihar	0.206893	0.003373	0.076884	0.004835
Gujarat	0.180061	0.019217	0.200723	0.001475
Kerala	0.002423	0.023955	0.164139	0.020250
Madhya Pradesh	0.161109	0.002410	0.158653	0.002625
Tamil Nadu	0.026415	0.023536	0.184857	0.001617
Maharashtra	0.066198	0.129070	0.199475	0.006045
Karnataka	0.035320	0.070250	0.164401	0.005996
Orissa	0.249718	0.001607	0.085686	0.001455
Punjab	0.125073	0.006328	0.116723	0.006839
Rajasthan	0.142753	0.012042	0.135764	0.002243
Uttar Pradesh	0.169999	0.003948	0.160491	0.003981
West Bengal	0.104266	0.004155	0.137337	0.012180
Delhi	0.318419	0.002616	0.092191	0.001087
Haryana	0.114972	0.005618	0.114232	0.002634

(continued)

Table A-10 : (continued)

State	Coal	Petroleum Products	Electricity	Other Fuels
<u>Industry 271</u>				
Andhra Pradesh	0.735249	0.056198	0.544088	0.013698
Gujarat	0.703083	0.144643	0.428069	0.007057
Madhya Pradesh	0.767614	0.035331	0.134799	0.000611
Tamil Nadu	0.360853	0.135721	0.315755	0.008706
Maharashtra	0.145460	0.063353	0.181107	0.007685
Karnataka	0.740768	0.102141	0.428641	0.010792
Orissa	1.219347	0.031744	0.314205	0.015881
Uttar Pradesh	0.908631	0.035553	0.345821	0.003532
West Bengal	1.023928	0.014334	0.232943	0.015377
Haryana	0.958340	0.004710	0.087763	0.004249
<u>Industry 311.1.1</u>				
Andhra Pradesh	0.000023	0.205674	0.474827	0.001128
Bihar	2.523416	0.079027	0.049610	0.032389
Gujarat	0.000071	0.026508	0.685420	0.003136
Tamil Nadu	0.004249	0.155472	0.361601	0.003832
Maharashtra	0.000949	0.230296	0.635865	0.002146
<u>Industry 311.2</u>				
Andhra Pradesh	0.301525	0.164494	1.088036	0.003626
Bihar	0.229099	0.000435	1.546361	0.062737
Gujarat	0.342590	0.604018	0.114411	0.098465
Kerala	-	0.209137	0.573635	0.001594
Tamil Nadu	0.014361	0.324816	1.872904	0.020283
Maharashtra	0.022576	0.194757	0.381620	0.009506
Uttar Pradesh	0.974735	0.062892	1.066920	0.058931
West Bengal	0.216985	0.020376	0.584652	0.011675

(continued)

Table A-10 : (continued)

State	Coal	Petroleum Products	Electricity	Other Fuels
<u>Industry 311 (R)</u>				
Andhra Pradesh	-	0.002918	0.650223	0.021356
Gujarat	0.126879	0.120008	0.133227	0.001881
Tamil Nadu	-	0.003134	0.192648	0.007175
Maharashtra	0.000039	0.179893	0.269647	0.003970
West Bengal	0.136180	0.038580	0.234550	0.004257
<u>Industry 331</u>				
Bihar	1.871441	0.212269	0.158990	0.006777
Gujarat	1.653487	0.255994	0.049605	0.402466
Kerala	0.038135	0.064287	0.110316	3.137910
Madhya Pradesh	1.995899	0.091368	0.120290	0.421510
Tamil Nadu	0.152499	1.188118	0.121061	0.046949
Maharashtra	0.755857	0.703562	0.198739	0.103420
Karnataka	0.161844	0.066789	0.070494	3.431941
Orissa	1.765209	0.197657	0.163226	0.618300
West Bengal	2.383491	0.026379	0.153757	0.000791
<u>Industry 332</u>				
Bihar	3.042107	0.057050	0.016077	0.147908
Maharashtra	0.027900	0.734865	0.183954	0.014363
Uttar Pradesh	1.672340	0.343153	0.089821	0.116960
West Bengal	0.682037	0.553955	0.115163	0.006986
Delhi	1.573147	0.334989	0.073099	-
Haryana	0.022976	0.429507	0.257459	0.001066
<u>Industry 333</u>				
Andhra Pradesh	3.386751	0.001749	0.106722	0.076195
Gujarat	1.220569	0.539784	0.162543	0.027939
Madhya Pradesh	1.874682	0.324613	0.174733	0.046943
Uttar Pradesh	2.684822	0.018965	0.218083	0.012831
West Bengal	0.603052	0.172037	0.170820	0.346511
Delhi	2.380095	0.005602	0.118768	0.032354
Haryana	1.720953	0.005993	0.154477	0.001722

(continued)

Table A-10 : (continued)

State	Coal	Petroleum Products	Electricity	Other Fuels
<u>Industry 334</u>				
Andhra Pradesh	2.156100	0.032747	0.696951	0.002707
Bihar	2.487924	0.034891	0.568126	0.004858
Gujarat	2.074393	0.616446	0.446647	0.003471
Madhya Pradesh	2.280750	0.047152	0.425446	0.006856
Tamil Nadu	1.812639	0.289737	0.584189	0.005625
Karnataka	2.281470	0.041514	0.722774	0.003871
Rajasthan	2.810636	0.035879	0.228984	0.010541
<u>Industry 341.1</u>				
Andhra Pradesh	0.018702	0.150047	0.131303	0.007046
Assam	0.048905	0.145542	0.156497	0.004639
Bihar	1.690898	0.126026	0.182492	0.254965
Gujarat	0.003002	0.091266	0.073118	0.005493
Madhya Pradesh	0.189599	0.049152	0.255499	0.001344
Tamil Nadu	0.003158	0.087243	0.112318	0.011234
Maharashtra	0.006550	0.106698	0.177804	0.007577
Karnataka	0.313123	0.382030	2.357848	0.565152
Orissa	2.080885	0.079258	0.215233	0.002247
Punjab	0.161160	0.061831	0.077417	0.010213
Uttar Pradesh	0.133096	0.092115	0.354405	0.037197
West Bengal	0.149166	0.070115	0.201861	0.033544
Delhi	0.017914	0.122386	0.056549	0.058391
Haryana	0.089140	0.094033	0.160343	0.007203

(continued)

Table A-10 : (continued)

State	Coal	Petroleum Products	Electricity	Other Fuels
<u>Industry 341 (R)</u>				
Andhra Pradesh	0.007863	0.146817	0.152931	0.045891
Assam	0.061046	0.165564	0.080270	0.150921
Bihar	0.675553	0.061797	0.595482	0.100466
Gujarat	0.004063	0.063036	0.069953	0.119729
Madhya Pradesh	0.047772	0.134555	0.463125	0.084066
Tamil Nadu	0.001069	0.099922	0.195538	0.041376
Maharashtra	0.003646	0.113907	0.347643	0.048704
Karnataka	0.024056	0.013993	0.168520	0.275434
Orissa	0.019394	0.021002	2.362242	0.106313
Punjab	0.071540	0.063626	0.233438	0.165101
Rajasthan	0.024923	0.006703	0.032025	0.502819
Uttar Pradesh	0.120096	0.052401	0.061469	0.100079
West Bengal	0.069775	0.051596	0.135699	0.302677
Delhi	0.135604	0.053055	0.029763	0.276692
Haryana	0.000311	0.040653	0.054934	0.013038
<u>Industry 342</u>				
Bihar	0.572300	0.140217	0.066618	0.013492
Gujarat	-	0.065702	0.123596	0.019916
Tamil Nadu	-	0.043393	0.373112	0.007590
Maharashtra	0.000417	0.043408	0.057661	0.005743
Karnataka	-	0.166009	0.337592	0.001596
Rajasthan	0.001920	0.018692	0.094756	0.019142
West Bengal	0.003035	0.049121	0.106186	0.006872

(continued)

Table A-10 : (continued)

State	Coal	Petroleum Products	Electricity	Other Fuels
<u>Industry 511</u>				
Andhra Pradesh	3.121851	0.060793	-	-
Assam	-	1.141708	0.000132	-
Bihar	0.232499	0.824428	0.000034	0.000519
Gujarat	1.751031	0.772829	0.003574	0.003348
Kerala	-	0.004551	0.000048	0.000060
Madhya Pradesh	5.584589	0.013021	-	0.001656
Tamil Nadu	3.163954	0.053446	0.000008	0.003728
Maharashtra	1.096168	0.049240	0.001362	0.003175
Karnataka	-	0.000895	0.000013	0.000175
Orissa	3.471949	0.261796	0.002873	-
Punjab	0.046854	0.024178	0.000016	0.000609
Rajasthan	0.201433	0.186568	0.000023	0.001192
Uttar Pradesh	4.476556	0.017166	0.000417	0.001089
West Bengal	4.672856	0.160558	0.000484	0.002127

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