ENERGY LADDER PROFILE OF ALL INDIA HOUSEHOLD ENERGY DEMAND IN RURAL AND URBAN CONTEXT

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I, Ms. P. V. PRATIBHA, hereby declare that the work embodied in this Thesis entitled "ENERGY LADDER PROFILE OF **ALL INDIA** HOUSEHOLD ENERGY DEMAND IN RURAL AND URBAN CONTEXT" is carried out by me under the supervision of DR. V. B. N. S. MADDURI, Faculty, Department of Economics, University of Hyderabad, for the award of the degree of DOCTOR OF PHILOSOPHY in ECONOMICS, and has not been submitted in part or in full in any other university or institution.

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CONTENTS

I

INTRODUCTION

1.0 INTRODUCTION

Energy is the basic natural resource which is essential for the existence of mankind. It plays a vital role in human welfare as all important economic activities of development are dependent on the use of energy. The availability of cheap energy may serve to stimulate industrial development, make cooking possible, and increase agricultural production. In other words, energy is an important parameter of overall economic developmental activity of a country. That is the reason why the process of economic development demands increasingly higher levels of energy consumption. As an economy develops, its demand for energy tends to increase and its consumption pattern with respect to the forms of energy and energy sources also tends to change.

1.1 ENERGY - THE HOUSEHOLD SECTOR

One of the important characteristics of energy consumption especially, for the household sector, is that a major part of the total energy consumption is accounted by non-commercial sources, consisting of fuelwood, animal and agricultural wastes, and other biomass sources. As non-commercial sources of energy are available at almost zero or negligible cost, it constitutes an important source of energy for the poorer sections of the population, especially in the rural areas. Population in the rural areas who survive mostly on non-commercial energy sources, consume about 5,600 kal. per capita per day as against 2 times higher level of 11,200 kal per capita, per day energy in case of affluent urban households [Veena; 1988].

1.2 INCOME, FAMILY SIZE AND CHOICE OF FUEL

An increasing population would directly raise the total demand for energy in domestic sector, where the degree of urbanization and income changes would cause shifts in the demand for fuel consumed. The energy consumption pattern, in fact varies from place to place, and in some areas, from season to season. Dependency of rural households on various types of sources of fuel varies according to the income level of household and even the end-use pattern, which again varies across the various income classes **and** regions, for example, water heating may be an essential end-use in chilly areas, whereas in relatively warmer areas, it is considered a luxury.

1.3 RURAL, URBAN AREAS AND ENERGY CONSUMPTION

In the rural areas, energy consumption generally comprises of energy consumption by the domestic sector, agricultural sector **and** non-agricultural sector. Out of all these, it is the domestic sector which accounts for almost more than 90 % of the rural energy consumed [Rao; 1990].

Low efficiency of energy use forms another dimension of rural energy problem, though the effective use of energy is very low in both the urban and the rural areas. Though the rural areas are electrified and provided with 1-2 street lights, electricity has not yet reached all the rural households. The major commercial forms of energy consumed both in the rural and urban areas are kerosene and electricity. The use of kerosene for cooking is very limited in the poorer sections of rural areas, and it is mainly used for lighting purposes. More than 90 % of the households consume kerosene for one end-use or the other. Kerosene is a superior form of fuel compared to fuelwood or agricultural wastes, and hence an increase in the level of income when the purchasing capacity of the households improves, their preference for cooking fuel shifts from fuelwood (or any other inferior fuel) to kerosene. But the consumption of kerosene in the rural areas depends not only on the purchasing power, but also on the availability of the fuel.

On the other hand, in the urban areas, there is a wide variety of fuels available and consumed by the household sector. The fuels available in the urban areas range from coke, fuelwood to LPG and electricity. The consumption of a particular fuel depends on the income of the household, and other socio - economic factors like tastes, preferences and customs, etc. More than the availability of fuel, the consumption of a particular fuel in the urban areas depends on the affordability and income levels. In short it can be said that, for both the urban and the rural areas, an increase in the family income leads to an increase in the energy consumed, an increase in quantity of energy consumed, a change in the type of fuel consumed, a change in the end-use of energy consumed, and a change in the mode of obtaining fuel.

Other factors influencing the choice of fuel, other than household incomes is the size of land-holdings (special reference to rural areas), and family size.

1.4 ENERGY LADDER

The domestic or household sector is a complex field for analysis as far as the energy consumption is concerned, this sector uses both the commercial and non-commercial forms of energy, Besides, the consumption of any particular energy form depends upon various economic and socio-economic factors. One of the major factors on which the choice of energy dependents is the income of households. Generally it can be observed that the poorer households depend on non-commercial sources of energy, which are available at almost zero cost. Energy forms like fuelwood, animal and agricultural wastes assume importance for such households.

On the other hand, with an increase in incomes, and to some extent, a change in the occupation structure of the household, different kinds of energy sources are demanded. For example, with an increase in income of a household, after meeting essentials like food, clothing, etc. , the household expenditure would be for a better quality of fuel, which can be from crop wastes to fuelwood to kerosene, or from kerosene to LPG. If all the sources of fuel which are preferred one after the other, in a vertical scale, one can observe that starting from fuelwood, the different rungs will lead to LPG and electricity. This hypothetical scale or ladder is called **energy ladder.**

The concept of energy ladder indicates that the pattern of energy use in different households varies with their economic status and each step of the ladder corresponds to different and more sophisticated energy carrier, and the step to which the household climbs the ladder depends mainly on its income. The ladder can be from fuelwood, cow dung, agricultural wastes, to coal, kerosene, charcoal to LPG and electricity. The height of the ladder step is determined by factors like capital cost of the fuel utilizing device, price of the energy and household energy consumption.

1.5 DATA, SOURCES, FUNCTIONAL FORMS AND METHODOLOGY

For the present study, sample data from the National Sample Survey Organization will be used. The cross sectional data is for five rounds, used for three sections of calculations. The rounds are, 27th, 28th, 32nd, 38th and 44th. The data covers all India, rural and urban areas separately. The data and the calculations are divided into three sections pertaining to fuel and light, total expenditure, fuel-wise expenditure and expenditure on fuel and light according to monthly per capita expenditure categories.

Regression analysis is used for the estimation, and six functional forms are tried. The functional forms are - linear, log-linear, semi-log, quadratic and inverse forms.

1.6 OBJECTIVES AND ASSUMPTIONS

There are three main objectives of the present study -

1. To estimate the the share of fuel and light expenditure out of total household expenditure. For this, four rounds - 27th, 32nd, 38th and 44th rounds were considered.
2. To examine the share of a particular fuel expenditure on total expenditure on fuel and light. The four fuels selected are coke, fuelwood, kerosene and electricity. In this case the data is for three rounds, 27th, 32nd and 38th rounds.
3. The third and final objective is to examine the impact of family size on the fuel and light expenditure in a sampled household.

Engel curve analysis will be the appropriate methodology to show that, as the income increases, the expenditure on a particular item (in this case, energy source) will increase initially, later increase at a decreasing rate, and ultimately decrease. This is to say that, the share of energy expenditure out of total expenditure increases at a decreasing rate over time.

The main objective of the dissertation will be to prove the existence of an energy ladder. This theory implies that with an increase in the household income, not only the quantity or expenditure of domestic fuel increases, but also, there is a positive change in the quality of fuel consumed.

There are certain assumptions made for the present study.

1. The total expenditure is equal to total income for the household sector, where, whatever is earned is spent. Due to lack of any other reliable secondary source of data this assumption is imposed.
2. Only four fuels are considered in this study. These are the most popular forms of energy sources consumed by the household sector. The four fuels are coke, fuelwood, kerosene and electricity. Across the country these are consumed in high proportion.
3. The monetary income of the households is assumed to increase with different rounds. The household income from the 28th

round to the 38th round is assumed to have increased, that is, from year to year.

The energy ladder concept is based on the studies dealing with the changes in fuel expenditure patterns according to income classes. In this context engel curve analysis is the most appropriate one. Keeping in view the literature and studies done in the area, the results are expected to prove the existence of an energy ladder, for the rural and the urban areas. The Engel curve analysis employed, is expected to show that the increase of fuel expenditure out of total expenditure increases at a decreasing rate. The results are expected to show that energy forms an important part of total household budget and an increase in the income would bring about a change in the amount of energy used, and the type of energy used.

1.7 CHAPTERS OUTLINE

For the dissertation, the chapterization is as follows. The next chapter deals with the Land-use pattern and the fuelwood demand, where the different alternative uses of land are analyzed. The third chapter deals with the Economics of Rural Energy Crisis, where the various issues related to the fuelwood consumption are dealt with. The relation between rural household energy and fuelwood is also studied in detail. Alternative sources of energy which can be used by the household sector are also considered.

The fourth chapter emphasises the pricing of energy resources, with special emphasis on pricing of fuelwood and its non-price cost. The chapter also focusses on the possibility of energy substitution in the household and inter-fuel substitution vis-a-vis fuelwood. The fifth chapter is about the efficiency factors. The various issues related in efficiency, both fuel efficiency and cooking appliance efficiency are dealt here. The next, sixth, chapter deals with the main issue of the study, that is, energy ladder, and the related studies in the area. Seventh chapter provides an outline of the study area in India. The eighth chapter details the data used and its analysis. In the nenth chapter the methodological aspects used for the present study are discussed. Tenth chapter gives a detailed analysis of the regression results, and its implications to the objectives of the study. The final, eleventh chapter concludes the study summary and conclusions, with data gaps, and shortcomings policy implications, and recommendations coming from this study.

II

LAND-USE AND FUELWOOD DEMAND

2.0 INTRODUCTION

The land available at given time is fixed, though the land area available for any particular use can vary according to time and need. In both the short run and long run, the supply of land is fixed. The area of land used for farming or land for providing fuel (fuelwood and other biomass fuels) is always at the cost of the other, because the supply of land ultimately fixed.

The most basic use of land is for living (industrial purposes, houses, forests, roads, and water bodies like lakes, rivers, etc.), then for production of food, that is agriculture, and then to provide energy for various end-uses. Whether it is fuelwood, which is used mainly by the rural population, or petroleum, gas, coal, etc., all come out of either below or above land. As the supply of land ultimately is fixed (in the long run it is fixed, though in the short-run even land can be taken as variable), the use of land for a particular use precludes its use for any other activity. This chapter covers issues like the land use **and the** size of population. These are closely interlinked in the sense **that,** if the population is large, there is a larger demand for food and fuel (to cook the food), hence more demand for land. Alternative uses of land, that is, basically, for food or for fuel **and** land degradation is also covered in the chapter.

2.1 LAND-USE AND POPULATION

The main problems of land use arise because of increasing population. The Asian countries in particular covers a major percentage of total world population, whereas the land covered is relatively small, leading to the problems, of what is termed by FAO as *land shortages* [1993]. Thus, the land available for agriculture is a major constraint and will be increasingly so, till either population is controlled, or higher yields are achieved.

Increasing population is a major problem as far as optimal land-use is concerned, because with more mouths to feed, the primary concern is of increasing food supply. The first problem which the rural areas have to face (and make an almost an impossible choice) is of the choice of food versus fuel. This is because almost 90 % of the rural energy sources come from forests. With increasing pressure on land, the need for fuel supply takes a second place, as the food problem assumes more importance. Thus, in its most simple form, the land-use issue for fuelwood relates to the use of land for two equally important uses - food and fuel.

Rapid depletion of forests and loss of forest area will also create serious problems of soil erosion, floods, siltation and **desertification**. This means that there is a need for extensive plantations for meeting the energy and food requirements, consistent with soil protection. It is in view of this clash of interest for land-use that great stress is being laid on the exploitation and development of alternative sources of energy to meet the energy requirements of the rural sector. A major consequence, as seen by Vimal and Bhat [1989], of the shortages of fuelwood has been the large-scale burning of agricultural wastes and animal dung, which otherwise would have been used for restoring soil fertility and increasing agricultural production.

In this sense, land availability not only determines the supply, but also the demand of fuelwood by the rural communities [Munslow; 1988]. This is so because as the fuelwood supplies start going down and it becomes dearer, the people search for, and settle for alternatives to fuelwood, which are more often than not, at the cost of soil fertility as seen earlier.

2.2 ALTERNATE USES OF LAND

In an agricultural ecosystem (like India's and some African countries), there are several demands upon the available land, like housing and other parts of human settlement. But the bulk of the land is devoted to crop and pastures.

The traditional land-utilization practice is to have woodlots only on non-arable lands. As this does not lead to any conflict between food and fodder on the one hand and fuel on the other hand. But the situation has reached such a stage now that to feed the ever increasing population, more and more land is being brought under cultivation. The competing demand for land for food and forest is not just for food versus fuel , but on the other areas as well. For example, wood not only provides fuel to **the** rural people, it also is a major source of construction material, industrial use, etc.

FAO [1987] in one of its study concludes that the land-use information should be such that it shows as to actually who *uses* the land and a distinction should be made between the *owner* of the land and the *user* of the land. For example, in case of fuelwood prices, the prices rarely reflect the land cost, as the fuelwood, if marketed in the rural areas is 'collected' from nearby forests and the only cost is labour cost, not land cost.

There are some ways in which the conflict between woodlots and land for agriculture can be managed as was seen in a project by FAO and SIDA [1983] -

a. fuelwood requirement can be eliminated by the adoption of alternatives to fuelwood, or the demand can be reduced by improving the efficiency with which fuelwood is used. This leads to the adoption and widespread usage of improved cook stoves,
b. area set for grazing land or pastures can be reduced through **the** cultivation of high productivity fodder species,
c. **pasture land and** fallow land can **be** put to multiple use by **combining the growth** of fodder species and fuelwood trees

together,

d. land yield can be increased so that more land need not be taken up to feed additional mouths. Here the role of Green Revolution is noteworthy.

2.3 LAND DEGRADATION AND LAND-USE

An interesting aspect comes to light in the land-use pattern. If land is cleared for cultivation, it will lead to soil erosion ultimately, thus, deteriorating the cleared land. Natural manure like crop and animal residues cannot be applied to the land, as reduced fuelwood supply (due to cutting of forests to cultivate the land), make them the next best alternative source of energy in the rural areas. Thus, soil fertility gets reduced fast and then results in deterioration of the quality of crop land. The result is that to increase food production, more land is cleared, **with** the same result. Thus, the land gets caught in a vicious cycle of degradation and clearance, which will ultimately lead to ecological disaster.

In terms of geographical distribution, Rajasthan has the highest area of wastelands (18 mil.ha.), followed by Madhya Pradesh (13 mil. ha.) and Maharashtra (12 mil. ha.). In India, the total non-forest area comes to about 93.69 mil. ha., of which nearly 12.93 mil. ha. is wind eroded, because of land degradation. The clearing of land for subsistence farming is often inevitable in the poorer developing countries. It is more so for countries **with** large and rapidly increasing populations. This is also the reason for large scale unorganized and unauthorized encroachment and land occupation of the state lands on the fringes of villages and bordering forest lands [Tuan, 1989].

The conflict between food and fuel on the one hand and problem of environment can be solved to a great extent by the introduction of a practice (a large programme of activities are involved in this) called Social Forestry or Community Forestry. This is one way in which the forests can benefit the rural poor, as it offers increasing food production potential along with, not only adequate fuel, but a whole range of other benefits. Though classical forestry viewed the forest and field as separate items, under social forestry they are profitably integrated.

The main aim of community forestry is to bring together the agriculture, forestry and also livestock activity. The goal is to achieve an integrated scheme in which cultivators (need not necessarily be land-owners) work with a tree or crop or livestock system, which is both environmentally sound and more profitable than existing practices. This also solves the land-use problem, as instead of food and fuel becoming conflicting interests, they become complementary to one another.

III

ECONOMICS OF RURAL ENERGY CRISIS

3.0 INTRODUCTION

Energy is a critical commodity for day to day life. It functions as a factor of production, as a process feed stock and as a consumer good. As an economy develops, its energy demand also tends to increase, and its consumption pattern in terms of energy forms and energy sources also tends to change [Veena; 1988].

The energy crisis being faced by the rural areas is because of the shortage of supply of fuelwood (which is the main form of energy used in the rural areas). These shortages are occuring because, firstly, the forests and other wood sources under severe pressure because of increasing demand, as a result of increasing population, and secondly, because there is a relative increase in incomes of the households. This means that, with the increased purchasing power, there is a demand for better, efficient fuels, leading to the increased consumption of fuelwood, which is considered more efficient than crop wastes and other biomass fuels in **the** rural areas. With increasing demand for food to satisfy **the** increasing population, more forest areas are being brought under cultivation, thus worsening the fuelwood availability in the rural areas. The depleting sources of fuelwood on one hand, **and** increasing demand on the other, are leading to the energy crisis in the rural areas.

This chapter will discuss in detail the importance of energy in the economy, population size and fuelwood use, household energy and the alternatives to fuelwood are studied. The alternatives to fuelwood is studied under three categories - commercial forms, non-commercial forms and potential forms of energy.

3.1 IMPORTANCE OF ENERGY IN THE ECONOMY

Energy is the most important ingredient both for material and human development in the world. An important dimension of energy's place in the economic activity can be gauged by its becoming an imperative indicator of per capita production. Consumption of energy in the sphere of assessing the economic development of a country is also an important indicator for the nation as a whole.

In India, the process of development translates into improving the standard of living or quality of life of people in the rural areas, as most of the Indian population live in the rural areas. Energy is an essential input for any kind of development and social advancement, whether it is requirement for food or for shelter, clothing or drinking water, health or education. Energy plays an important role in making these necessities available to mankind. Broader attention to rural energy needs and development of *appropriate* alternative energy sources are necessary for faster development of the rural areas. The conservation of fuelwood by the adoption of efficient wood stoves (which can be taken as an alternative source of energy, where increasing amounts of the energy sources can be saved or conserved), biogas, etc., can become an important part in the solution of the forest and environmental problems.

The demand for fuelwood in the rural areas is not just because it is a traditional fuel and the people are used to use it, but the economics of fuelwood has many related issues attached to it, like income of consumers, size of the family, end-use for which fuelwood or other substitutable non-commercial fuels are used for, size of land holdings of the land-owning households ,the distance from the fuel source, cultural habits and religious practices of the consumers, the level of technology regarding fuel efficiency availability of improved stock of animals (cattle mainly) in the household, etc.

To look into the economics of fuelwood demand, the income of the household should be looked into first. One factor which emerges from various studies is that the choice of fuel is directly related to the income level of the household. Biomass fuels tend to dominate the fuel consumption patterns of the poor, and the satisfaction of fuel use by income is more or less similar in most of the countries [Foley; 1986]. The main reason is that the discomfort associated with most cheap and non-commercial fuels like smoke, soot, low efficiency etc, can be avoided by the adoption of slightly expensive fuels (like kerosene) by relatively better off consumers. Also, the adoption of commercial fuels is widely regarded as an indicator of modernity and higher social status by their users.

Another observation, by Leach and Gowen [1987] is a strong **and** steady relationship between total energy consumption and income, and a tendency of energy use to rise steeply at low income and to 'saturate' at higher incomes. As spending power increases in rural areas, consumers can buy their way out of biomass fuel shortages and / or have sufficient land to grow their own biofuels. In both rural and urban areas, greater purchasing power pulls families toward more efficient and convenient modern fuels and their new end-users they allow.

With increasing incomes, for some time, there is an increase in fuelwood consumption, due to the easier access to biofuels with increased land and / or cattle ownership, and the ability to buy them. There is a substitution between biomass fuels for cooking. This is not only a matter of taste, but also of convenience. The degree of substitution and the income level at which substitution begins depend on the relative prices of fuelwood and other fuel sources, There is a greater use of modern fuels and electricity for end - uses other than cooking. For lighting, there is an increased kerosene use, followed by a decline at higher incomes as electric lighting is installed, and finally there is a tendency of saturation for modern fuels at the highest income levels.

Another trend which can be observed is that domestic energy consumption rises proportionately much less than income, at least among the lowest income groups. In India, for example, energy consumption per household in quantity terms is at about 1/3 of the rate of increase in income [Celeski, Dunkerley & Ramsay; 1985].

The quantity of energy consumed by the poor is frequently described as inelastic, in the sense that it is a basic necessity which must be provided under all circumstances. This inelasticity has two aspects. Firstly, it implies that energy consumption is not responsive to price changes, and secondly, a certain income inelasticity of demand for energy or say gross energy inputs, at low levels of income is evident. After a certain 'threshold' level of income, there may be a sharp increase in household consumption of fuel as access to new sources of energy become feasible.

In rural areas as well as urban areas, expenditure on fuel increases as income rises, though less rapidly than the rise in income. The quantity of energy consumption and the quantity and type of fuel used are very much influenced by the income level of the household, size of land holding and family size. One can say that, as observed by Rao [1990], with an increase in income -

a. an increase in per capita quantity of energy consumed is apparent,
b. there will be a change in type of fuel consumed, end-use of energy, and the mode of obtaining it, and the fuel will be

bought rather than collected,

c. larger land holdings reduce demand for twigs and branches and other types of inferior fuels.

As the income increases, there is a tendency to purchase trees grown on other's lands (wherever such practice is prevalent), and such trees are mainly used for fuel purposes. Households whose income come from regular wage, salary or business income, have relatively higher purchasing capacity, with which they can buy fuelwood, rather than collecting it, unlike the practice with most poor families. If fuelwood is in short supply, their effective demand for food is also very low due to their low level of income. As fuel is costly, they prefer to have lesser cooked meals, or cook only once a day.

With an increase in income level, the use of fuelwood for various end - uses also increases. For example, while for the lowest income households, the use of fuelwood is limited to cooking, but as income rises, it is also used for water heating, which is considered as a 'luxury' in many rural areas. The coefficients of correlation between income and fuelwood consumption, as found by Bhargava and Karkezi [1990], are not only positive, but are also highly significant. This shows that along with an increase in income of a household, the consumption of fuelwood increases.

Within a village, an increase in income leads to a shift in demand from less efficient fuels (for example, twigs and branches, leaves, etc.), to better types of fuel, and subject to availability, even to commercial fuels. Thus, with an increase in income, a household's preference changes from gathering to purchase of fuel (mode of procurement).

With an increase in income of households, the participation of children for fuel collection also declines significantly. Thus, the labour participation in procurement of fuel decreases. People at the bottom of the economic ladder find it difficult, or almost impossible to switch over to other costlier substitutes of fuel on the one hand, and even other non-commercial alternatives [Vimal & Tyagi; 1986].

In absolute terms, cooking fuel constitutes the largest energy requirement in the rural areas, and fuelwood is the main source of cooking for both landless and land owning households. The poor families not only collect fuelwood for self - consumption, but it becomes a source of income for those who sell it to the relatively richer households. Thus, from being a free and non-monetized commodity, the fuelwood is slowly becoming a marketable economic good. [Islam, Morse & Soesatro, 1984].

Fuelwood and income of household are also related in another way, where, in the poorer sections, in relatively developed villages, it becomes a source of income, thus helping the poorer sections to sustain their day to day life, as was observed by Chambers and Leach [1990] in their study in the area of household energy and occupational structure. Thus, fuelwood can be a source of income for the poor households, apart from providing a source of fuel to them.

3.2 FUELWOOD CONSUMPTION AND POPULATION SIZE

It has been noted that fuelwood consumption is more prevalent among families with large number of members, and as the family size increases, proportion of households using fuelwood also increases, because with an increase in family size, consumption of the fuel also increases. In other words, family size has a positive correlation coefficient with the use of fuelwood.

Household size has as great an effect on energy consumption as other major variables like incomes associated with income. On an average, large families tend to have more income earners (as even when there are small children in the family, they tend to work in the unorganized sector and earn a daily wage, contributing to the family income, at the cost of education). In case of south Asia at least, the rising curve for household energy plotted against household income are mostly a function of increasing family size with households income.

Adam Smith in his classical book, *Wealth of Nations* was concerned with the growth of population and thought it was both a consequence and cause of economic progress. According to him, increasing division of labour would bring about greater productivity and would furnish an enlarged revenue and stock from which greater wage fund will result, and an increased demand for labour and higher wages, hence, economic conditions for population growth. He concluded that population growth would stimulate progress, which in turn would enhance further growth and expansion.

This argument of Adam Smith's may hold correct and be practical for areas with low population, low or shortage of labour force and abundance of natural and capital resources. But in present day developing countries, population is a cause, and a consequence of poverty, under-development and scarcity of resources. Here the population problem is not one of shortage, but rather of over-population, where the natural resources like forests, with their given natural regeneration rate, are not able to keep pace with the increasing demand.

There is theoretically a maximum to the population which can be supported by either food produced from a given area of land, or forest area which can produce fuelwood. This so-called 'carrying capacity' depends on the way the resource is exploited, time given for regeneration and human and other capital and materials applied to it.

An increasing human population leads, in the absence of alternative cooking fuels, to an increasing fuelwood demand. There is a direct conflict between human population and fuelwood resources. A growth in human population leads to increased demand for all the other non-cooking-fuel uses of wood, that is, for other domestic uses and industrial uses.

Population in rural areas who consume non-commercial fuels, consume about 5600 K.cals per capita per day, as against 2 times higher, 11200 K.cals per capita per day for the urban areas. If we consider a reasonable need of energy for a satisfactory life pattern which is estimated to be around 28000 K cal per day then it implies that only 20% of the energy needs of the rural population are met. This is not just on account of the non-commercial fuel use which the rural population relies on, but also because the number of members per household in the rural areas is more than the urban areas. The increasing population would directly raise the total demand for energy in the domestic sector, where the increase in income and development would cause shifts in demand for fuel consumed [Veena; 1988].

Though the population growth is positive in most regions, the rate of growth varies across regions, hence the fuel demand also varies accordingly. One basic aspect is that consumption grows directly with population growth, whereas the mean annual increment of the existing wood stocks decline in direct proportion to the decline in **the** stocks, both the annual increment and the stocks decline at accelerating rates. [Anderson & Fishwick, 1984].

Consumption of fuelwood can be seen as-

$$C = (A/P)^{\rho t}$$

where, A is constant, P is price and p is population growth rate, over time t.

Studies of the population supporting capacities of land indicate that pressure on land will increase in areas where population is fast increasing. Though the world as a whole should have enough cultivable land to feed more than the maximum population, the land resources are very unevenly distributed in relation to population. Also, the provision of land to grow wood for fuel is essential to meet the basic needs of the poor rural people, who need to cook the food, apart from growing it [FAO, 1985].

From the demand point of view, energy sources can be considered in two groups, commercial sources and non-commercial sources of energy. Commercial energy can be differentiated in its two forms like, primary and secondary. The primary forms of energy use are those which are used in the form in which they are found, example coal, oil and natural gas etc. On the other hand, the secondary forms of commercial energy are the ones where the basic source is transformed, mainly from the primary source, for example, electricity.

The non-commercial fuels are obtained from agro-waste, animal waste, firewood etc. Though non-commercial sources of energy are not very convenient to use as fuel, they are available at almost zero or negligible cost. Non-commercial fuels are in the nature of inferior goods; and tend to be substituted by commercial fuels as income level increases. Since non-commercial fuels are available at almost zero or negligible cost, it constitutes an important source of energy for poorer sections of the population, especially in the rural areas. This is because a large majority of the rural population do not have enough purchasing power, they survive on non-commercial energy sources like firewood dung-cake and agricultural wastes. Thus, in the rural areas, wood is the basic cooking fuel, and where it is scarce, dung and agricultural wastes are adopted.

With development, increase in incomes of the households, and of course an increase in population, the demand for energy increases almost exponentially. Energy consumption in the domestic or household sector depends mainly on the above mentioned reasons, that is, development, increase in income and an increase in family size. The household energy sources consists mainly of fuelwood, crop residues, animal dung and twigs and branches on the one hand and coal, kerosene, electricity and LPG on the other. Most of these sources of energy act as substitutes for one another, at one point or the other.

3.3 HOUSEHOLD ENERGY IN INDIA

In India, as in most of the developing countries, most of the consumers of non-commercial sources of energy are those who obtain their woodfuel, agricultural wastes or animal dung without attaching any monetary value for it. Consumers of commercial sources of energy on the other hand, like coal, oil, gas, electricity, etc. , pay for the fuel that they consume. In this, we can count even those consumers who buy fuelwood from the market in the later category. Thus, fuelwood can be taken to be both a commercial fuel, depending on its source of supply, or the method of procurement. But, in the rural areas, 90 % of the fuelwood used in the households is non-commercial, that is, which is gathered free of cost.

In the household sector, income of a household plays an important role in the type of fuel consumed, the mode of procurement, and the quantity of the same. In areas where fuelwood is available easily from the market, relatively higher income group households prefer buying fuelwood from the market, rather than collect it. On the other hand, if alternatives are available, then there is a preference for more 'efficient and clean' fuels than the wood based fuels used mostly in rural households.

3.4 ALTERNATIVES TO FUELWOOD - REVERSE SUBSTITUTION

There is another feature to the alternatives to fuelwood, that is, *reverse substitution*, in which people change back to wood fuels as a result of increase in price of conventional fuels. Relative changes in the prices of wood fuels and conventional fuels have little effect on consumer behaviour. In the short-term, domestic fuel consumption patterns are resistant to change. The choice of fuels appears to be strongly related to income level of the consumers. Wood fuels tend to dominate the fuel consumption pattern of the poor. The stratification of fuel by income is broadly similar in most of the developing countries.

As alternatives to fuelwood, commercial sources cannot play an important part in the rural areas, because on the one hand their availability is restricted and on the other, they are prohibitively expensive. As the traditional fuelwood sources become depleted due to over-exploitation because of increase in incomes, population and standards of life, throughout the developing world, the problem of how to meet peoples' future energy need becomes most urgent. The switch from fuelwood to commercial sources of fuel may be better if energy efficiency perspective is taken, but in terms of cost to the consumer, in the short and the long run, it becomes prohibitive. The move away from fuelwood may either be voluntary (due to increase in income of the household, or improvement in standard of living) or forced (due to non - availability of fuelwood).

The alternatives to fuelwood may be either commercial, non - commercial or other potential fuels. The alternative fuels can be divided as Commercial Fuels like oil that is, petrol, diesel, kerosene, coal and coal products like briquettes, LPG, natural gas, propane, butane, electricity - hydro, thermal and nuclear. The Non-commercial Fuels can be divided into agricultural wastes, animal wastes, biogas, forest products, and shrubs, and the Potential sources of fuel (non-conventional sources) can be divided into solar - direct, solar electricity, fuel cells and solar cookers, wind energy, tidal energy, and geothermal energy.

3.4.1 Commercial Sources

Of the above listed alternatives, the viable and preferred sources of fuel for the rural household consumption are the non-commercial and potential sources of fuel. The commercial sources of fuel are not only non-renewable and almost near exhaustion (given the present known reserves), they form the foundation of the industrial structure, and most importantly, they have very high environmental costs attached to their usage and future development.

The most common usage of electricity at present is for lighting purposes. Cooking by electricity is rare in the rural areas, and even in the urban areas, it is very expensive to use electricity for cooking purposes. Also, cooking by electricity is rare in the developing countries, and wherever it occurs, it is usually among the richer members of the region. Where it is adopted for cooking, it tends to replace or displace gas or kerosene rather than fuelwood, and its direct impact on woodfuel demand in the reasonably near future is likely to be relatively minor.

The fact that a major shift to kerosene is theoretically possible does not imply that it is either feasible or desirable in a country. The lack of adequate transportation and distribution systems completely precludes a significant shift to commercial fuels by rural consumers in the majority of the third world countries. The relative costs of cooking with different fuels might be expected to have an impact on the choice made between the fuels by the consumers.

3.4.2 Alternative Non-Commercial Sources

1. Improved Stoves

Regarding non-commercial source alternatives to fuelwood, most important and presently most feasible would be the introduction of improved stoves, using fuelwood, or twigs and branches. It not only conserves the wood fuel, it also makes the cooking activity easier because of more efficient use of the fuel source than compared to the traditional stoves. It has been observed that on an average, about 5 % of the fuelwood can be saved in the bigger cook stoves and about 10 % in the smaller ones [Tyagi and Bhat; 1985]. But one major problem with the large scale adoption of the improved cook stoves is the cost involved, which needs periodical repairs or rebuilding, as most of the stoves are made of mud, bricks and other locally available material. Their relative non-flexibility and longer labour time (for cutting the wood and other fuel to a particular size to fit the stoves) act as other constraints.

2. Agricultural Wastes

The use of agricultural wastes is dependent on agricultural production and its availability is seasonal. Apart from this, there are many other uses for the agricultural wastes, like it is an excellent fodder for the farm animals, house making (thatch roof for the houses) and some wastes are also used as fertilizers (green manure). Thus, the use of agricultural wastes can at best be limited to occasional use and full time dependence on it as a household fuel is neither possible nor feasible.

3. **Animal Wastes**

Animal wastes like cow dung is used on a large scale in the rural areas of India. It is also used to some extent in the poorer sections of urban areas also. Cow dung is not only a source of energy, it is also natural fertilizer. Cow dung cakes, though are a popular source of fuel in many areas, it is not an efficient fuel. The main drawback of using cow dung cakes as fuel is that its use deprives the farmer of a valuable natural fertilizer.

4. Biogas

The best alternative may be the usage of cow dung for the generation of biogas or *gobar-gas.* This can be a viable alternative for fuelwood in the rural areas, especially, as its usage as a source of fuel does not mean that it cannot be used as a fertilizer. In fact, the by product dung - out of the biogas plant is said to be a better fertilizer source for the fields.

The use of biogas can check the rate of deforestation, but the impact of promotion of biogas may increase the size of livestock population, which in turn, needs more fodder and in the rural areas, fodder is mainly derived from tree - leaves, branches cut from nearby trees or from local forests and other miscellaneous trees. Thus, even with the promotion and use of biogas, some amount of deforestation takes place. But biogas technology is a major alternative because it not only provides crop manure of a higher nutrient content, but also a very convenient fuel source, which can be used for cooking, heating and lighting purposes.

A biogas project being taken up must explore variables like the number of family members, size of land - holding, livestock population, daily dung production, daily fuelwood consumption, the amount of dung used to produce biogas, consumption of other kitchen fuel, if any, like kerosene.

Over 74,000 biogas plants were installed from April to December 1989 in the rural areas. This saved fuelwood worth Rs. 175.65 crores a year and also provided enriched manure valued at Rs. 174.50 crores annually [Vimal and Tyagi; 1986].

Though it is a clean, efficient fuel, and can be used for cooking and lighting and gives manure for the fields, its high initial cost in spite of the subsidy given by the government, and its continuous operating costs make it unacceptable and inaccessible to most of the rural households.

3.5 POTENTIAL SOURCES OF ENERGY

The third categories of alternative sources of fuel are **the** potential sources of fuel, which are still under development and as of now, not an economical prospect. But their development is underway, as they are all renewable sources of fuel and are by and large, non-polluting. Thus there will not be any adverse affect by their development and usage, but they have yet to be brought under usage on a commercial scale. The energy from sun, sea tides and wind is considered as very useful source. Even these sources have made the people realize the importance of non-commercial and potential sources of energy, and its optimal utilization for meeting the growing needs of the people of the world in general and developing countries in particular.

3.5.1 Potential Sources

1. Solar Energy

Of the potential sources of energy, solar energy is the most important. Though solar energy, is the most basic source of energy, its harnessing and use in the required way is of recent origin. Solar energy has been used for lighting, drying, heating, and other uses from the earliest of times, harnessing it and using the same even when sun has set is the *source of energy* which is of interest here. **The** problem in respect of direct usage of solar energy is in its diffused stage and being not constantly available - both in terms of time and in terms of extent of energy received. The solar energy received by earth in a second is 10 joules, which is equivalent to more than the electricity generated in a month all over India, or eight days of sunshine is equal to the total available source of energy in the world put together for a period of about one year.

Basically there are three ways of catching sun's rays to use either for heating or for generating electricity -

a. by means of **solar panels** on the roof of a house or building, and storing as much heat as possible or converting these rays into electric current,
b. keeping water in insulated tubes is a good medium where there is lot of sunshine,
c. by **photovoltaic cells,** where the cells generate energy because of a chemical reaction, triggered on by the sun rays falling on the cell, filled with chemicals.

Other potential use of solar energy in households is by solar cookers. In this method, at a time two to eight dishes can be prepared at a time and the cost of fuel is nothing. The only cost is of the cooker itself. The solar cooker works on the *reflector* principle, where the sun rays are made to fall on one or a few mirrors and then they heat up the cooker and cook the dishes kept inside in cooker. Solar water heaters are mainly of two types - thermosyphon systems and forced-flow systems.

Another use of solar energy is by solar battery. The battery is operated with semi-conductor crystals which are quite similar to those used in transistors, either of germanium or of silicon. An electric current is generated when sunlight strikes such a crystal. Solar power can be an ideal alternative to other commercial and non-commercial sources of energy because of its inexhaustive nature and also because there is no shortage of the source in a tropical country like India.

2. Wind Power

Another source of energy which can be developed as an alternative to fuelwood is wind-energy. Apart from generating electricity by wind-mills, it can be used for various small uses like crop-drying, husking, irrigation, etc. This can be useful and free of pollution as long as wind of a particular velocity is available.

3. Sea Tides or Tidal Energy

The sea tides are another source of energy, which is derived from tides, thus it can be called *Lunar Energy.* But it is in **an** initial stage of development to provide a viable alternative to fuelwood.

3.6 RURAL ENERGY CRISIS - A PROBLEM

Domestic or household sector accounts for more than 75 % of total energy consumption in the rural areas. Due to the fast deforestation and dwindling supply of firewood and gradual commercialization of traditional fuel sources, it has become very difficult for the rural people to secure adequate energy supply at a cost affordable by them. Furthermore, the fragmentation of land-holdings has also stopped many farmers from growing their own fuelwood.

On the other hand, there is a lot of wastage of available energy due to inefficient energy gadgets used and also due to ignorance. Many studies reveal that energy consumption has a positive relationship with the development and income levels of traditional fuels like fuelwood and dung and agricultural wastes, etc. Energy consumption pattern varies from place to place and also from season to season. The dependency on various fuel sources depend on, and varies according to the income level of the households and the end-use pattern of the same.

In most of the rural areas, apart from fuelwood (wherever available), twigs and branches (T&B) are the major sources of fuel for the villagers. Forests and trees outside villages are the main sources of fuelwood. Agricultural waste as a source of fuel is negligible. Kerosene is used mainly (only) for lighting in the rural areas of most states.

3.7 ENERGY CONSUMPTION PATTERN

The quantity and quality and type of fuel used are very much influenced by the income level of the household, size of land holdings and family size. An increase in per capita income leads to an increase in the quantity of energy consumed. Also along with an increase in income level, there will be a change in the type of fuel consumed, change in the end-use of energy consumed and a change in the mode of obtaining fuel. Another thing is that the demand for energy is positively related with family size and larger the land holdings of a farmer or rural dweller, smaller will be his demand for twigs and branches and other inferior type of fuel.

In the present context, the relative superiority or inferiority of a fuel is judged by the energy released and energy used per unit of weight of the energy source, and the efficient use of the same per unit of weight.

3.7.1 Fuelwood Demand and Development

Use of fuelwood in the households is restricted in almost all the rural areas to cooking and water heating, and because of the availability of fuelwood, demand for it is created in relatively developed villages. With development in the rural areas, only the number of consumers of fuelwood increase, but also the per household quantity of consumption of fuelwood increases. This is because the use of fuelwood is not limited for just cooking, but for relatively *luxurious* use like water heating.

Thus, the level of development and prosperity of the villagers is an important determinant of fuelwood consumption in the rural areas. In developed villages, owing to good demand from the villagers, fuelwood supply conditions are also good, in the sense that fuelwood is available for sale either through fuelwood depots or in open markets (hawkers, or weekly markets), whereas such is not the case in backward or underdeveloped and poorer villages. This is because of lack of purchasing capacity and lack of supply of fuelwood in these areas as the usage of relatively inferior fuel source - twigs and branches is more, and fuelwood becomes a relatively superior form of fuel in these areas.

3.7.2 Income Level and Fuelwood Demand

Consumption of fuelwood is also influenced to a great extent by **the** income level of various households, their land holding size **and** family size. But the income level has the greatest influence on the level of consumption and the pattern of end-use of fuelwood. The coefficients of correlation between income and fuelwood consumption **are** not only positive but also are highly significant. This shows that along with an increase in income of the household, their consumption of fuelwood also increases. Also there is likely to be a shift in the demand from inferior form of fuelwood, that is, from twigs and branches to chopped logs etc. , which are sold at a price in the market.

All the above factors are inter-related and have a cause-effect relationship on the fuelwood consumption pattern. The consumption of fuelwood is more prevalent among large sized families. As the family size increases, the proportion of households using fuelwood also increases. On the other hand, higher demand for fuelwood also emanates from higher income households. All the other factors contributing to the demand of fuelwood will be examined in detail in the following chapters. This consumption trend is severely negative in the urban areas, where fuelwood is used by the poorest sections. As incomes increase the shift to other forms of fuel is faster than that in the rural areas.

3.8 FUELWOOD SOURCES

The main sources of obtaining fuelwood are, own sources, purchased and collected. Own sources like agricultural land, orchards, gardens, trees owned. Purchased, from fuelwood dealers, government depots, within or outside the villages. Alternatively, collected or gathering from wastelands, nearby forests tree-lots, other gardens and from roadside trees. The dependence is often on no more than one source.

In those villages which are relatively developed and affluent, the major source of fuelwood is by purchase in the open market and by own sources; rather than collection. Also the dependence on fuelwood goes down after a certain income level. Thus, the purchase of fuelwood has a positive relationship with income. For many a household, fuel collection and fuelwood selling is a major occupation and means of livelihood. Thus, not only for fuelwood use and a fuelwood market to be present, accessibility to forests, trees shrubs within convenient distances is one of the important factors supporting gathering and selling of fuelwood.

Purchase of fuelwood or collection of twigs and branches also depends on the occupation of the households. Normally, households having "service" as their main occupation go in for purchase of fuelwood rather than for fuel collection. Thus, different factors are responsible for the method of procurement of fuel, like purchase against collection.

The procurement of fuelwood is by gathering if -

a. fuelwood is relatively freely available and is easily accessible
b. if there are unemployed members in the family, for example, housewife, children, not going to school and below the age of fifteen
c. economic status of the household - lack of fuelwood purchasing capacity
d. if there is not adequate land to grow own sources of fuel -

either in the form of branches of trees, or agricultural wastes.

On the other hand, villagers prefer to **purchase fuelwood if -**

a. **the main** occupation of the household is anything other than agriculture

b. economic situation - having purchasing capacity

c. fuelwood is sold within the village or in the nearby markets

d. if unemployed members are not available in the household and **the** children go to school and others are occupied in any other gainful employment.

Thus there is a direct relationship between income level and consumption of twigs and branches and other biomass fuels, in **the** sense that twigs and branches used for cooking have a negative correlation with income and the size of land holding.

3.9 CONSUMPTION OF INFERIOR FUELS

Broadly, the consumption of twigs and branches, an inferior fuel is a function of income level or income size and size of land holding. An increase in income - a shift in the demand from less efficient source of fuel (like T&B) to better type of fuel and an increase in income leads to a fall in the demand or consumption **of twigs and** branches. With an improvement in the economic **status** of the household, the method of procurement of fuel also changes **from gathering to purchase of fuel.**

The analysis of end-use pattern shows -

a. when income increases there is a shift in final demand for energy for cooking purposes from an inferior fuel to an alternative superior fuel, say for example, from twigs and branches to fuelwood in the form of chopped logs,

b. any change in income or land holding, first influences the demand pattern of fuel sources for cooking purposes,

c. complete shift in the fuel for various end-uses takes place only when income changes significantly.

The quantity of fuelwood gathered depends upon the purpose also for which it is gathered. If the fuelwood is collected for own consumption, then the amount of fuelwood collected may be significantly less compared to when it is collected or gathered for sale in the market.

Another traditional, inferior fuel which is used in large quantities is agricultural wastes. This is more prevalent in areas where availability of fuelwood is not very easy, and even if it is available, it is sold rather than freely available. The usage of agricultural wastes is rather restricted when compared to fuelwood, because its availability is seasonal, difficult to store, it is also used as fodder for the farm animals, it is available only with the households owning some land, and most important, it is an inefficient fuel compared to fuelwood.

To some extent, with an increase in the size of land holdings, the household consumption of agricultural wastes increases, but the purpose for which it is used, may not be for cooking. When the land holding is big and the income level increases, the households shift to a relatively efficient fuel like fuelwood or kerosene, even if it has to be bought. The main reason for the limited usage of agricultural wastes is cropping pattern, and another reason is occupation structure of the people - whether farming is the main activity or any other more important activity.

The pattern and the extent of fuelwood consumption in the rural areas throws up various issues, which are all inter-related, but influence the availability and consumption of fuelwood in the rural areas. The various issues related to this are -

a. alternatives - The alternatives to fuelwood can either be commercial sources of energy like kerosene, coal, LPG or electricity, or also potential sources of energy like biogas, wind energy, tidal energy. But the usage of the last two sources of energy may not be viable in the foreseeable future as they are highly capital intensive and need large amount of investment,
b. price of the fuelwood and of alternative sources of **fuel,**
c. economic status of the households or level of household income,
d. size of the family of the household or population level,
e. size **of the land** holding of **the** farmers - land fragmentation,
f. availability of fuelwood within the vicinity of the villages,
g. end-use, or the purpose for which fuelwood is used, **whether it**

is for essential activity like cooking or for relatively luxurious end-use like water heating,

h. technology and efficiency improvement,

i. the stage of development of any region or village,

j. environmental impact of fuelwood consumption,

k. alternative usages of wood, and wood based industries.

3.10 CONCLUSION

In a developing country like India, rural population forms more than 60 % of the total population. As was observed in the chapter, fuelwood forms the main fuel form for the rural households. With the decreasing fuelwood supplies due to fast depletion of the source, and increasing demand due to population increase, there is a crisis situation in most of the rural areas for energy products. This becomes more serious because the availability of alternatives is severely restricted. Apart from the shortage of fuelwood supplies and non-availability of alternatives, capital expenditure constraints exist and where non-renewable resources are not only scarce, but also expensive, the prospects for massive industrialization and development of the rural areas and the country as a whole on conventional economic lines is naturally difficult. Energy in whatever form it is used, is vital for conducting daily activities in rural areas, be it in agriculture where pump sets are used for irrigation, small scale and cottage industries where machines are used, or in the homes where the daily cooking is done.

Encouragement has been given to the increased production of cooking gas, though its distribution in the rural areas is almost non-existent. A system of controlled prices and priority distribution has been evolved to give priority to those areas where the need for substitution is thought to be the greatest. But the major problem with such substitution for wood has become particularly difficult because of the rapidly increasing commercial fuel prices and reduced supply reliability.

Cooking with wood in open fires requires twice as much energy as cooking with charcoal which in turn needs twice as much as cooking with kerosene or LPG. But the price of kerosene in comparison to that of wood rarely reflects its advantage in energy efficiency. Many people are paying considerably more for their cooking by using wood fuels than if they were using kerosene (or LPG). But the main problem for the regular usage of commercial sources of fuel is that they are not necessarily available for sale in many rural areas on a regular basis; consumers may therefore have no choice but to use wood-fuels. In some areas, wood and charcoal are demanded for the sake of flavour they impart to certain traditional meals. The cost of stoves also may be a barrier to the use of commercial fuels.

IV

ENERGY PRICING AND SUBSTITUTION

4.0 INTRODUCTION

Energy is required by all, for various uses - be it as a final good or as an intermediate good, and there is a price attached to all. The price may be expressed in terms of money or it may be expressed in terms of money or it may an 'intangible price'. The management of energy production and pricing are to be based on three main aspects - basic needs, economic growth, and, conservation [Sarkar and Kadekodi; 1987].

There can be no substitution for energy, be it human, animal or inanimate. But, there can be a substitution between one form of energy for another, though there are many factors involved in substitution of one energy for another like, apart from prices, the tastes, convenience, habit, prestige, availability and sunk costs of the energy using device. This chapter studies the issues related to the price of fuels, with special reference to fuelwood and the possibilities of substitution in the rural areas. The substitution possibilities are observed to be more in urban areas.

4.1 PRICING OF ENERGY - THEORY

One of the most basic criterion for pricing is on the basis of

Marginal Cost (MC). In case of energy pricing, the basic principle should be the welfare principle, where the pricing is such that it is within the reach of all, more so because, no economic activity can be undertaken without some form of energy or the other - be it animate or inanimate energy.

The principle of Marginal Cost Pricing leads to optimum welfare economics and optimum resource allocation [Keshava; 1991]. For allocating the limited, scarce resources efficiently among various alternative uses, the price of the source of energy must equal the MC of its production. This is so because pricing any good have two main economic functions, to discourage excessive consumption of a commodity and, to induce the desired supply of that commodity. The purpose of MC pricing is to allocate resources efficiently by providing appropriate signals [Mahajan; 1991]. The above mentioned MC principle works well for the pricing of any commodities and for any of the commercial fuels like kerosene, coal, electricity, etc., but when the pricing of traditional fuels like fuelwood, agricultural wastes, cow dung, and other fuels, pricing cannot be done based on MC principle, as to start with, the 'production cost' of these fuels cannot be counted or calculated. Fuelwood and other traditional fuels in the rural areas are taken as public good, or *free good* and are gathered, rather than bought from the market. Thus, increase in *price* may not increase supply or suppress demand. If there is an increase in *price* of traditional fuels, people readily shift to other fuels.

4.2 PRICING OF TRADITIONAL FUELS - SHADOW PRICING

For almost all of the traditional fuels, a price cannot be assigned as they are not bought and sold in the open market. The rural areas do not have a formal market for the traditional fuels. In such a case, if any price is to be assigned to the fuel consumption and fuel demand and supply, **shadow pricing** is used. Shadow pricing is defined as that value assigned to a commodity that contributes to a change in the economy's socio-economic objectives through a marginal change in the availability of the shadow priced commodity [Siddayao; 1984].

Shadow prices can be assigned to traditional fuels, which reflects the social opportunity cost of their consumption and production. The alternative cost of consuming a certain commodity or energy source like fuelwood (which has many alternative uses) is one main issue. For example, another way to look at it would be, if this fuel is not used, what would be the cost of the alternate fuel? The usual approach to shadow pricing is to start by determining supply-related costs. For example, in case of fuelwood, what are the *costs* of supplying wood to the rural households ? The costs may be both tangible like cost of wood and cost of land used. and intangible costs like *cost* to the person who collects the fuel, cost to the environment and ecology, cost of the depletion of a natural resource, etc. The costs of externalities, which are not captured by direct costing are also added to the shadow prices.

In this way, shadow prices measure the value of the fuel supply, taking into account the interactions within the energy system. The shadow prices can also be used to value the importance of efficiency improvements in both the conversion from primary to secondary fuels and at the end-use level [Hosier & Bernstein; 1992].

4.3 ENERGY PRICING

Though energy prices can be shown to affect levels of consumption, the energy pricing provides a policy instrument for securing changes in energy consumption patterns. There is a conceptual difficulty is assigning a *price* to the non-commercial traditional fuels, which are not traded. It has been observed that prices paid by rural dwellers, despite subsidies are much higher than those paid by the urban dwellers [Cecelski, Dunkerley & Ramsay; 1987].

Pricing for energy sources is a particularly important tool to achieve long-run changes. The objectives of energy pricing are closely related to the general goals of energy policy, which can be - economic growth and efficient allocation of resources, social objectives like subsidized prices so as to reach even the poorest, viability and autonomy of energy sector, and energy conservation.

Though according to economic principles, energy like all other goods and services, reflect the cost of its production and distribution, and pricing will prevent large scale price fluctuations, in many rural areas, where the fuel is not *priced,* may throw the rural economy into confusion if all of a sudden, taxes (like stumpage tax in case of fuelwood) and *prices* are attached to traditional fuels. Thus, energy pricing should be seen in a welfare framework - from the income distribution **pattern** of a society. The consumption of a particular fuel as estimated by Kadekodi [1987], depends on many factors like, population, income of households and level of development, price of the fuel - both in monetary and non-monetary terms, quantity of fuel available, and relative prices of other fuels [Kadekodi; 1987]. In view of this, the traditional fuel sub-sector has been relatively neglected as transactions involving these forms of energy are usually of a non-commercial nature.

4.4 FUELWOOD

The *pricing* of fuelwood in most of the third world countries is generally not based on sound economic principles (like MC principle), but more on population, income, etc. In countries like India, with low land-man ratio, the opportunity cost of raising energy plantations is very high. This affects the supply to a great extent. A way to manage this shortage is not always by putting a monetary price to the local fuels used, but there are many options before the policy makers, like -

a. distribution of alternatives (like kerosene) to poorer sections by **cross-subsidization**

b. stimulating the use of efficient fuelwood stoves

c. promoting fuelwood plantations of fast growing species, instead of using commercial fuels (like kerosene, coal, etc.)

d. taxing fuelwood (though it is not practically possible), to make users conserve fuelwood in their daily use [Bowonder, Prasad and Unni; 1988].

Observing the fuelwood shortages, the *price* of fuelwood should have gone up as the fuel becomes *costlier* to procure, but according to Saxena [1993], the fuelwood prices seem to have declined in real terms. This can be attributed, in the north-west India, to the glut of eucalyptus in that region. Even now, the fuelwood from public lands and other miscellaneous lands can provide fuel for both consumption and sale at almost zero opportunity costs to the poor. The only *cost* is the time spent in collection of the fuel.

When fuelwood is traded as a commercial good, it tends to be viewed differently from when it is gathered without payment. The transition from the use of non-commercial to commercial fuel can be very important to the domestic fuel consumption patterns. This mainly happens when the fuel (fuelwood) is demanded by the urban areas, and it is at a higher price. On the other hand, when no commercial market exists and people obtain their fuelwood without cash payments, they will tend to respond to a scarcity of fuelwood by shifting to other non-commercial fuel, for example, to cow dung or to some extent to agricultural wastes [Foley & Moss; 1985].

People who usually buy their wood-fuel, have a clear cash incentive to invest in fuel-saving devices when wood becomes scarce and more expensive. Thus, the pricing of fuelwood may actually save the fuel and bring about a conservation of the fuel, which may be difficult to achieve if the fuel is a *free good.* In this way, the cost of fuelwood to the poor people would be the time spent in collection and the alternate use the time could have been put to.

4.4.1 Non-Price Aspects of Fuelwood Prices

The global statistics of fuelwood crisis conceal what it means to run short of the energy needed for cooking and heating and kerosene can provide a substitute only for the wealthy minority. As fuelwood becomes scarce, women and children, who are usually responsible for heating and cooking the food are the first to suffer. This can be called the 'human cost of fuelwood shortages' [FAO; 1985]. Rural dwellers have to walk farther and farther to collect the bare minimum of wood needed for cooking.

Involved also into the *price* of fuelwood are the traditions, acceptability, aroma and the way in which the fuel burns and **the** requirements of the traditional cooking. These factors are not only reflected in price of fuelwood in general, but also in the relative pricing of a particular species of wood for fuel (for example, demand for sandalwood for some religious purposes). Actually, as it is so *easily* available, and is a traditional source of energy, fuelwood is considered to be a cheap fuel. In fact, the real total cost of fuelwood cannot be estimated in numbers as it consists of various *hidden and invisible* costs. One part of the hidden cost of fuelwood is family labour and the lost opportunity to do more productive or important work. For wood merchants, the cost of labour, its transportation, storage, his own profit, capital costs (like ax, saw, chain-saw, etc.) forms part of the final cost of wood. In fact, the market price of wood really gives no more than a vague indication of the actual utility cost to consumers. The *price* of the fuel may be so low that it provides no incentives to economize on fuel consumption. Galloping inflation of fuelwood prices is in itself a warning about forest destruction and depletion of future supplies. The economic prices of fuelwood should be able to depict the cost of competing fuels, cost of transportation - human and machine, the quantities purchased - small bundles in markets costs more and big bundles costs less comparatively, the quality of the wood fuels, the sale value by producers, which includes the profit margin as well - to the *producer* [Leach & Goven; 1985]. Denton [1983] adds to the list of the *costs* that fuelwood prices should show with, the land cost, costs of planting and caring for trees, harvesting costs, and marketing costs.

Surrounding forest area and population size has a direct impact on fuelwood price. The monetization of urban fuelwood market is making a major portion of out-turn of fuelwood to urban areas, hence decreasing the supplies to rural areas, thus making even the rural areas a place where fuelwood is a monetized commodity. This is because of increased pressure on forest resources [Bowonder, Prasad & Unni; 1986].

4.4.2 Inter-Fuel Substitution

Whether consumers of traditional fuels switch from one fuel form to another, depends, apart from prices, upon the tastes, convenience, habit, prestige and sunk costs of the energy using devices (mainly stoves) and availability of appropriate technology [Sarkar & Kadekodi; 1987]. The relative price increase in prices of fuelwood has implications for inter-fuel substitution. In reality, consumers using fuelwood are paying more per unit of energy delivered, that is, net energy consumed. This is because poorer sections of the rural areas consider fuelwood to be a cheaper fuel, fuelwood stoves can be used to burn other biomass fuels, hence, in case of shortages, if there has to be a substitution, it will not incur an additional cost of the stove, fuelwood stoves are most inexpensive, kerosene (the major alternative) supply is controlled and one cannot have more than a specified quantity, if there is a need, as it is rationed, and the migratory families prefer to buy/collect the *free fuel* rather than buy a fuel.

One of the basic reasons for lack of any efforts for inter - **fuel** substitution away from fuelwood is, with an increase in fuelwood prices in the short term, there is an inducement for illegal extraction and increased monetization of even the rural market.

4.5 SUBSTITUTION

One of the main possibilities for rural energy development is fuel-substitution using alternative fuels-either commercial **or** non-commercial. The rural areas rely mainly on wood energy, thus the substitution, wherever possible, has been in mainly areas where wood shortage is severe. Also, kerosene substitution **for** wood has become very difficult because of rapidly rising kerosene prices and reduced supply reliability [Moss & Morgan; 1981].

4.6 ELASTICITIES OF SUBSTITUTION

When talking of substitution, the elasticities (preferences) of substitution have to be taken into account. The elasticities are either **own-price elasticity,** where the relation between consumption and price reflects the extent to which the demand **for** a particular fuel would change in response to a change in its **own** price. Most of the time in rural areas, this elasticity does not operate, as the rural energy 'market' is non-monetized and the consumers are already at subsistence level as far as fuel consumption is concerned, so irrespective of the 'price', the demand would not become less. Another type of elasticity is **cross-price elasticity,** where, changes in the price of a particular fuel will affect the consumption of other fuels as well. This again, cannot be observed in the rural areas, where alternatives, if at all available are either of cheaper but inefficient fuels, or the too expensive commercial fuels like kerosene, which will not be accepted so long as there is fuelwood available, however difficult it may be to procure it [Leach & Gowen; 1987].

4.7 POSSIBLE SUBSTITUTES FOR FUELWOOD

A study conducted by FAO in 1985, which looks into the problems of wood as energy states that the best alternative for wood is more fuelwood, because providing energy in the form of wood solves far more than a drastic energy shortage. Wood plantations can take many different forms and provide many different advantages. Rather than substitution for fuelwood, supplements can be found in the form of biogas or solar energy. Thus the transaction, if needed will not be drastic and acceptance can be brought about slowly. With respect to fossil fuel substitutes, for the rural household use, kerosene is particularly important. But the major problem with substitutes everywhere is that they are difficult to introduce, especially for domestic use, as generally housewives are attached to the traditional fuels, and cannot afford the cost of either the substitute fuels or the equivalent needed to use it.

A main reason for fuelwood substitutes to be included is because, in many of the rural areas, the real costs of cooking with fuelwood have risen above the real costs of cooking with commercial fuels such as kerosene, LPG or coal and electricity.

In *urban* areas, there is an economic gain from substitution. On the other hand, in *rural* areas, the costs of distributing commercial fuels are very high, given the distances involved and the poor infrastructure. Thus, the private cost differences between fuelwood and its commercial alternatives continue to favour the consumption of fuelwood, or once this becomes unattainable, crop residues or animal waste alternatives.

The Nigeria Energy Assessment Mission concludes that "The thrust of any fuel substitution effort will have to be in urban areas where fuel use is most influenced by price, rather than in the rural areas where most people live outside the monetized economy, and wood is considered a *free good"* [Anderson & Fishwick; 1988].

Of the various sources of energy in the rural areas, human and animal energy and the management of human resource in villages is important and the use of human energy can be for agriculture, industries, household or even to collect and use energy. As, in the case of rural scenario, it is used to collect fuelwood from nearby sources, cutting it to size and using it to cook the food etc. A practical line of action in this connection would be to either substitute human energy for more commercial energy forms, or if the energy is in short supply, to supplement and substitute commercial or non-commercial energy with human energy. In the rural areas, the maximum scope for substitution of energy is in the household for cooking purposes [Veena; 1988].

4.8 IS SUBSTITUTION POSSIBLE ?

There is very little scope or evidence, in practice, on the possibility of substitution between energy and labour in developing countries. Though some labour-intensive activities or technologies can also be fuel saving [Kumar; 1984]. Among the commercial sources of energy, electricity may be regarded as an important substitute for fuelwood, at least for lighting and space heating, and since it is capable of being produced by a variety of means and fuels, provides a source of power in which the system of supply offers considerable means of substitution while providing a consistent product for the consumers. But the continuous shortages of electricity and power-cuts and increasingly outstripped demand compared to supply make it difficult for people to rely on it on a regular basis, either for cooking or for lighting in the rural areas.

To a certain extent, the resources can be substituted for one another, and some of the alternatives will be feasible, because of the cost factor, but only very few are viable and economically desirable by the consuming households. As the income at the disposal of a household is limited, there comes the element of choice and substitution. There can be three different alternatives or substitution possibilities -

a. substitution of electricity or kerosene for fuelwood in heating,

b. substitution of electricity for kerosene used in lighting to allow the kerosene so released to substitute for fuelwood, and,

c. substitution of chemical fertilizers for dung in order to substitute the dung for fuelwood [Somasekhara; 1986].

Thus here, the substitution is not one-to-one, but three or four substitutes are involved so as to conserve or *release* a particular fuel, in this case, fuelwood. *Perfect substitution* is possible only in a perfectly competitive market, where there are no 'external' factors like tastes and preferences and the commodities (or fuel sources) are perfect substitutes or identical. Thus, taking into consideration a market like fuel market, where there is a large degree of product differentiation, one fuel cannot be perfectly substituted for another. Another factor is that peoples' tastes and preferences and also the income of a household, along with the availability make fuel-substitution difficult. Hence, even if theoretically substitution is possible, because of the various external factors involved in the process, the actual substitution may not be possible and feasible.

Here, even if substitution is possible, the possibility is more in the urban areas than the rural areas. The substitution possibility is low in the rural areas because the people use *mere* subsistent level of energy inputs for their daily use and they use more of human and animal energy for their day to day requirements, for which there can rarely, if any substitution is possible.

V

FUEL AND COOKING APPLIANCE EFFICIENCY

5.0 INTRODUCTION

Traditional methods of cooking are carried out at efficiencies estimated at 10-15 %. The prospect of an increase in energy consumption as economic development proceeds focuses its attention on the efficiency of fuel use. The fuel efficiency for fuelwood is more or less fixed in the form it is used. The way efficiency of fuel use can be increased with using fuelwood when the cooking device and the cooking medium efficiency is increased.

Many a time, energy consumption habits may reflect an efficiency defined by local preferences. This can be seen in the problems with the introduction of more efficient stoves (using biomass or other commercial fuels) had to face, which required unfamiliar methods of cooking, new types of utensils, and not matching the needs of the users as was observed by Cecelski, Dunkerley, and Ramsay [1985]. The traditional ways of burning wood for cooking and heating generally are inefficient. In a study in Indonesia by Arnold and Jongma [1979], it was found that on the usual types of fuelwood stove 94% of the heat value of the wood was wasted and simple improvements in wood preparation (making charcoal, briquettes, charcoal-powder balls, etc.), in some design (for example, **the stove** ASTRA developed in Bangalore) and cooking **pot** design (using aluminum pots instead of clay ones), reduced **the** consumption of fuelwood for cooking by 70 %.

The aspect of efficiency and conservation of wood resources go hand in hand. Transforming wood into charcoal can be seen as a means of extending the wood-based fuel base. Though the properties of charcoal vary with the wood raw material, and particular woods have to be used for charcoals for certain special purposes, almost all woods can be converted into charcoal. But its low-conversion factor tends to make charcoal making unprofitable, when the cost of growing (or procuring) of wood has to be taken into consideration.

5.1 CHARCOAL VERSUS FUELWOOD

Charcoal is produced by a partial chemical reduction of wood under controlled conditions. The yield of charcoal by weight is usually about 20-30 % of the dry weight of the wood used, and the yield by volume is about 50 %. There are some advantages and disadvantages associated with the usage of charcoal and wood. They are that it is almost smokeless, radiates high proportion energy, it can be ground and used with standard equipment, its calorific value is similar to high quality coal, and, it has various industrial uses.

But charcoal use has a few disadvantages as well, like, its low bulk density necessitates special transportation, it is easily broken, and care has to be taken during combustion to ensure that there is free circulation of air because of the danger of carbon mono-oxide poisoning.

On the other hand, there are advantages of using fuelwood, because, it is the cheapest fuel available, not only per ton, but also per unit of heat, it burns safely and easily if properly dried, there is no special storage facilities are required. But fuelwood is a fuel which is not only inefficient, it has some other disadvantages as well, like, it is a very carbon-intensive fuel, forests and other trees around human habitation become depleted, and, the calorific value is lower than that of other fossil fuels.

5.2 FUEL EFFICIENCY

The delivered energy content of a fuel measures the potential heat available form it. The fraction of the energy utilized defines the efficiency of the end-use device. Efficiencies are usually defined in terms of delivered energy but can also be given on a primary energy basis.

$$\text{Efficiency for a end - use} = \frac{\text{Energy utilized for the task}}{\text{Energy delivered to conversion device for task}}$$

This is the utilized energy efficiency, expressed as Percentage Heat Utilized (PHU). When any fuel is burned, its energy is usually transferred to the end - use task in several stages. There are, various measured of efficiency. The three basic ones, as enumerated by Leach and Gowen [1987] are -

a. Combustion Efficiency (C.E.) - It allows for energy losses in the combustion process and heat that does not reach the point where it could be transferred to the final task.

$$= \frac{\text{Heat generated by combustion (MJ)}}{\text{Delivered energy of fuel (MJ)}}$$

b. Heat Transfer Efficiency (H.T.E.) - It allows for energy losses between the combustion outlet and the end-use task, especially heat transfer and radiation losses.

$$= \frac{\text{Energy absorbed by end-use task (MJ)}}{\text{Heat generated by combustion (MJ)}}$$

c. System or End-Use Efficiency (S.E.) - It is the product of the Combustion and HTE, or the overall efficiency. It is often referred to as conversion, gross, thermal and end-use efficiency.

Percentage of Heat Utilized (PHU) is the energy utilized and expressed as a percentage of that available at any stage in the energy conversion process. The overall PHU is commonly referred to as appliance efficiency.

The long-run solutions to the shortages of domestic fuel in developing countries, mainly in the rural areas involve both an increase in the supply of fuel and a reduction in demand. Both these can be 'managed' by improving the usage efficiency either by preparing wood before use (drying or making charcoal) or by using improved, less fuel using stoves.

When one has to make a distinction between efficiency of fuel in purely technical terms and economic efficiency of energy supply and use, a distinction between the concepts of energy intensity, energy saving and energy rationalization is necessary. Energy Intensity is the consumption of energy per unit of product output or GDP, Energy Saving represents a reduction in this intensity; and Energy Rationalization is a combination of energy savings and switching from higher cost to lower cost fuels [Hume; 1988].

Thus, fuel conservation (or improvements in the efficiency of energy conservation), and improvements in conversion which lead to increased quality or productivity, or to improved working conditions, can be treated as one option for economizing fuelwood use in the rural areas.

5.3 COOKING APPLIANCE EFFICIENCY

There are two facets of fuel efficiency, especially fuelwood efficiency. One is, the efficient use of fuel itself by various 'preparations' of the fuel, the other is efficiency of use, that is, efficiency of the appliances through which the fuelwood is used. In this are included the technological and economic aspects of stoves and vessel usage and their design. Appliance efficiency is simply a measure of the effectiveness with which heat is transferred from the fuel when the appliance is being used with a particular end in view. The efficiency of an appliance can be defined as the amount of heat in the original fuel which is directly utilized in the cooking task. In controlled conditions (or tests in the laboratory), this is usually measured by taking the total amount of heat absorbed by the cooking pot and its contents over a period of time and expressing it as a percentage of the total amount of heat released from the fuel; this is referred to as the Percentage Heat Utilized (PHU).

A variety of factors can distort the performance figures, and make comparisons misleading. For example, the moisture control of fuel can have a great effect on the amount of useful energy that can be derived from it [Vimal & Bhat; 1989]. The majority of stove design work in recent years has been concentrated on improving the efficiency with which fuel is used for cooking. The aim in all the cases is to find methods of countering the main ways in which energy is lost from a cooking fire.

In many places in rural areas, it is a common practice to cook over open fire, with the 'three-stone-stove', where there is a substantial loss of energy. A simple way to upgrade its performance may be by providing people with means to cut down on the loss radiant heat and protect it against wind or draughts. Apart from the simplest method of constructing 'surrounds' for open-fire cooking, it was observed by Anderson and Fishwick [1984] that the use of aluminum pots, whether on open-fires or on mud or metal stoves, add 5-8 % to the efficiency with which the task is performed.

Some reasons for the poor response for improved stoves was found by Cecelski, Dunkerley and Ramsay [1985]. The reasons given were the defects in the stove design itself. In many areas, its improper use and also, the stoves which were designed to be smokeless were not suitable to many users, who preferred a certain level of smokiness to reduce the insect pests and maintain thatched roofs.

Moisture Content Dry Basis (MCDB) refers to the ratio of the weight of water in the fuel to the weight of dry material. Moisture Content Wet Basis (MCWB) is the ratio of the weight of water in the fuel to the total weight of fuel. Both are expressed as percentages. Heating values of biomass fuels are often given as the energy content per unit weight or volume at various stages as 'green', 'air - dried' and 'oven - dried' material. The basic reason for the adoption of improved stove is the long-term solution to the shortage of domestic fuel in developing countries, which involve both an increase in supply of fuel and a reduction in demand. The main aim for undertaking improved stove programme was not solely for fuel economy, but also on improved health by reducing the quantity of smoke produced.

5.4 THE EARLIEST IMPROVED STOVES

The first controlled laboratory tests to be carried out on an improved stove were those conducted by Theodorovic in 1954 in Egypt. The stove was an adapted version of the 'Hyderabad Smokeless Chula' developed in India. In the experiment carried out, it was found that on an average the improved stove used 16 % less fuel than the traditional stove, for boiling one liter of water and 28 % less for boiling two liters of water.

Next came the stove developed by Singer in 1961. Next series of development of improved stoves was in 1970s, when in 1976, the 'Lorena' stove was developed in Guatemala. It had a chimney and its ability to reduce the quantity of smoke was a major advantage.

5.5 NEW DEVELOPMENTS IN STOVE DESIGN

The new series of stoves use metal sheets and they are in many instances, portable and they use generally charcoal or coal, though they can also use wood chips and wood cut in a particular size to fit the fire chamber. In Africa, there is 'Jiko' , which is normally made in the form of cylinder about 25 cm.s in diameter and 15 cm.s high, and has a perforated metal grate at almost its mid-height. A very similar stove is used in India, which is called *angeethie*. It is used in areas where coal or charcoal is in use, as the use of wood in these stoves does not give equal amount of heat required for cooking the whole meal [Foley & Moss; 1985].

In the rural areas, using fuelwood and other agricultural wastes, fixed 'mud' stoves are more popular. They are built on the floor of the dwelling and in some cases, they are directly made in their final shape and placed in the cooking area. One main shortcoming of the mud-stoves is that they are not very durable. The heat of the fire causes them to crack. They are also very vulnerable to water spilling on them. Because of this problem, one innovative idea is that of making a ceramic 'stove-liner' which is then covered on the outside with a mixture of sand and clay.

The success or failure of an improved stove depends completely on the acceptable by the people for whom it is designed, and whether it satisfies all their needs, with minimum changes in their traditional ways of cooking.

Apart from these local and specific requirements for an improved stove, the financial context is also very crucial as far as acceptance by the poor people is concerned. The success or failure of any improved stove programme depends on the various factors ranging from cost to fuel availability, fuel efficiency, to acceptance because of social and cultural factors.

VI
ENERGY LADDER

6.0 INTRODUCTION

Availability of energy is crucial for human survival, and welfare, so energy plays a dual role of *consumption good* (in domestic sector), and *intermediate fuel* in production activities. On the one hand, energy resources like sun, wind, animal and agricultural wastes are free, commercial energy sources like oil, coal, gas, etc., on the other hand are not only non-renewable in nature, they also have a measurable price attached to them. The issue of the energy consumption and the quantity and quality of energy consumed has to be studied because of the diverse forms of energy available and their various uses. The choice of fuel for a particular use depends not only on the availability, but also on the prices of the fuel and other substitutes, the appliances used and the efficiency of the fuel itself. The main factor behind the usage of a particular fuel (for example, in a household) is the income. This aspect of fuel choice and shift from one fuel to another is studied under the concept of energy ladder.

The *energy ladder* is a concept used to describe the way in which households **will move to** more sophisticated fuels as their economic status (incomes) improves. Though households do move away from wood to kerosene and electricity as their economic status improves, a large number of other factors are important in determining household fuel choice. After seeing the various factors on which the demand and consumption of fuelwood depends, like land use pattern, size of family, population, income of household, tastes and preferences, etc., now, the concept of energy ladder will be analyzed. The concept of *Energy Ladder* is where the households climb up or down an imaginative *ladder where* the 'energy ladder' or shift from one inferior fuel source to the other, superior source with an increase in their economic status [Reddy; 1994].

The energy ladder, as also called as *Fuel-Ladder* by Veer and Enevoldsen (1993), illustrates the general point of 'upward shifting' of consumers preferences for more convenient sources/devices of energy. As found by them, most of the energy policies focus, almost exclusively on the possibilities to influence the transition at, or towards the top of the ladder, and more for the urban users, than the rural.

The concept of energy ladder is closely connected with urbanization (it does not mean that the rural areas are becoming urban, but source consumption patterns, fuel consumption among them, follow the urban pattern with an increase in income. The fuel or energy shifts (carrier shifts) are stimulated by an increase in monetary income mainly and also because of the availability of better and superior fuel sources locally. This shift in many cases, becomes a status symbol also in **the** rural areas. For example, it is only the relatively better off farmers or land - owners who go for biogas plants, as not only they can afford it, but also because it indicates an upper shift in their fuel use (usually from fuelwood).

Other factors like non-availability of agricultural wastes, cow-dung or fuel wood also make the households to go in for fuel shifts and if the shift is from these fuels, then it is always for the better fuels as these fuels (fuelwood, agricultural and animal wastes) form the bottom part of the energy ladder.

The concept of energy ladder indicates that the pattern of energy use in different households varies with their economic status and each step of the ladder corresponds to different and more sophisticated energy carrier, and the step to which the household climbs the ladder depends mainly on its income. The ladder can be from fuelwood, cow dung, agricultural wastes, to coal, kerosene, charcoal to LPG and electricity. The height of the ladder step is determined by factors like capital cost of the fuel utilizing device, price of the energy and household energy consumption.

In a way, the household shifts from a fuel of lower efficiency to higher efficiency, apart from a cheaper fuel to costlier fuel, in terms of money. Thus, from a purely economic point of view, the shift from a fuel of lower efficiency to more efficient fuel is good, apart from the wood saving which can be achieved if a major percentage of population can shift away from fuelwood usage. But for the present, given the economic status of the majority of the population and the availability situation of alternative fuels, this may not be possible.

As development proceeds, not only does energy consumption increase, but also the mix of fuels relied upon changes. In its cross - sectional form, this work shows that wealthier countries will rely more heavily on petroleum and electricity than poorer countries. Poorer countries rely more heavily on biomass fuels. In its longitudinal form, this work shows that as a country progresses through the industrialization process, its reliance on petroleum and electricity increases and the importance of biomass decreases.

The underlying assumption is that the households are faced with an array of energy supply choices which can be arranged in the order of increasing technological sophistication. At the top of the list is electricity, while the low - end of the range includes fuelwood, dung and crop wastes. As a household's economic well - being increases, it is assumed to move ‘up’ the energy ladder to more sophisticated energy carriers. If the economic status decrease through either a decrease in income or an increase in fuel price, the household is expected to move 'down' the energy ladder to less sophisticated energy carriers. Thus, the energy ladder serves as a stylized extension of the economic theory of the consumer : as income increases (or falls) households consume not only more (or less) of the same goods, but they also shift to consuming higher (or lower) quality goods.

For a number of developing countries this is very important from policy stand - point. Rural households in these countries face serious to severe fuelwood shortages. The question about how to encourage households to make fuel substitution is an important one. Much of the policy work undertaken to date has assumed that an energy ladder exists but that most households are so constrained that they have no choice but to remain dependent upon fuelwood for the foreseeable future. As a result, policy efforts have focussed on rural afforestation and ignored any possibilities of inter-fuel substitution, particularly those which involve movements up the energy ladder.

6.1 PHYSICAL AND CONCEPTUAL BACKGROUND

The *Energy Ladder* concept takes as its standing point the differences in energy - use patterns between households with differing economic status. Households are assumed to behave in a manner consistent with the neo-classical consumer, moving to more sophisticated energy as their incomes increase. As opposed to wood and crop wastes burned by the poor, wealthier households will utilize electricity and petroleum products. While a large number of household energy surveys have been undertaken in recent years, none of them has explicitly addressed the validity of this assumption. The energy ladder always hovers in the background without ever being put to the test.

Bajracharya [1983] notes that energy - use patterns in the village he studied in Nepal differed according to the social class of the household. Kennes, et. al . [1984] note that the energy consumption patterns of different socio - economic groups in Bangladesh are radically different. In particular households with earnings from formal employment rely much more heavily on commercial fuels than do landless or marginal farmer households.

For India, a study done by Alam, *et. al.* (1985) for Hyderabad found that households fuel - choice decisions vary directly with income level. The higher the income level, the greater the tendency for the households to choose petroleum-based commercial fuels over biomass fuels. Reddy (1981) notes that for the Indian villages studied, there is a strong correlation between the size of land holding and household energy use. Barnes *et. al.* (1985) note that households fuel - mixes in Kenya vary according to the households level of involvement with the monetary economy. In general, the literature on households energy - use in developing countries supports the concept that households energy - use patterns are differentiated with respect to the economic status.

6.2 IS ENERGY LADDER POSSIBLE ?

A main question which arises in this respect, which should come up next, but rarely does is, how far are the households free to choose between different energy sources (or carriers)? Are they actually able to exercise the choice between different fuels, or is their movement along the energy ladder heavily restricted by their physical or economic environment? But most of the literature maintains that the households in the developing countries are so poor that economic conditions dictate that the bulk of the rural households will be dependent upon wood for the foreseeable future and rural households have such limited incomes that they cannot possibly opt out to utilize commercial fuels. It is another matter that in most of the rural areas, any type of commercial fuels are rarely, if at all available. It is not just that the purchasing power is not there, but even the fuels are not physically available. Thus, they continue to rely on fuelwood, which is their only alternative.

Despite these negations of the existence of decision making in household energy consumptions, it has been observed that some form of decision making does take place in fuel selection. For example, as observed by Briscoe (1979), in Bangladesh, households do move along the energy ladder, but the fuels in question here are different form those observed in the other countries. In the general observation, the fuels involved in decision making for energy ladder (or fuel ladder) are the biomass fuels (mainly fuelwood) and other commercial energy forms, like coal, kerosene, gas and other petroleum products, and mostly with electricity occupying the top of the energy ladder. But in case of the rural areas in most of the developing countries, the fuels involved are non-commercial in nature, and fuelwood, instead of occupying the base of the energy ladder, occupies the top or the near-top position. In **this** respect, the most visible movements **are** those of the poorer households switching either toward less sophisticated energy carriers or towards purchased fuels (in many rural areas, fuelwood is already a *bought* commodity).

Hosier (1985) observed in Kenya that the decision making process for the fuel choice in the rural areas involved a two-staged decision. In the first stage, a consumer (or household) must decide about the fuel to use or purchase, and in the second stage, he also must decide how much of each (if he is using a combination of *inferior* and *superior* fuel) fuel is to be used. The options in each case will depend upon the households resources (purchasing capacity). The higher the economic status, more choices will be available to a household, both in terms of fuel sources and more efficient fuels.

A major problem which modelling the decision choices of the households and energy use pattern faces, is that most of the biomass fuels are not purchased, but are collected from the nearby trees and forests, and any *cost* attached to it will be arbitrary. Markets, wherever exist, are also fragmented and chaotic. Even the government depots (outlets selling fuelwood) are not true indicators of the fuelwood use and purchase. Even if a household uses fuelwood and other biomass fuels, it may be a combination of *purchased* and *gathered* fuel. As a result, households which do purchase fuelwood rarely pay prices which reflect the actual opportunity cost of the use of fuelwood as fuel. In case it is gathered, from the households point of view, it is an advantage as it enables the households to obtain its energy requirements without spending any monetary resources.

From the point of view of policy making, it is difficult to judge the actual energy requirements and the actual environmental impact, as a result of the degradation of the tree resources. This may be one reason why most of the efforts and programmes aimed at substitution and efficiency in household energy use are in the urban sector, where fuel - markets are operative and households *have to* purchase fuels, rather than collect them.

6.3 THE IDEAL FUEL

The *ideal* situation of energy usage by a consumer, be it an urban user or a rural one is where, the energy source is clean to use, delivered to the house, instead of spending long hours collecting it, with no storage needed, and is a versatile fuel, that is, it should be possible to control the heat-output of the source, with high efficiency and all this at low cost. But this kind of *ideal* fuel is impossible to find, at best, one can aim to get an energy which can fulfill at least a few of the *ideal* requirements.

An example of urban fuel preference and constraints and an energy ladder was envisaged by Leach (1992) and Veer and Enevoldsen (1993), both of which, almost identical in nature is given in the following table (Table 6.1).

Table 6.1

URBAN FUEL PREFERENCES AND CONSTRAINTS

FUEL PREFERENCE LADDER	EQUIPMENT COST	FUEL PAYMENTS	ACCESS
ELECTRICITY ↑	Very high	Lumpy	Restricted
BOTTLED GAS (Natural) ↑	High	Lumpy	Often restricted bulky to transport
KEROSENE ↑	Medium-high	Small	Often restricted in low income areas
CHARCOAL (May be higher in some cultures) ↑	Medium	Small	Good dispersed markets and reliable supplies
FIREWOOD ↑	Low/Zero	Small/Zero	Good dispersed markets and reliable supplies
CROP RESIDUES/ ANIMAL WASTES	Low/Zero	Small/Zero	Can usually be gathered free

Source : Leach, G. "The Energy Transition." Energy Policy, Vol. 20 Pp. 116-123, 1992.

Household energy consumption is normally assumed to vary according to the levels of the household income. It can also be said that the differences in energy consumption behaviour by the domestic sector are solely the reflection of the differences in the monetary incomes. This can be seen to hold true even for the rural domestic consumers of energy. Thus, the differentiation by income class lies at the basis of the energy ladder hypothesis, that is, as income increases, the quality of energy carriers is supposed to increase.

In the table given by Leach, 'Ideal' goals which a household (or a user) looks for are, that the energy source be clean to use, delivered to the user, with no storage costs and the fuel should be versatile to use, that is, good control of heat output, as high efficiency reduces costs in the long run.

In case of fuelwood and animal wastes, etc., it is possible to convert them into high grade energy forms like biogas, and electricity. Many household surveys on expenditure and energy expenditure show that most families have an ideal fuel preference 'ladder' running from biomass fuels through kerosene, LPG to electricity. The dominant cooking fuel most preferred by the richer households is LPG and electricity in India, (as will be observed later in the study). The main reason for their preference is that they are clean to use, highly controlled in terms of power output to match different household needs and storing and fetching costs are almost negligible.

It may lead one to conclude that the desire to climb up the energy ladder is not by a desire to use modern fuels just for their use, but rather, because of the socio-economic changes which help to break the constraints on their wider use, especially by the majority of the poor biomass / fuelwood using households.

6.4 RELATED STUDIES

Any study which explores the expenditure on fuel and light and expenditure according to different fuel sources, across various survey periods and for various income / expenditure categories has not been done for India as a whole, though some studies have been done for a particular city or a state. A number of studies done for other countries have explored the issue of income of the household and fuel preference and consumption. The studies have taken into account various other parameters along with the parameters like income of the household, family size, availability, etc.

A study done by Assimakopolous and Domenikos [1991] for Greece households observes the income elasticities, to study the influence of income on consumption commodities, for the analysis of household budgets. In this, the types of goods studied are foods and beverages, energy, industrial goods and services. The study focuses on the performance of Engel curves, where, energy coefficients (income elasticities) were found to be 0.119 (logarithmic), 0.114 (linear), 0.223 (translog).

Another study done for Nepal, done by Rijal, Bansal and Grover [1990] has estimated the rural household energy demand, where they have taken eight parameters, standard population, household expenditure, agricultural commodity, number of livestock, number of cook stoves, area covered by housing, topography and forest accessibility condition of a particular area. In this, the Total household energy demand (THE) for Baijnathpur village is estimated as, THE = f (Constant, Agricultural commodity per household (AC), Livestock per household (LS), Total household expenditure (EX), and Standard population per household (SP)).

The resultant regression equation looks like -

$$THE = 20015.9 + 2631.2\ AC + 2301.5\ LS + 1.1\ EX + 1549.5\ SP$$

From the general model developed it was observed that household expenditure, area covered by housing and agricultural commodities did not play a significant role in determining the cooking requirements of a household. The various socio-economic factors like number of persons, income of household, type of housing (dwelling), amount spent on fuel, occupation of the household, heating requirements, etc. also determine the type of fuel is preferred and the type of energy ladder that is faced by a household.

A household biomass energy model developed by FAO using aggregate data for 40 developing countries for 81-84, as reported by Leach [1992] takes population, income and hectare of forest land as its main variables (independent variables) to determine the total energy. Other variables taken were Heating Degree Days (HDD) to base 18 $^{\circ}$C, percentage of biomass in total energy and percent population urbanized. The coefficients (or elasticities, as the regression equations are in logarithms), are positive for population, income and even forest land. It was found that as the income and population increases, there is an increase in HDD. If the bioshare (that is percentage of biomass in total energy) is positive then the percentage population urbanized is negative, clearly showing that biomass (mainly fuelwood and agricultural wastes) is becoming more limited to rural areas with urban households opting for other commercial modern fuels.

This once again proves that the driving force behind energy ladder or transition from one fuel to another and the differences in energy use in rural and urban areas is not for a desire for modern fuel, but rather the socio-economic changes which help to break the constrains on the use of traditional fuels.

An empirical study conducted by Hosier (1987) for fuel choices in Zimbabwe found that fuelwood consumption *per se* did not appear to change with income, but there was a significant decrease in the proportion of households relying on fuelwood. As the income increased, the importance of fuelwood as domestic fuel decreased. The quantity of kerosene consumed increased with the increase in income. This was accompanied by a decline in the percentage of households actually using it as income rise further. Thus kerosene is characterized as a traditional fuel, but superior to fuelwood, and we can say that as incomes increased, households **will** purchase kerosene, but at a declining rate, as then **the** preferred fuel is gas (LPG) or electricity. Hence, kerosene can be taken as a *transitional* fuel.

6.5 CONCLUSION

A households make different decisions about which fuel to use for cooking. Their preferences are influenced, by income of the household, and by their particular economic, physical and social environment. The likelihood of choosing any one particular fuel by a household will be dependent upon the characteristics of the household in question. Thus the decisions faced by households are discrete decisions on fuel choice. The energy ladder is, hence conceived of as a problem involving the *environment* of the individual households.

A factor which significantly influences fuel choice is the location of the household. *Urban* household is more likely to utilize higher, costlier, and more efficient fuel than a *rural* household. Even within the rural area itself, households within areas of wood scarcity would move more slowly away from the non-woody fuels than the households elsewhere. In such areas, the large-scale existence and usage of *transitional* fuel like kerosene can be found, even at great cost to the households as the other alternatives would be more costlier. On the other hand, households in the wood-surplus areas, which do not have difficulty in procuring fuelwood for their daily need tend to prefer to gather wood or at the most use some percentage of transition fuel (instead of depending on it fully), rather than opt for an commercial alternative. Thus if fuelwood is plentiful, households will tend not to move away from it to another fuel.

VII

INDIA

7.0 INDIA - A PROFILE

India covers an area of 32,87,263 sq. kms. extending from the snow covered Himalayas in the north to the tropical rain forests of the south. As the seventh largest country in the world, India is well marked off from the rest of Asia by mountains and the sea. Lying entirely in the northern hemisphere, the mainland extends between latitudes of 8°4′ and 37°6′ north and longitudes of 68°7′ and 97°25′ east. On its northern frontiers India is bound by the Great Himalayas and it stretches south-ward beyond the Tropic of Cancer. It narrows down to form the Great Indian peninsula which ends up in the Indian ocean with Cape Comorin (Kanyakumari) as its southernmost tip. On the east, lie Andaman and Nicobar Islands and on the west, in the Arabian sea are the Lakshadweep Islands. It has a land frontier of about 15,200 kms. and the total length of the coast line of the mainland, and the Islands of Lakshadweep and Andaman and Nicobar is 7,516.6 kms.

7.1 GEOGRAPHIC FEATURES

Physically, there are practically all the types of geographic features which are present in India. From the Himalayas forming the great mountain zone, to the plains of Ganga and the Indus, the two desert regions - great desert extending from the edge of Rann of Kutch and northward to the river Luni. The little desert extends from the Luni between Jaisalmer and Jodhpur up to the northern wastes. Then there is the Peninsula of the south, which is one of the main features of India.

Climatically, India can be broadly classified as tropical monsoon type, with four main seasons. The main seasons are - a) winter (January - February), b) hot weather summer (March - May), c) rainy south-western monsoon period (June - September), and d) post monsoon period, also known as the north-east monsoon period in the southern Peninsula (October - December). India's climate is affected by two seasonal winds - the north-east monsoon and the south-west monsoon.

The area of India covers 2.4 % of the earth's surface, but has a population of about 16 % of the world's. Administratively, India is made up of 25 states and 7 centrally administrated units called Union Territories. Of the total area, 47 % (about 329 million hectares) area is under cultivation, and forests account for about 22.8 % of the total area. The rest of the 30.2 % of area accounts for fallow lands, residential areas and other commercial and industrial area.

A 1991 government assessment of forest cover as reported in *World Resources,* 1994-95, estimated India's forest cover at 63.9 million hectares, about 19 per cent of the country's total geographical area. Forest land with a crown density of 40 % or more covers

38.5 million hectares, or about 11.7 % of India's total area. Open forest land with a crown density of 10 - 40 % covers 25 million hectares (about 7.6 %) of the total area. A survey in 1991 showed a modest annual increase of about 28,000 hectares of cover since an earlier survey in 1989. This may not be because of any actual improvement in the forest cover, but may be due to the technical changes in assessment techniques, like better satellite imagery, more accurate interpretation, and corrections in geographical area.

Though forest area is not shrinking, there is large scale degradation of the forest areas. Wood, which is the primary fuel of the rural population, is gathered or collected from the nearby forests or other tree-lots. India's forests can sustainably provide an estimated 41 million cubic meters of fuelwood per year, the current annual demand is thought to be around 240 million cubic meters [Collins, Sayer and Whitmore; 1991, FAO; 1991].

7.2 POPULATION - RATIOS AND DENSITY

India's population as on March 1, 1991 stood at 844.32 million, including the projected population of 7.72 million of Jammu and Kashmir. India houses 16 % of the world population and is the second most populous country (with China occupying the first place). In absolute terms, the population of the country has grown by 160.99 million during the decade 1981-1991. The state of Uttar Pradesh was found to be the most populated state with 16.47%

of the total population living there.

The density of population was recorded as 683 per sq. mile (or 267 persons per kilometer). Density was found to be the highest in the capital city of New Delhi (6319 per km.), with Arunachal Pradesh the most sparsely populated with 10 persons per kilometer. The growth rate of population of India is estimated to be about 1.9 %, and the population is estimated to be about 1,026,271,000 in the year 2000 AD. The population doubles every 37 years, given the rate of population growth of 1.9 %. It can be assumed that, the rural population also would follow the rate of growth and the doubling of rural population may be slightly less on account of the migration of rural population to the urban areas, and urbanization of some rural areas, or development in them.

7.3 **MAIN SECTORS**

India is a developing country with a predominantly agrarian economy, and a major portion of her population resides in the rural areas. The rural population of India is estimated to be around 75 - 80 % of the total population. Thus, the rural sector is the main sector of the economy. The proportion of rural population to total population was 76.7 % during the 1981 census, which reduced to 74.3 % during the 1991 census. Thus, nearly three - fourths of the population lives in the rural areas.

India's geographical area is 2.4 % of the world's total area, whereas, its forest area covers only 0.33 % of the total forest area, and the population is as seen above, a substantial 16 % of the world population. In India, 9.4 % of the districts do not have any forest cover of any sort, and 52.54 % of the districts have a forest cover up to 19 % and 12.59 % of the districts have a forest cover between 19 - 33 %, and only about 25.42 % of the districts have a forest cover of more than 33 %.

7.4 BASIC ECONOMIC DATA

The NNP in 1994-95 at Factor Cost (Rs. Crores) at constant (1980-81) prices was Rs. 2,17,041 during, and the per capita NNP at constant prices was Rs. 2,401The gross domestic savings was 24.4 % and the gross domestic capital formation was 25.2 % during the same period, 1994-95. The main imports are petroleum products, machinery, iron and steel, chemical products, edible oils and fertilizers. On the other hand, the major exports are pearls, jewellery, clothing, machinery, vehicles, metal products, tea, iron ore, cotton products, petroleum, precious stones **and** handicrafts. The balance of trade has been negative, against India for a number of years now.

India is rich in natural resources, like coal, iron ore, manganese, mica, bauxite, chromite, limestone, barite, natural gas, diamonds, copper, zinc, lead and gold. In the field of agriculture, almost all the main tropical crops are grown. The cultivation and export of rubber, tea, coffee, spices, jute is one main feature of the commercial aspect of Indian agriculture. In food grains, rice, wheat, barley, jowar, various pulses, oilseeds, sugarcane etc. are grown.

The major industries are cement, iron and steel, sugar, cotton textiles, nitrogenous fertilizer, pulp and paper products, jute products, soda ash, motor vehicles and parts, sewing machines, commercial vehicles, tractors, etc. Mining and quarrying is active for aluminum, bauxite, copper, diamonds, gold, iron ore, lead, phosphates, sale, tin, etc.

7.5 ENERGY CONSUMPTION PATTERNS

Energy has been associated with mankind, directly or indirectly, from the earliest times of civilization. The role of energy for economic development, civilization and welfare of human beings is very significant. As the number of people grew and the per capita variety and number of goods and services increased, the importance of energy and its use also increased. All the activities of various economic sectors and scientific inventions are controlled and directed by the energy consumption and its availability. Thus, the energy potential and per capita consumption of energy has become an important parameter or acts as a barometer of its economic growth and development. Technology and social organization are the tools with which society transforms physical resources and human labour into goods and services with the help of available energy sources.

In India, biomass (fuelwood, twigs and branches, animal residues and crop wastes, etc.) form 57 % of the total energy use, and of this biomass fuel, fuelwood accounts for almost 90 - 92 %. The fuelwood production is almost 164384 x 10^3 tonnes (in 1987), which is used directly as a fuel and for the production of charcoal. This does not include wood residues recycled for energy use. [Select Statistics of Biomass from Forests, TIDE, Vol. 1 (3), Jul.-Sep. 1991, Pp. 54-59].

The living standards of rural India are essentially determined by the availability of food, fodder and fuel. Hence, the rural economics is directed towards balancing the income, efforts and time to ensure supply of these three essentials. While food and to some extent fodder are generated, the bulk of the fodder and fuel are drawn from nature. That is why, the sustainable development of India means the sustainable supply of these three essentials.

The life styles in rural India are mainly regulated by the sensitive relationship and balance between the energy sources and economic systems. From the stand point of fuel energy in general and fuelwood and charcoal in particular, the balance is being disrupted due to various reasons like population growth, consumption patterns, management practices, end-uses, etc. Besides, the overall present energy situation draws the attention to the fact **that the** firewood and charcoal together **with** agricultural and animal waste have still remained as predominant fuel for the rural areas of India.

Hydrocarbon fuel resources are limited and their price is also very high in India. Nearly 60 - 70 % of India's foreign exchange earnings is still spent on import of petroleum products, with an adverse impact on other essential requirements of the economy. The reserves of various energy resources are as below -

TABLE 7.1
COMMERCIAL SOURCES OF ENERGY IN INDIA - 1992

ENERGY SOURCE	RESERVES	PRODUCTION	CONSUMPTION	PER CAPITA
COAL	62,548 (mil.m.t)	197,565 ('000 m.t)		0.2 (m.t)
NATURAL GAS	1,100 (bil. m^3)	10,620 (mil.m^3)	6,909 (mil.m^3)	8 (m^3)
CRUDE OIL	4,345 (mil.brl.s)	256 (mil.brl.s)	358 (mil.brl.s)	0.4 (brl.s)

The power generation scenario shows that power (electricity) is generated by thermal, hydro and nuclear sources, though the last only on an experimental basis. The total generating capacity was envisaged to be around 22,245.25 MW during the Seventh Plan. Additions to the total power generation capacity was to the tune of 4,598.5 MW during the year 1994-95.

7.6 NON-COMMERCIAL FUELS IN DOMESTIC USE

The importance of woodfuel as a source of energy in the country is evident from the pattern of energy use in rural India where 80 % of the population lives. It is estimated that 80 - 85 % energy consumed comes from non - commercial sources of energy, as can be observed from the Table 7.2. A major of the non-commercial energy consumed, in India (68.5 - 70 %) is obtained from woodfuel. The quantum of energy consumed indicates that the order of priorities for energy are - cooking (64 %), agriculture purposes (22 %), village rural industries (7 %), lighting (4 %) and transportation (3 %). This indicates that for 80 % of the population of India, energy priority is for sheer survival.

Agriculture is the backbone of India's economy providing employment or occupation to about 60 % of the country's working force, generating direct employment to over 74 % of the labour force, and contributing nearly 40 % of the national income and

TABLE 7.2

CONSUMPTION OF ENERGY IN THE HOUSEHOLD SECTOR (1985)

Energy Source	Rural Per Capita Energy Cons.	Urban Per Capita Energy Cons.
	% share of energy	% share of energy
1. Electricity	0.6	5.9
2. Oil products	16.9	30.2
3. Coal products	2.3	13.7
4. Fuelwood	68.5	45.5
5. Animal wastes	8.3	3.2
6. Others	3.4	1.5
Share of Commercial Fuels	20.0	49.0
Share of Non-Commr. Fuels	80.0	51.0

Source: Report of the Working Group of Energy Policy, GOI, 1979
Wood Based Energy System in Rural Industries and Village Applications : India. By J.S. Juneja, FAO Bangkok, 1989, Field Document No. 18.

accounts for a share of 35 % in India's exports. It forms the basis of many premier industries of India, including cotton textile, jute, sugar, etc. There are two major cropping seasons in India, Kharif (monsoon) and Rabi (winter). Important among the kharif crops are rice, jowar, bajra, maize, etc. and most important among the rabi crops are wheat, barley, pulses and mustard. Food crops are grown on nearly 73 % of the gross sown area with the remaining 27 % used for cash crops like sugarcane, cotton, jute, tobacco,. etc.

7.7 INDIAN FORESTS

Of the 75 million hectares of forest area, about 61.1 million hectares are either exploited (44.8 million ha.) or potentially exploitable (16.3 million ha.), the remaining forests are inaccessible or required and maintained for protection purposes. With regard to the non-forest area, it is estimated that about 30 million tons of fuelwood is obtained from farm lands, village common lands and trees from homesteads. In addition to this, another 4 million tons is produced under social forestry schemes.

The demand for fuelwood in 1989 in India has been estimated at about 146 million tons (which is about 202 million cubic meters), whereas the production of fuelwood from various sources is estimated to be about 60 - 70 million tons. Thus, there is an enormous gap between the demand and supply of fuelwood in the country. Part of this demand is met with illegal pilferages from the forests and other tree-lots.

Forests are the basic source of fuelwood. The fuelwood used mostly free of cost comes from the miscellaneous trees and trees growing on common land, grazing areas, besides the road and railways tracks, around the farms, around the houses, etc. After these sources of fuelwood are exhausted, people look to the surrounding forests, which are accessible to them. Thus, the forests nearest to human settlements get degraded first. Same is the case for the urban areas, where the fuelwood demand is met with the trees from the nearest forest area or woodlots.

One main aspect with the continuing demand and consumption of fuelwood is that, as the fuelwood becomes dearer, and difficult to procure, people opt for alternative sources of fuel like coal or kerosene. If the 'cost' of fuelwood, be it in terms of time required to procure the fuel, or actual monetary cost, is equal to that of the next dearer fuel, for example kerosene, then there is a possibility of a shift from fuelwood to kerosene. In this case, there is a shift from a fuel of inferior efficiency (fuelwood) to a fuel of higher efficiency (kerosene), because of the non - availability and cost similarities of the previously preferred fuel.

VIII

NSS DATA BASE - FUEL & LIGHT AND TOTAL EXPENDITURE

8.0 INTRODUCTION

For the analysis of energy ladder concept the National Sample Survey data is used. The residential sector in the rural areas in India is the largest consumer of energy, accounting for almost 40% (CMIE, 1990) of the energy consumed in the country. Even though energy is a crucial item of consumption for the household sector, the importance and the actual 'cost' of the energy, is rarely seen and counted for in the national statistics. This is the case **for** energy in the 'commercial sectors' like the industrial sector or the services sectors as well. This chapter contains the data analysis of the survey data used for the study. The data analyzed is for fuel and light and total expenditure covered in four rounds, fuel wise expenditure across three rounds, and fuel expenditure by four monthly per capita expenditure (MPCE) categories. The actual data is given in the appendices.

8.1 NSS-CSO DATA BASE

The data used for the present study is taken from various (27th, 28th, 32nd, 38th and 44th) rounds of household sample survey conducted by the National Sample Survey Organization, Department of Statistics, Ministry of Planning, Government of India. The National Sample Survey Organization conducts four sub - round surveys every year, generally to coincide either with the four climatic seasons or four main agricultural seasons. The sample units are equally distributed over the four sub-rounds in such a manner so as to provide equally valid estimates for each of the sub-round period. The survey is conducted for the whole country, covering all the states and union territories, for both urban and rural sectors. In different rounds some state or the other is not surveyed, due to various reasons like internal disturbances in the region, or due to redistribution of states, and other reasons.

A stratified two - stage sampling method is adopted for the survey, with census villages and urban blocks as the first stage units respectively for the rural and urban areas and households as the second stage units. The sample villages are selected with probability proportional to size and with replacement in the form of two independent interpenetrating samples (IPNS). Sample households in the second stage (10 from each first stage unit) are selected circular systematically after arranging all the households of the first stage units in a specified manner. In each of the selected first stage units, 10 (usually) households are selected as the second stage units.

8.2 DATA ON CONSUMER EXPENDITURE

Data on consumer expenditure was collected in every round of the National Sample Survey (NSS) beginning from the first round (1950) through to the 28th round (1973-74). But after the 26th round it was decided that the survey on consumer expenditure and employment and unemployment be undertaken together once every five years, beginning from the 27th round. Thus, the consumer expenditure data for energy - fuel-wise is available in detail for the 27 th, 32 nd and 38th rounds. But later on, to maintain continuity of survey data on consumer expenditure, it was decided to carry out the enquiry in every NSS round in a smaller sample, in addition to the quinquennial large scale surveys.

The reference period for collection of data on consumer expenditure is 30 days prior to the date of survey. The expenditure data is collected for the MPCE (Monthly Per Capita Expenditure) classes, which vary from round to round. For example, in the 28th round, the MPCE classes were for Rs. 0 - 13, Rs. 13 - 15, Rs. 15 - 18, and so on, whereas for the 38th round the MPCE classes were Rs. 0-30, Rs. 30-40, Rs. 40-50, and so on, finally, for the 44th round, the class intervals were, for rural areas, Less than Rs. 65, Rs. 65 - 80, Rs. 80 - 95, etc., and for the urban areas, Less than Rs. 90, Rs. 90 - 110, Rs. 110 - 135, and so on. Thus, with time, the increase in the household expenditure for various items was taken into account, and for the 44th round, there was a recognition of the different expenditure for the rural and the urban areas. Thus the data reflects a sort of price escalation over time, due to inflation.

The major categories included in the survey on Total Expenditure are Food, Non-Food and Miscellaneous. Under the category of Food,

food items like rice, wheat, pulses, **oil**, etc., are included. Under the category of Non-Food, Light and Fuel, Pan and Tobacco, Footwear, etc., is included. In the last category, miscellaneous items like rent are included.

8.3 CONCEPTS AND DEFINITIONS

The concepts and definitions followed in the consumer expenditure data are as follows -

a) **Household** : **A** *household* is defined as a group of persons normally living together and taking food from a common kitchen. On the other hand, a boarding house, a hostel or a hotel is treated as a cluster of households, where each individual boarder (with his dependents and guests) form a household. Floating population, having no normal place of residence and foreign national's households are also excluded from the definition of a household.

b) **Persons per Household** : Each individual of a group constituting the household is a member of the household. Household members are grouped into three categories, like, adult male, adult female and child. Any person completing the age of 15 years is considered as adult. Any person, who usually lives and takes the principal meals with the household is considered a member of the household.

c) **Household Size** : The total number of members (as defined above) in a household is the size of the household.

d) **Household Consumer Expenditure** : The expenditure incurred by a household on domestic consumption during the reference period is the household's consumer expenditure. The household consumer expenditure is the total of the monetary values of consumption of various groups of items like -

(i) food, pan, tobacco, intoxicants and Fuel and Light

(ii) clothing, and footwear, and

(iii) miscellaneous goods and services and durable articles.

For groups (i) and (ii), the total value of consumption is derived by aggregating the monetary value of goods *actually consumed* during the reference period.

8.4 THE RESIDENTIAL SECTOR IN INDIA

Household or the residential sector in India consumes about 40 - 50 % of the total energy consumed in the economy. The bulk of the energy consumed in the household sector comprises of traditional, non-commercial fuels like fuelwood, animal wastes, crop residues, and others. The main issue with the energy consumption in the total household scenario and the rural sector in particular is that, in the last couple of decades or so, the energy supply, be it of the traditional fuels or the commercial fuels has not kept pace with the increasing demand. Another aspect of the energy consumption is that, as the total family incomes increase both in the rural and the urban sectors, the demand for more 'efficient' and 'clean' energy sources gains momentum and the limited supply of the same results in increase in price of the 'efficient' fuels. There is a definite shift in the household consumption of energy sources from traditional fuels to modern fuels, which is seen to be linked to the increasing monetary incomes of the households and demands of the modern day kitchens.

With the increasing scarcity of the traditional fuels and monetization of the fuel market, there is a forced shift away from the traditional fuels towards the purchased commercial fuels. This shift is not just because of the scarcity of availability of the traditional fuels, but also because with the relative affluence (increase in monetary incomes) of a household, and the shortage of time for fuel collection and more emphasis being given on education and health of the family members. Thus, it can be observed that there is a broad spectrum of energy sources available and used from twigs and leaves, fuelwood, to coal, kerosene, LPG and electricity, and other energy sources in the household sector in India for cooking mainly, and for other end-uses (lighting, space heating, water heating, etc.). The concept of energy ladder also talks about the choice of fuel out of an array of alternatives available. The choice is based on the economic status of the households, that is, the level of income and other socio-economic conditions like size of the family, customs followed, etc.

A major problem in most of the developing economies to estimate and to evaluate the extent of the energy consumed and required in the household sector is the lack of up-to-date information on non-commercial sources of energy. Though some indicative data gathered through field surveys is available, it is not on regular basis. The NCAER (National Council for Applied Economic Research) has collected some information to establish the broad trends in energy consumption during the five-year period from 1974-75 to 1978-79. But the available data relate only to the number of households using a particular type of fuel, and not to the actual or estimated quantities of fuels used.

Field surveys indicate a rise in per capita energy consumption as well as a shift away from non-commercial fuels with increased incomes in urban areas. This reflects the fact that a significant proportion of energy used in the rural areas is collected at zero-cost. This in turn highlight the urban-rural differences in the energy profile of the households, with regards to both the supply and consumption of energy in the household sector in the country.

8.5 CONSUMPTION OF FUEL & LIGHT

The survey on consumer expenditure during the 27th round extended over the whole of rural and urban areas of the country, except Ladakh districts of Jammu and Kashmir and some areas of Madhya Pradesh, Maharashtra, Nagaland, Tripura, Chandigarh, Arunachal Pradesh, Andaman and Nicobar Islands, Mizoram, Lakshadweep and Dadra and Nagar Haveli. The 32nd round covered areas, apart from those covered in the 27th round, areas of Arunachal Pradesh, Mizoram, Tripura and Nagaland (urban areas only). 38th round covered the entire country, excepting areas of Ladakh and Kargil districts of Jammu and Kashmir and rural areas of Nagaland.

The definition of Fuel and Light across the four rounds remained the same, that is, Fuel and Light include fuels used for cooking and lighting purposes. The information on the household consumption of fuel and light, based on the results of central sample of 27th, 32nd and 38th rounds covers a period of about 10 years, from September 1972 to December 1983. The items grouped under the category of 'fuel and light' are coke, coal, electricity, gas, kerosene, methylated spirit, firewood & chips, dung cake, charcoal, matches, candles, other oil used for lighting and other fuel and light. The items *coal gas* and *gobar gas* for the 27th and 32nd rounds were clubbed under the category of 'gas', which was separated for the 38th round.

Expenditure on fuel and light form an important part of the total household expenditure, if not in terms of percentage, then in terms of the importance of energy for the household daily - for cooking, lighting at least.

As seen in the Table 8.1, the per capita total consumer expenditure in different rounds has registered a steady increase in the rounds, along with an increase in the amount spent on fuel and light. There was a slight decrease in the percentage of fuel and light out of total expenditure in the 32nd round for the rural sector. From 5.64 % in the 27th round, the percentage of expenditure on fuel and light for the rural sector decreased to 5.56 % in the 32 nd round.

Table 8.1

Per Capita Total Consumer Expenditure and Value of Consumption on Fuel & Light for 30 Days - Rural and Urban Sectors
All India - 27, 32 and 38 Rounds of NSS

NSS Round	Per capita total con. expn. (Rs.)		Per capita expn. on F & L (Rs.)		% age share of expn. on F & L to total expn.	
	Rural	Urban	Rural	Urban	Rural	Urban
27 th (1972-73)	44.17	63.33	2.49	3.57	5.64	5.64
32 nd (1977-78)	73.55	104.58	4.09	5.97	5.56	5.71
38 th (1983-83)	112.31	165.80	7.95	11.31	7.08	6.82
V, increase in 32nd round over 27th round	66.52	65.14	64.26	67.23		
% increase in 38th round over 27th round	154.27	161.80	219.28	216.80		

Source : Sarvekshana, Vol. XIV, Jan. Mar. 1991

In the Table 8.2, the percentage share of some selected items of fuel and light to total household consumer expenditure is given. It can be observed that the share of value of consumption of different items of fuel and light differs vastly over the rural and urban sectors of India. The share of fuel sources like coke, coal, kerosene **and** electricity is considerably less for the rural sector **than** compared to the urban areas. On the other hand, the share of fuelwood is much higher for the rural sector than the urban areas, This difference can be observed even in the results of the percentage of households reporting consumption of the different items of fuel and light, except for kerosene. The kerosene consumption in the rural areas is higher than compared to the urban areas, owing to the fact that it is a major source of lighting in the rural areas, whereas, electricity is the major source of lighting in the urban areas, and kerosene is used mainly for cooking by the poorer households.

TABLE 8.2
Percentage Share of Selected Items of Fuels to Total Value Consumption of Fuel & Light - For 30 Days
All India - Rural and Urban Sectors

N Round	% share to total value of consumption of F & L				% of households reporting consumption of				
	coal	fl.wd.	kero.	elect.	coke coal		fl.wd.	kero.	elect.
RURAL									
27 th (1972-73)	1.2	60.2	15.7	1.2	1	2	90	96	4
32 nd (1977-78)	1.7	55.5	16.9	2.4	1	2	90	96	7
38 th (1983-83)	1.9	55.4	14.3	4.0	2	1	86	95	14
URBAN									
27 th (1972-73)	11.8	35.3	18.5	16.8	10	12	62	86	38
32 nd (1977-78)	10.9	31.8	23.5	16.8	8	15	61	88	42
38 th (1983-83)	9.6	30.5	22.4	20.3	14	4	56	88	54

Source : Sarvekshana, Vol. XIV, Jan.-Mar. 1991

8.6 TOTAL EXPENDITURE AND FUEL & LIGHT ACROSS ROUNDS

The data on consumption of fuel and light and total consumer expenditure is in average per capita rupees (0.00) for a period of 30 **days (one month).** The actual data is shown in Appendix A. This data is for 4 rounds, viz., 27, 32, 38 and 44th rounds, and for 15 states.

As seen from the Table 8.3, in the 27th round, in case of rural areas, the state spending the highest average per capita amount on fuel and light was Himachal Pradesh, spending Rs. 5.79, and the lowest was West Bengal with Rs. 1.84. In the same round, even in the urban areas, Himachal Pradesh spent the highest amount on fuel and light, with Rs. 7.62, and the lowest spender was Andhra Pradesh with Rs. 2.94. Even if the total (rural + urban) is taken, Himachal Pradesh spent the highest and Andhra Pradesh spent lowest with Rs. 13.41 and Rs. 4.93 respectively. The data on per capita total consumer expenditure shows that in all the areas - rural, urban and total, Himachal Pradesh is the highest spender with Rs. 70.14 in the rural areas, Rs. 101.45 in the urban areas, and for total, Rs. 171.59. But the lowest per capita spenders in the same round are Orissa for the rural areas with Rs. 34.96, Jammu and Kashmir in the urban areas, with Rs. 49.38, and for the total, Tamil Nadu with Rs. 91.72.

TABLE 8.3

PER CAPITA FUEL **AND** LIGHT CONSUMPTION

	Lowest Case				Highest Case			
	27	32	38	44	27	32	38	44
RURAL	1.84 *(W.B)*	2.97 *(TRI)*	6.26 *(BIH)*	10.65 *(A.P)*	5.79 *(H.P)*	11.40 ***(GUJ)***	13.47 *(H.P)*	18.94 *(PJB)*
URBAN	2.94 *(A.P)*	3.69 ***(0R1)***	8.95 *(BIH)*	13.64 *(A.P)*	7.62 *(H.P)*	8.86 *(H.P)*	16.72 *(H.P)*	22.58 *(ORI)*
TOTAL	4.93 *(A.P)*	7.22 *(BIH)*	15.21 *(BIH)*	24.29 *(A.P)*	13.41 *(H.P)*	17.61 ***(GUJ)***	30.19 *(H.P)*	36.69 *(PJB)*

(W.B.- West Bengal; TRI - Tripura; BIH - Bihar; H.P - Himachal Pradesh; GUJ - Gujarat; PJB - Punjab; A.P - Andhra Pradesh; ORI - Orissa)

For the 32nd round, in the rural areas, the state with the highest per capita expenditure on fuel and light was Gujarat with Rs. 11.40, and the lowest Tripura with Rs. 2.97. For the urban areas, once again Himachal Pradesh was the state with the highest **per** capita expenditure on fuel and light with Rs. 8.86, and the lowest was Orissa with Rs. 3.69. For the total areas, the lowest was Bihar, and the highest was Gujarat with Rs. 7.22 and Rs. 17.61, respectively. Regarding the total expenditure, for the rural areas, the lowest and the highest per capita spenders were, Orissa and Punjab, with Rs. 53.19 and Rs. 126.68, respectively. In the case of urban areas, Kerala and Madhya Pradesh were the states with lowest and highest per capita total expenditure, with Rs. 83.09 and Rs. 137.97 respectively. For the total areas, again Orissa and Punjab occupied the lowest and the highest places, with Rs. 140.78 and Rs. 252.41 respectively.

In case of the 38th round, the states with highest and lowest per capita expenditure on fuel and light were same for the rural, urban and total areas. They were Himachal Pradesh and Bihar, with Rs. 13.47 and Rs. 6.26 for rural areas, Rs. 16.72 and Rs. 8.95 for urban areas, and for total, Rs. 30.19 and Rs. 15.21, respectively. For per capita total expenditure, for the rural areas, Bihar was the lowest with Rs. 93.76, highest was Punjab with 170.30; for urban areas, Uttar Pradesh was the lowest and Himachal Pradesh, the highest, with Rs. 137.84 and Rs. 257.09 respectively. In the case of total areas, the lowest and highest remained same as for the per capita expenditure on fuel and light is concerned, that is, Bihar and Himachal Pradesh with Rs. 233.34 and Rs. **407.14,** respectively.

In the 27th, for the rural areas, the state with least per capita expenditure for fuel and light was West Bengal with Rs. 1.84, and the state with highest per capita expenditure was, Haryana, with Rs. 3.68. For urban areas, the least was Andhra Pradesh with Rs. 2.94, and highest was Uttar Pradesh with Rs. 7.74. In case of the total areas, again, the lowest was Andhra Pradesh with Rs. 4.93 and the highest was Uttar Pradesh with Rs. 10.29. Regarding the per capita total expenditure, as seen in the Table 8.4, for the rural areas in the 27th round, the highest and the lowest were, Punjab and Orissa with Rs. 74.62 and Rs. 34.96 respectively. For the urban areas, the corresponding figures were, Uttar Pradesh lowest with Rs. 53.55 and Punjab again highest with Rs. 77.88. In the case of total areas, the highest again was Punjab with Rs. 152.50, and lowest was Tamil Nadu with Rs. 91.72. Thus, the state of Punjab had the highest per capita total expenditure for both

TABLE 8.4

PER CAPITA TOTAL EXPENDITURE

	Lowest Case				Highest Case			
	27	32	38	44	27	32	38	44
RURAL	34.96 *(ORI)*	53.19 *(ORI)*	93.76 *(BIH)*	152.89 *(BIH)*	70.14 *(H.P)*	126.68 *(GUJ)*	170.30 *(PJB)*	264.71 *(PJB)*
URBAN	49.38 *(J&K)*	83.09 *(KER)*	137.84 *(U.P)*	227.87 *(BIH)*	101.45 *(H.P)*	137.97 *(H.P)*	257.09 *(H.P)*	311.76 *(M.P)*
TOTAL	91.72 *(T.N)*	140.78 *(ORI)*	233.34 *(BIH)*	380.76 *(BIH)*	171.59 *(H.P)*	252.41 *(GUJ)*	407.14 *(H.P)*	528.83 *(PJB)*

(T.N.- Tamil Nadu; BIH- Bihar, H.P.- Himachal Pradesh, J&K - Jammu and Kashmir; GUJ- Gujarat; PJB- Punjab; KER- Kerala; ORI- Orissa) the rural and the urban areas. In the case of 32nd round, for rural areas, Bihar with Rs. 3.34 was the lowest and with Rs. 11.40, Gujarat was the highest in terms of per capita expenditure for fuel and light. For the urban areas, Orissa spent the least, per capita, with Rs. 3.69 and Maharashtra was the highest with Rs. 7.15. For the total areas, Madhya Pradesh spent least with Rs. 8.29 and Gujarat spent most with Rs. 17.61. Now taking the figures for per capita total consumer expenditure, it can be seen that for the rural areas Orissa again was spending least with Rs. 53.19, and Punjab had the highest per capita total expenditure of Rs. 126.68. For the urban areas, Kerala was the least with Rs. 83.09 and Madhya Pradesh was highest with Rs. 137.97. For the total areas, Bihar was the least with Rs. 151.74, and with Rs. 252.41 Punjab once again was the highest.

In the case of 38th round, for all the areas - rural, urban and total, Bihar had the lowest per capita expenditure for fuel and light, with Rs. 6.26. Rs. 8.95, Rs. 15.21, respectively. Punjab was once again the state with the highest per capita expenditure on fuel and light for all the areas with Rs. 11.62, Rs. 14.93, Rs. 26.55, respectively. In the case of per capita total expenditure, again Bihar was the lowest with Rs. 93.76, and Punjab was highest with Rs. 170.30, for the rural areas. In case of the urban areas, the lowest was Uttar Pradesh and highest was Maharashtra, with Rs. 137.84 and Rs. 187.56, respectively. For the total areas, Bihar again was the state with the least per capita total expenditure and the highest was Punjab, with Rs. 233.34 and Rs. 354.68

respectively.

For the last, 44th round, the state with the lowest per capita expenditure for fuel and light for all the areas - rural, urban and total was Andhra Pradesh, with Rs. 10.65, Rs. 13.64, Rs. 24.29 respectively. The states with the highest expenditure for fuel and light were, Punjab for the rural areas with Rs. 18.94, Orissa for urban areas with Rs. 22.58, and Punjab again for the total areas with Rs. 36.69. For the per capita total expenditure, the states with the lowest expenditure was Bihar for all, rural urban and total areas with Rs. 152.89, Rs. 227.87 and Rs. 380.76, respectively. The states with the highest per capita expenditure were, Punjab for the rural areas with Rs. 264.71, for the urban areas, it was Madhya Pradesh with Rs. 311.76, and Punjab once again with Rs. 528.83.

When we see the across the rounds per capita expenditure, there has been an increase in the expenditure on fuel and light and per capita total expenditure from the first, 27th round to the latest, 44th round. Regarding the fuel and light expenditure for the rural areas, there has been an increase from Rs. 1.84 (lowest per capita expenditure) in the 27th round (West Bengal) to Rs. 6.26 (Bihar) in the 38th round, which further increased to Rs. 10.65 (Andhra Pradesh) in the 44th round. In the case of highest per capita expenditure for fuel and light, it increased from Rs. 5.79 (Himachal Pradesh) to Rs. 11.40 (Gujarat) in the 32nd round, to Rs. 13.47 (Himachal Pradesh) in 38th round to Rs. 18.94 (Punjab) in the 44th round.

For the urban areas, with higher expenditure both in terms of fuel and light expenditure and total expenditure, in all the rounds, the per capita expenditure on fuel and light increased from (lowest case) Rs. 2.94 (Andhra Pradesh) in the 27th round to Rs. 3.69 (Orissa) in the 32nd round, to Rs. 8.95 (Bihar) in the 38th round to Rs. 13.64 (Andhra Pradesh) in the 44th round, showing a growth rate of almost 363.95 % over the rounds. This same trend was observed even in the case of total areas.

There has been a steep growth of the per capita expenditure across the rounds. For the rural areas, an increase from Rs. 34.96 (Orissa for the lowest case) in the 27th round to Rs. 53.19 (Orissa again) in the 32nd round, to Rs. 93.76 (Bihar) in the 38th round and finally, to Rs. 152.89 (Bihar and Madhya Pradesh) in the 44th round was observed. In the case of highest expenditure in the rural areas, there was an increase from Rs.70.14 (Himachal Pradesh) in 27th round, to Rs. 126.68 (Punjab) in the 32nd round, to Rs. 170.30 in the 38th round (Punjab), and to Rs. 264.71 (Punjab) in the 44th round. For urban areas, the highest per capita expenditure was for Himachal Pradesh for the 27th, 32nd and **38th** rounds, **and** for 44th round, Madhya Pradesh. The corresponding figures for the four rounds are Rs. 101.45, Rs. 137.97, Rs. 257.09, and Rs. 311.76.

8.7 ENERGY CONSUMPTION IN HOUSEHOLD SECTOR

In 1991-92, total commercial energy consumed in the household sector was estimated to be 13 MTOE (million tons of oil equivalent), accounting for 10 % of the total consumption. The household sector showed a steady shift away from the traditional, non-commercial energy to commercial energy sources between 1984-85 to 1991-92. Petroleum products like kerosene, LPG are of importance among the commercial sources, accounting for nearly two-thirds of the consumption of commercial fuels. In others, the share of coal is one-fourth and that of electricity is, one-tenth. In 1982-83, non - commercial sources of energy met 93 % of the total energy demand in this sector, and of that, fuelwood continued to be dominant fuel source with 63 % households using it as a fuel source, followed by animal residues (dung), 22 % and crop residues, 15 %.

Any information on patterns of household energy consumption is available mainly from the sample surveys (for example, those conducted by the NSSO, Central Statistical Organization). But the major drawback is that in these surveys, the actual energy - use is not measured while conducting the survey. The data available can in a limited scope, be compared with the official estimates of energy sales to households, as this comparison is possible only for the commercial sources of energy, like LPG, coke, kerosene, electricity, that too mainly for the urban areas.

In **the** Table 8.5, it car be observed that as the annual household income levels increase, the dependence, or consumption of traditional fuels like vegetable wastes, dung and fuelwood is decreasing **and the usage** of more efficient and costlier fuels **like** kerosene, LPG and electricity is increasing. This trend can be observed for both the rural and the urban sectors of the economy. In case of rural households, when the annual income level is upto Rs. 3000, fuelwood accounts for nearly 61 % of the total energy

TABLE 8.5
Fuel Used by Urban and Rural Households of Different Income Categories (%)

FUEL	ANNUAL HOUSEHOLD INCOME (RS.)					
	UPTO 3000	3000-6000	6000-12000	12000 18000	18000 & ABOVE	AVERAGE
RURAL						
Soft Coke	1.3	1.6	4.7	4.9	7.3	2.1
Kerosene	2.7	2.6	2.3	1.8	1.8	2.6
Elect.	0.2	0.4	0.6	0.9	1.0	0.4
Fl.wood	60.8	59.0	56.8	53.5	49.3	59.2
V.Wastes	16. 1	14.6	15.6	18.2	16.6	15.6
Dung	18.9	21.8	20.0	20.7	24.0	20.1
Commr.	4.2	4.6	7.6	7.6	10.1	5.1
N.Commr.	95.8	95.4	92.4	92.4	89.9	94.9
URBAN						
Soft Coke	14.9	23.6	31.1	20.0	19.8	23.2
Kerosene	19.4	**23.8**	19.6	17.7	14.8	21.1
Electr.	0.8	1.7	2.6	3.5	4.9	1.9
LPG	-	5.2	15.9	34.0	41.3	9.8
Fl.wood	**54.9**	37.3	22.8	16.7	13.9	35.5
V.Wastes	2.6.	1.4	1.4	2.7	1. 1	1.7
Dung	5.2	4.5	3.9	4.1	2.3	4.5
Charcoal	2.2	2.5	2.7	1.3	1.5	2.3
Commr.	37.3	56.8	71.9	76.5	82.7	**58.3**
N.Commr.	62.7	**43.2**	**28.1**	23.5	17.3	41.5

Source : TEDDY. 1995/96. TERI. **New** Dell consumption, which reduces to 49 % when the income level increases to Rs. 18000 and above, and the share of electricity increases from 0.2 % to 1.0 % for the same income categories. Thus the share of commercial fuels increase from 4.2 % to 10.1 %, and that of non-commercial fuels decrease from 95.8 % to 89.9 % in the rural sector. In the case of urban sector, the same trend can be observed, but in a more obvious manner. The share of fuelwood decrease from 54.9 % in the annual income class of upto Rs. 3000 to 13.9 % for the above Rs. 18000 annual income class. The corresponding figures for electricity are, an increase from 0.8 % to 4.9 %, and for LPG, which shows the most dramatic change, increase from nil in upto Rs. 3000 class to 41.3 % in the class of above Rs. 18000.

The Table 8.6 shows that the share of commercial fuels in the household sector increases with time and decrease in the dependence on non - commercial fuels is at the cost of more

TABLE 8.6
Changes in Energy Consumption in Household Sector
1970-71 and 1982-83

				% COMPOSITION	
FUEL	1970-71	1982-83	% CHANGE	1970-71	1982-83
COMMERCIAL					
Coal (MT)	3.2	4.6	45	1.7	1.8
Oil (MT)	3.7	5.7	55	4.0	4.6
Electricity(Twh)	3.8	12.0	211	0.4	0.8
Total (MTOE)	5.6	9.1	61	6.1	7.2
NON-COMMERCIAL					
Fuelwood	117.9	154.0	31	60.7	58.6
Crop Res.	36.3	40.0	10	16.4	13.5
Dung	64.6	109.0	69	16.8	20.7
Total	86.5	115.8	34	93.9	92.8
Grand Total	92.2	124.8	35	100.0	100.0

efficient commercial fuels. Another aspect of this is that more people are demanding commercial fuels, but it may not be able to meet their demand, thus for the poorer sections of the population, there is no other option, but to depend on the non - commercial fuels till the time that they are able to buy them. Thus, fuel demand / consumption are inter - related with the income of the household on the one hand, and on the level of development and availability of the fuel sources on the other.

8.8 FUEL-WISE ENERGY CONSUMPTION ACROSS ROUNDS

There are many options available for the rural and urban households as far as energy sources are concerned. The main sources of energy are coal or coke, kerosene, fuelwood, animal wastes, crop wastes, LPG, electricity, and other traditional, non-commercial fuels like coconut shells (used mainly in the coastal states of Kerala and Goa), paddy husk (it is mainly used along with fuelwood), twigs, branches and leaves. But the main sources of energy taken for the present study are coke, fuelwood, kerosene and electricity.

The data taken is for three rounds of NSS, that is 27th, 32nd and 38th rounds, for the rural, urban and total areas. The data is in Rs. '00000. The relative share of each of the four fuel sources and the share of others is also calculated. It has been found that of all the fuel sources, fuelwood occupies the foremost position as far as the percentage of the consumption out of the total fuel and light consumption. The actual data and the percentages of each is given in Appendix B.

In the 27th round, in the states of Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Tamil Nadu and Uttar Pradesh, no coke was used for cooking. The state using the highest amount of coke in monetary terms was West Bengal, which consumed Rs. 966.00 (x '00000), forming 12.04 % of its total fuel and light bill. Himachal Pradesh used the highest percentage of fuelwood out of total fuel and light, spending 86.26 % of its total fuel and light expenditure on fuelwood. But, the state which consumed **the** highest amount in terms of money was Uttar Pradesh, accounting for Rs. 13273.00 out of its total, forming 53.88 %. The state spending the least amount on fuelwood was Tripura with Rs. 368.00, but it formed 76.83 % of its total fuel and light expenditure. Bihar spent the least in percentage terms, with fuelwood accounting only for 32.71 % of its total. In the case of kerosene, West Bengal used the highest percentage of 20.94 % (Rs. 1680.00), and in terms of rupees, the state using the highest amount of money for kerosene consumption was Uttar Pradesh, with Rs. 3438.00 (forming 13.96 •/.). Himachal Pradesh used the least percent out of total on kerosene, with 6.28 •/. (Rs. 150.00). Tripura used the least in terms of money, spending Rs. 71.00 on kerosene. In the case of electricity, the states of Assam, Bihar, Tripura and West Bengal did not use electricity for cooking in the 27th round, in the rural areas. The state using the highest amount on **electricity was** Tamil Nadu with Rs. 324.00 (3.51 %), and in terms of percentage, Punjab accounted for the highest percentage with 5.64 % (Rs. 247.00). As far as the total is concerned, Tripura spent the least amount on energy (compared to the other states, **which** can be because of the **low** population of the state), that is Rs. 479.00. Uttar Pradesh (a big state **both** in terms of area and population) spent the highest amount, Rs. 24636.00 on fuel and light. Again for the 32nd round, in the rural areas many states did not use coke for cooking. The state using the highest amount and percentage for coke was West Bengal, with Rs. 2549.00, forming 16.09 % of the total.

In case of 32nd round for the rural areas, there were very few states using coke. Among the users, the highest share was from West Bengal, using Rs. 2594.00 worth of coke, accounting for 16.91 % of its total fuel and light expenditure. Then Bihar satisfied 4.72 % of its energy needs for cooking with coke, amounting to Rs. 1085.00. In case of fuelwood, again all the states used fuelwood in very substantial amounts. The highest user in terms of money was again Uttar Pradesh with Rs. 18058.00, and in terms of percentage it was Himachal pradesh, accounting for 79.77 %. The lowest user was Punjab with only 31.96 %, and in terms of money, Tripura with Rs. 449.00. The continued presence in the lowest category of energy users can be due to the fact that not only is it a relatively backward state (there are virtually no major industries situated there) and the population is also small, using **more traditional** forms of fuel. Fuelwood usage accounted for 72.42 % **in** the state, though the total in terms of money was least. Kerosene in the 32nd round was used maximum by Assam in terms of percentage, that is, 22.14 % (Rs. 1946.00). Himachal Pradesh used the least with only 7.32 % (Rs. 221.00), and the largest user was Uttar Pradesh with Rs. 5723.00 (13.68 %), and the lowest user in terms of money was Tripura again, with Rs. 132.00 (21.29 %). In case of electricity, Bihar used the least with 0.30 % (Rs. 68.00), but the lowest user in terms of money was once again Tripura where there was no usage of electricity for cooking in the 32nd round in the rural areas. Tamil Nadu was the largest user with Rs. 806.00 (5.28 %), and in percentage terms it was Himachal Pradesh using 5.86 % (Rs. 177.00) electricity out of of its total energy use. In the category of 'other' fuels, Haryana consumed largest percentage of fuels which were other than the four main fuel sources mentioned here, with 48.61 % of its energy coming from other sources. The lowest user of other fuels was Assam using only 4.80 % of other fuels. In monetary terms, the lowest user was Tripura (Rs. 39.00) once again, and the largest, once again Uttar Pradesh (Rs. 17565.00). Again for the total energy consumption, Tripura spent the least (Rs. 620.00) and Uttar Pradesh spent the highest (Rs. 41839) in comparison to other states.

By the 38th round, all the states had started using coke for cooking, though West Bengal continued to be the highest user of coke, both in terms of money spent and percentage, accounting for 5.39 % of its total fuel use, and spending Rs. 4588.00. The lowest user was Jammu and Kashmir with Rs. 18.00, forming 0.29 %

of its total fuel and light expenditure, but the lowest in percentage terms was Haryana with only 0.25 % (Rs. 31.00).

Fuelwood continued to be the dominant fuel for cooking in the rural households even in the 38th round with Himachal Pradesh accounting for 77.25 % (Rs. 5185.00) of its total fuel use, and the highest in terms of money was Uttar Pradesh with Rs. 37788.00). The lowest percentage was used by West Bengal, using only 16.86 % (Rs. 14350.00), and Tripura as earlier spending the least with Rs. 1112.00. In the case of kenosene, Himachal Pradesh used the least percentage with only 6.96 % (Rs. 467.00) of its total expenditure on fuel going in for consuming kerosene. The least was spent in monetary terms, again by Tripura, spending only Rs. 294.00 (17.63 %). The largest consumer was West Bengal, both in terms of percentage and rupees, accounting for 71.79 % and Rs. 61092.00, respectively. Electricity was used on a limited basis in the rural areas even in the 38th round. The highest user in percentage terms was Punjab with 13.02 % (Rs. 2287.00), and in terms of rupees, it was Maharashtra with Rs. 2779.00 (5.92 %). The lowest user was Tripura in terms of money, spending Rs. 85.00, and in percentage terms, it was, Bihar with 0.56 % (Rs. 247.00). Uttar Pradesh used the largest amount of other fuels in monetary terms with Rs. 42512.00 (45.76 %) and in terms of percentage, it was Haryana, using almost 46.63 % of other fuels. Haryana, basically is an agriculture dominated state, with low level of industrialization. There are only pockets of developed areas, and the whole state is basically agrarian and rural. The forest cover is also very low, hence the low dependence on fuelwood. The major fuel sources in this state would be dung, biogas and agricultural wastes.

Assam used the least percentage of other fuels, using only 4.56 %, and the state using the lowest amount of other fuels in money terms was Tripura, which relied mainly on fuelwood, as seen earlier. Tripura spent the lowest amount on fuel and light in the rural areas, during the 38th round, spending only Rs. 1668.00, on the other hand, Uttar Pradesh used the highest, spending Rs. 92907 on fuel and light.

In the urban areas, in the 27th round, there were a few states which did not use coke as fuel. The states were Jammu and Kashmir and Tripura. The state using the highest amount on coke, as in the rural areas, was West Bengal, which used coke more than any other state, both in terms of rupees and percentage, with Rs. 1893.00 and 39.83 % respectively. Fuelwood continued to be an important source of fuel for most of the states even in the urban areas, though it accounted only for 7.26 % for West Bengal (Rs. 345.00), with the lowest amount spent by Tripura with Rs. 64.00, though it formed the highest in terms of percentage, 71.91%. In terms of money the highest amount was spent by Tamil Nadu, Rs. 3016.00. Kerosene assumes a more important position in the urban areas, compared to the rural areas, with an overall improvement in percentage usage. The highest amount was spent by Maharashtra, which also accounted for the highest percentage with

Rs. 2406.00 and 32.44 % respectively. The least amount was spent by Jammu and Kashmir with Rs. 10.00, and the it was used least by Uttar Pradesh with 2.85 %, in the 27th round. Electricity also assumed an important place in the total fuel and light expenditure of the whole country. It accounted for 21. 52 % for Punjab, the highest percentage user, and West Bengal spent the most for electricity, spending Rs. 1022.00 (21.50 %). The lowest user in terms of money was Tripura with Rs. 6.00. The state of Jammu and Kashmir spent the least amount on total fuel and light with Rs. 53.00, and the largest amount was spent by Maharashtra, which spent Rs. 7417.00 totally for fuel and light.

During the 32nd round in the urban areas, there were some states which did not use coke. West Bengal once again spent the maximum amount on coke, both in terms of money and percentage, with Rs. 3769.00 and 41.24 % respectively. Fuelwood formed the maximum percentage for Orissa with 63.86 % (Rs. 1115.00), out of its total fuel and light consumption, and the state consuming the least percentage of fuelwood out of its total fuel use was West Bengal with only 7.11 % (Rs. 650.00) coming from fuelwood consumption. But Himachal Pradesh used the least in terms of money, using only Rs. 106.00, but it formed 32.62 % of its total fuel and light bill. Uttar Pradesh spent the highest amount on fuelwood, Rs. 4857.00, which was 39.89 % of its total.

Once again it can be observed that kerosene gained prominence in the urban areas, with an increase in its usage, when compared with the previous (27th round) round's consumption (or expenditure) data. Maharashtra used the highest amount on kerosene, and also spent the highest percent on it, out of its total fuel expenditure. It spent Rs. 6700.00 or 38.23 % on kerosene out of its total fuel expenditure. The state with the least expenditure on kerosene was Kerala in terms of percent, with 11.36 %, and in terms of money it was Tripura once again, with Rs. 35.00, which formed 19.55 % of its total. Regarding electricity, its consumption out of the total also increased for almost all the states compared to the earlier round. The maximum user out of total was Himachal Pradesh, with 23.08 % (Rs. 75.00) of its total. The highest user in terms of money was Maharashtra with Rs. 3690.00 (21.05 %). For Maharashtra, the number is large in all the rounds because it is a big state with a large urban population on the one hand, and on the other, it is one of the most industrialized states of the country, and electricity is one of the most crucial energy inputs in most of the industries. The state spending the least on electricity was Tripura with Rs. 26.00 (14.53 %), and the state spending the least in terms of percentage was Gujarat, spending only 2.84 % out of its total fuel use. Gujarat was the state in the 32nd round using the maximum percentage of other fuels in its urban areas, that is, 35.01 %, amounting to Rs. 2541.00. Gujarat was on of the earliest states where the biogas project was developed and was successful to a certain extent. Maharashtra spent the highest amount on other **fuels** with Rs. 3472.00 (19.81 %). Again Tripura was the **state** with the least percentage of **electricity** usage **and also in** terms of money, with 4.47 % and Rs. 8.00, respectively. Taking the fuel and light total, again Tripura was the state with the least figure with Rs. 179, and the highest was Maharashtra with Rs. 17527.00.

Finally, in the 38th round, for the urban areas, all the states had started using some amount of coke, with Jammu and Kashmir using the least percentage with 0.25 % (Rs. 6.00), and Tripura spending the least with Rs. 5.00 (1.49 %). Once again, as in the other rounds, West Bengal not only used the highest percentage, but also the highest amount on coke, that is, 39.52 % and Rs. 8398.00 respectively out of its total expenditure on fuel and light. Fuelwood accounted for 60.42 % of the total for Tripura which though was the highest percentage, but in terms of money, it spent the least with Rs. 203.00. The state with the least percentage expenditure on fuelwood was West Bengal with 6.60 %, and the state with the highest expenditure on fuelwood was once again Uttar Pradesh, amounting to Rs. 11600.00. For kerosene, Maharashtra spent the highest amount of money and the largest percent of its total fuel bill with Rs. 11991.00 and 31.93 % respectively. Haryana accounted for the least expenditure for kerosene with only 4.79 % of its total going for kerosene. Tripura as in the other rounds spent the least on kerosene with Rs. 41.00. Tripura's total expenditure on fuel and light has been the least in all the rounds and for both rural and urban areas.

In the case of electricity, as in the earlier rounds, Maharashtra spent the highest amount of Rs. 10570.00, (28.15 %), and Punjab spent the highest percentage on it with 31.83 %. Tripura again spent the least on electricity, that is, Rs. 63.00, and Bihar spent the least in terms of percentage, 10.77 %.

During the 38th round, Karnataka spent the highest percentage of expenditure on fuel and light on other fuels, accounting for 52.06 % of its total. Maharashtra spent the highest amount in terms of money, that is, Rs. 6853.00, and once again Tripura spent the least amount in money terms and percentage wise on other fuels, with Rs. 24.00 and 7.14 % respectively.

This same trend continued in the case of total (rural + urban) also. Across the round analysis of the all India fuel and light expenditure and the fuel-wise distribution shown in Table 8.7,

TABLE 8.7

All India Fuel-Wise Distribution of Fuels - For 3 Rounds of NSS

ROUND	COKE	FUELWOOD	KEROSENE	ELECTRICITY	OTHERS	TOTAL
			RURAL			
27	1971 *(1.43)*	83178 *(60.24)*	21626 *(15.66)*	1866 *(1.35)*	29435 *(21.32)*	138076
32	4275 *(1.79)*	132485 *(55.50)*	40271 *(16.87)*	5836 *(2.44)*	55840 *(23.39)*	238707
38	10019 *(1.91)*	190100 *(36.29)*	74816 *(14.28)*	20830 *(3.98)*	228076 *(43.54)*	523841
			URBAN			
27	5790 *(12.13)*	17369 *(35.29)*	9098 *(18.49)*	8271 *(16.81)*	8235 *(16.73)*	49213
32	11531 *(10.89)*	33705 *(31.83)*	24836 *(23.45)*	17740 *(16.75)*	18094 *(17.08)*	105906
38	23209 *(9.63)*	73571 *(30.51)*	54070 *(22.42)*	48848 *(20.26)*	41431 *(17.18)*	241129

* Figures in parenthesis are percentages

reveals that there was an increase in the usage of more efficient fuels from one round to the other, and it was at the cost of the traditional fuels.

Across the rounds analysis of all India fuel-wise energy consumption shows that there was an increase in the consumption of coke, in the rural areas, where it is considered a relatively more efficient fuel than fuelwood, agricultural wastes, animal wastes and twigs, and other types of fuel sources used in most of the rural households. The percentage of total expenditure on coke increased from 1.43 % (Rs. 1971.00) in the 27th round to 1.91 % (Rs. 5790.00) in the 38th round.

This holds the concept of energy ladder true to the extent that there was a shift from a relatively less efficient fuel to a more efficient one with development (assuming there was an overall development in the rural areas over the years). In the same way, there was a decline in the consumption of fuelwood from 60.24 % in the 27th round to 36.29 % (almost half) in the 38th round. Though percentage wise there was a decline, in terms of rupees, the expenditure on fuelwood registered an increase from Rs. 83178.00 in the 27th round to Rs. 190100.00 in the 38th. This reflects that there was an overall increase in the total expenditure for energy. The reduced usage of fuelwood may be because it is considered to be not as efficient as coke, and also because of its reduced availability and high 'cost' , both in terms of price and time spent for procuring it.

In the case of kerosene, the concept of Engel curves can be seen to play an important part, in the sense that there was an increase in the percentage out of total consumption from the 27th round to the 32nd round, but there was a decrease in the same during the the 38th round. The Engel curve analysis, as will be seen in the next chapter, basically means that, with an increase in income (of a household, or in this case, overall increase in incomes), there will be an increase in the consumption of a relatively superior commodity (here, a fuel source, kerosene), but with continued increase (at the higher levels of income), the consumption of that commodity goes down and another more efficient one takes its place. Thus, if a curve is drawn, it would be a backward bending curve.

The consumption of kerosene increased from 15.66 % in the 27th round to 16.87 % in the 32nd round, but it came down to 14.28 % during the 38th round. Again like in the case of fuelwood, there was an increase in the amount spent for kerosene, but there was a decline in the *percentage* of fuel consumed. In the case of electricity, there was an increase in all the rounds, from 1.35 % (Rs. 1866.00) in the 27th round to 2.44 % (Rs. 5836.00) in the 32nd round and finally, 3.98 % (Rs. 20830.00) in the 38th round. In the case of other fuels also there was an increase during the various rounds, from 21.32 % (Rs. 29435.00) in the 27th round to 23.39 % (Rs. 55840.00) in the 32nd round, to 43.54 % (Rs. 228076.00) in the 38th round. There was a substantial increase in the usage of LPG, biogas, natural gas, and other fuels, which add to the other fuels total.

Total amount spent on fuel and light in the rural areas registered an increase from Rs. 138076.00 in the 27th round to Rs. 238707.00 in the 32nd round, registering an increase of 172.88 %, and increased to Rs. 523841.00 in the 38th round, an increase of 219.45 % from 32nd round to 38th round. The rate of increase from 27th round to 38th round was, 379.39 %.

One important feature of the data on the fuel and light expenditure is that the amount spent on fuel in the rural areas is more than that in the urban areas. This may be because there is an inefficient use of energy in the rural areas (in the wood stoves, and three brick stoves, a major portion of heat is lost, hence forcing a use of larger quantity of fuel), thus forcing the households to buy/procure large amounts of fuel, to fulfill the same task (say cooking).

In the urban areas, the total fuel and light expenditure in the 27th round was Rs. 49213.00 and it increased to Rs. 105906.00 in the 32nd round, with a rate of increase at 215.20 %. For the 38th round, the total fuel expenditure was Rs. 241129.00, and the increase over the 32nd round was 227.68 %. The overall percentage of increase, from 27th round to 38th round was a massive 489.97 %. Among the major energy consuming sectors, household sector is one of the fastest growing sector, with the rate of increase in energy for cooking and lighting registering a very high percentage, both for the rural and the urban areas.

8.9 INCOME CATEGORIES AND SIZE OF THE FAMILY

Another set of data used for the present was according to Monthly Per Capita Expenditure (MPCE) categories, for two rounds - 28th and 38th rounds. The data given by NSS was for thirteen categories each. For the sake of convenience, the MPCE categories was brought down to 4 each. For the 28th round, the categories were, low, medium, high and very high expenditure category, that is, Rs.0-43, Rs.43-100, Rs.100-200, and Rs.200 and Above, and for 38th round, the categories were, Rs.0-100, (low) Rs.200-300, (medium) Rs.200-300 (high)and Rs.300 and Above (very high). The actual data is given in the Appendix C.

The average size of the family in both the rounds was found to be high in cases of the low income groups, compared to the higher income groups. Coming to the medium category (Rs.43-100), the family size was lowest for Tamil Nadu with 3.85, and highest for Haryana with 6.59. For the next two categories of high and very high, the family size ranged between 1.0 (Delhi and Tripura) to 5.85 (Himachal Pradesh) and 1.56 (Manipur) to 10.75 (Pondicherry), respectively. Coming to the Urban areas for the 28th round, the household size ranged between 1.76 (Punjab) and 11.25 (Goa) for low category, 4.47 (Tamil Nadu) and 7.00 (Meghalaya) for medium, 2.27 (Assam) and 4.00 (Goa) for high, and 1.00 (Jammu and Kashmir and Manipur) and 3.46 (Kerala) for the very high categories. It was generally found that the number of household members was more in case of the rural areas than the urban areas, it was found that there was an inverse relation between the size of the family and income.

The same trend continued even for the 38th round, where the low income groups were found to have a family size ranging between 4.28 (Delhi) and 7.55 (Jammu and Kashmir). In case of other categories, for medium, the average household size was found to be between 3.93 (Tamil Nadu) and 6.19 (Haryana), for high category, between 2.74 (Delhi) and 5.35 (Haryana), for very high category, between 2.00 (Andaman and Nicobar Islands) and 5.07 (Jammu and Kashmir). The same trend was observed in case of the urban areas as well.

It was also found that the average expenditure on fuel and light increased with the increase in income and the size of the family. Taking the case of lowest and highest household size for the medium and very high groups for the rural areas of 28th round, it is found that, in case of medium, Himachal Pradesh had the highest average household size of 6.59, and the per capita expenditure on fuel and light was Rs.4.05, which comes to Rs.26.69 for the total household, whereas, Tamil Nadu, with the lowest average household size (3.85) spent Rs.3.81 on fuel and light, which was totally Rs.14.67. Though there is not much difference in the per capita amount spent on energy and the per capita total consumption expenditure, there is a vast difference in the total expenditure on energy because of the big difference in the family size. Similarly, in case of very high group as well, the total amount spent on energy showed a big difference, with Rs.13.06 for Manipur and Rs.109.94 for Pondicherry. Same trend was observed for the urban areas as well and for the 38th round also.

8.10 CONCLUSION

The data used for the study thus, is based on the four main rounds on consumer expenditure and consumption of items of fuel and light. The NSS information is both quantitative and qualitative in scope. The data is used in the present study to study mainly two main issues -

i) to establish an energy - ladder for the urban and rural areas of the country. The energy - ladder will show the most preferred fuels for both the rural and urban areas. This would have taken into account the availability, income levels, and family size parameters,

ii) to see the rural - urban differences in the total consumer expenditure and the share of fuel and light out of the total and show with the help of Engel Curve analysis, that as the income increases, the increase in the expenditure on fuel and light is at a lower rate.

The detailed methodology used for carrying out the above mentioned work is given in the following chapter.

IX

METHODOLOGY AND THEORETICAL ASPECTS

9.0 INTRODUCTION

In the previous chapter, the data, sources and analysis was discussed. This chapter deals with the methodology used for the various calculations and the types of regressions establishing the energy ladder concept. For the present study, OLS (Ordinary Least Squares) method is adopted for testing the suitable specifications of regression equations. An attempt is made with Engel Curve Analysis to estimate the variation in fuel and light expenditure for changes in the income (total expenditure). The study will attempt to establish the existence of Engel Curve to support the Energy Ladder concept.

9.1 REGRESSION ANALYSIS

In the present study, three sets of regression calculations have been done, with different sets of variables. The three sets of equations are -

1) Fuel & Light = a + β Total Expenditure
2) Fuel = a + β Fuel & Light
3) Fuel & Light = a + β Total Expenditure + γ Family Size

Each of the **three** sets of regressions were tried with six different specifications. The specifications tried were -

1) Linear : $F\&L = a + \beta \, TE$

2) Log Linear : $\log F\&L = a + \beta \log TE$

3) Semi Log : $\log F\&L = a + \beta \, TE$

4) Semi Log : $F\&L = a + \beta \log TE$

5) Inverse : $F\&L = a + \beta \, TE + \gamma \, 1/TE$

6) Quadratic : $F\&L = a + \beta \, TE + \gamma \, TE^2$

where, F&L is Fuel and Light, and TE is Total Expenditure.

The regressions have been carried out for rural, urban areas, and a combination of the two as Total (Rural + Urban) areas. Thus each regression set was carried out with six specifications and for rural, urban and total. The data used here has been explained. The analysis was done for 4 rounds of NSS for 15 states (15 x 4 = 60 observations). This was carried out by pooling cross section data by the respective rounds.

The method used for carrying out the regressions was the OLS (Ordinary Least Squares) method, with the six specifications mentioned above. In case of the first set of equations, Fuel and Light is taken as a dependent variable, and the independent variable being the total expenditure (here, total expenditure is assumed to be same as total income) or total expenditure. In the case of second set of regression equations, consumption of particular fuels are taken to be dependent on the total expenditure on fuel and light by a particular household. For the third set, the expenditure on fuel and light is taken according to four expenditure (or income) categories (which differ from round to round, as seen earlier). The expenditure on fuel and light is taken to be not only dependent on the total expenditure, but also on the size of the family (that is, the average number of members in a particular household).

The size of the family has been included in the case of the regressions with income / expenditure categories because there are distinct differences in the family size of the lowest and the highest categories. It has been found that the lowest income groups tend to have larger families than compared to those of the higher income groups. The per capita expenditure on fuel and light and its corresponding total consumption expenditure, with the given household size will be used to observe the impact of the household size on the expenditure patterns on fuel and light. As was observed in the previous chapter, the household size makes a significant impact on the amount of money spent on fuel and light.

9.2 ENERGY LADDER

In this context of income categories, the concept of Energy Ladder is introduced. The concept of energy ladder, as seen earlier, states that with the increase in income of a household, there is a shift from lower quality fuels to higher quality fuels. The qualitative difference in fuels is on the basis of price, energy output, and efficiency. The fuels at the lower 'rungs' of the energy ladder are the traditional 'gathered' fuels like twigs, fuelwood, agricultural wastes, cow dung, etc. Then comes coal, charcoal, and kerosene. Higher up in importance and demand comes LPG and natural gas (not used in domestic sector in India), and finally at the top of the ladder is electricity. In India, electricity is used extensively for lighting only. The use of electricity for cooking is negligible and is limited to very high income groups, which is not taken into account in the present study.

The second and third set of regression equations are carried out to observe the presence of an energy ladder in the context of India, using the NSS data. The family size is taken into account in the case of the third set of equations as with the increasing in the number of family members, the expenditure on items like food assumes more importance, and energy is directly linked to the category of food, as most of the energy consumed is for cooking. As the income / expenditure per household increases, there is proportionately less amount out of the total income spent on energy. Another feature which can be observed from the different rounds of energy consumption data is that there is a decline in the usage of traditional fuels in the higher expenditure class and more of kerosene, LPG and electricity is used. This trend is more obvious in the urban areas. This change is visible in the estimated second and third sets of regressions.

9.3 ENGEL CURVE ANALYSIS

Consumer surveys like the NSS surveys are mainly concerned with the direct observation of the economic behaviour of households of varying social and economic conditions. The main usage of the data in econometrics is for the estimation of income elasticities of particular commodities. In this context, the Engel curve studies the relation of any category of expenditure to income in a cross-section sample of households of varying income levels. Thus, the relation of any characteristic of consumer behaviour to the consumer's income, *ceteris paribus*, is studied in Engel Curve Analysis. Since most of the data on consumer behaviour is to be found in household surveys, Engel curves are specifically identified with the relations that emerge from the analysis of household surveys.

The term Engel Curve derived its name from German statistician Ernst Engel. One of his major conclusions was that food expenditure increases with income, but at a lesser rate, that is, food demand is inelastic with respect to income. This is called Engel's (first) law, which is found to be still valid.

For the present study, instead of the income data (income categories), total expenditure (TE) is used. The estimates derived, thus would be called total expenditure coefficients, and not income coefficients. In terms of elasticities, the difference between the two is slight, as the elasticity of total expenditure in respect of income is usually close of unity. Thus, Engel curves studies the effect of income on consumer behaviour in respect of distinct commodities or expenditure categories, and the presence of a particular commodity in a household's budget is an attribute of the household concerned.

Consumer demand for any good depend upon the income of that consumer (or household), its price and prices of other commodities. The Engel curve is concerned with the issue of how *sensitive* is demand for a good to changes of income on the one hand, and prices on the other. The most direct measure of the sensitivity of a consumer's purchase of a good X to changes on income (I) would be the ratio . For small changes Ax and ΔI, this ratio can be interpreted as the slope of the Engel Curve. This can be written as the derivative $\frac{\quad}{\partial I}$, where 5 is partial effect of varying one of the underlying parameters with all other variables held constant.

At very low incomes, consumption is restricted to a small number of goods; as income increases, new commodities enter the household consumption basket. At and near 'threshold income' (a level where a large variety of goods are available to a household, and at which level the household or individual adds a commodity concerned to his budget), the commodity in question is a luxury which is just coming within the consumer's reach. At this stage, when the income continues to rise, expenditure will at first continue to rise steeply. But the expenditure on this good (which is entering the budget) will be affected in the same as it is succeeded by other newly introduced goods. Because of this, the slope of the Engel curve will decline with increasing income until it becomes zero at the stage of saturation. An average Engel curve thus would assume the shape of the letter 'S' as shown in the Fig. 9.1.

Expenditure↑

Income

Fig. 9.1 - An Average Engel Curve

At this level, after the demand for a commodity has reached saturation, expenditure may continue to rise as highly priced varieties are substituted for the cheaper kind (the concept reflects the idea behind Energy Ladder). It depends on the commodity classification how this affects the Engel Curve.

As an example of the above mentioned Engel curve analysis, here, data for the 28th round of NSS for two states, namely Gujarat and Haryana is taken. In the table, TP represents Total Persons per household, which is an average figure, FL is the per capita amount spent per month for Fuel and Light, and TCE is the Total Consumption Expenditure per capita, for one month, for different expenditure classes.

Table 9.1

Gujarat - 28th Round - Rural

MPCE-CL.	TP	FL	TCE
0-43	6.52	5.29	57.18
43-100	5.24	9.71	140.04
100-200	4.16	**12.94**	246.72
200 & AB	.09	14.53	443.58

Haryana - 28th Round - Rural

MPCE-CL.	TP	FL	TCE
0-43	6.83	5.74	56.86
43-100	6.19	9.90	140.48
100-200	5.35	13.06	247.51
200 & AB	4.65	16.03	397.58

- MPCE-CL. - Marginal Per Capita Expenditure - Class

In both cases, it can be seen that in the lower-income group (Rs. 0-43 class), the family size is largest and with the increase in the household income (or expenditure) the number of persons per household is decreasing. This sociological feature is an important aspect of the vicious cycle of poverty, that the poorer the household, the more the family members and, more the family members, the relative poverty is more. As seen in the Engel curve analysis, in case of per capita expenditure on fuel and light, there is an increase in the expenditure, but at a decreasing rate. The rate of increase, from the lowest category onwards is, for Gujarat, Rs. 4.42, Rs. 3.23 and Rs. 1.59, and for Haryana, it is Rs. 4.16, Rs. 3.16, and Rs. 2.97. Thus it can be clearly seen that with the increase in income, the expenditure on a particular commodity increases with a decreasing rate. If a graph is drawn with the data on fuel and light on Y axis and MPCE classes on X axis, we will get a curve which is very steep and if further data on expenditure is available, and with the trend, the curve may become backward bending.

Based on the above estimation the regression equations have been calculated for linear, logarithmic, and for semi-log forms.

9.4 ELASTICITIES

Elasticity is a measure of relationship in which the changes in both numerator and denominator are expressed in proportionate or percentage terms. In the case of the present study, the elasticities are calculated for the relationship between expenditure on fuel and light and total expenditure for one set and for the other (second set of equations), the relationship between the expenditure on different fuels and total expenditure on fuel and light. The elasticities are calculated only for the linear equations. The formula used for calculating the elasticity is as follows :

where, b is the derived (calculated) coefficient of the independent variable, and X is the mean of the independent variable and Y is the mean of the dependent variable in a regression equation like Y = a + bX + u.

9.5 CONCLUSION

All the sets of regression equations were calculated using the simple Ordinary Least Squares (OLS) method. An attempt was made to study the relation between the income (or expenditure) and the expenditure on the item - fuel and light. An attempt was also made to study the relation between the different fuels and the total expenditure on fuel and light.

All the sets of regression equations was tried with six above mentioned specifications. Three types of equations - for rural, urban and total areas of all India, was calculated. An attempt was also made to study whether Engel curve analysis holds good in case of expenditure on fuel and light and income (taken as total expenditure). Elasticities were also calculated for the linear equations to see the relation between the independent variable (total expenditure or total expenditure on fuel and light) and the dependent variable (expenditure on fuel and light or different fuels).

The results of the regressions, and the elasticities are presented in the following chapter.

X

ANALYSIS OF RESULTS

10.0 INTRODUCTION

The regression results are given in three sections, according to the three different types of equations tried, as mentioned in the previous chapter. The three different sections of equations were tried to bring out the different aspects of fuel and light consumption out of the total consumer expenditure. In the first set of regression equations, Fuel and Light is taken as a function of Total Expenditure. In the second set, consumer expenditure on four main types of fuel, namely, coke, fuelwood, kerosene and electricity is taken as a function of total expenditure on fuel and light. In the third and final set of equations, total expenditure on Fuel and Light is taken as a function of total consumption expenditure and average size of the family. This is taken for four income categories separately. Though the Total Consumption Expenditure by MPCE (Monthly Per Capita Expenditure) categories for each of the rounds was given for 13 categories (including All Categories together), for the sake of convenience and to observe the fuel and light expenditure out of the total expenditure, per expenditure block, rather than for small differences in expenditure.

The regression results reported are only **the** ones which were found to be good equations and were significant. Though six functional forms were tried for the three sets of equations, only double-log and semi-log in case of all the sets of equations are reported, and for the third set, double-log, and semi-log are reported, for two rounds. All the other regression equations tried and not reported here are given in Appendix D, at the end of the thesis.

10.1 FUEL & LIGHT - A FUNCTION OF TOTAL EXPENDITURE (4 ROUNDS)

1. <u>RURAL - LOGARITHMIC</u> - In the following equations, the number of observations were 60, and the degrees of freedom was 58. In the equations below, which is for rural areas, all India, state-wise, the coefficient on Total Expenditure (TE) which also represents the elasticity of expenditure on Fuel and Light with respect to Total Expenditure, indicates that it has decreased in the 32nd round from the 27th round, but increased again in the 38th round, followed by a decrease in the 44 th round. The elasticity is highest in the year 1973-74 (27th round), and the lowest in the

TABLE 10.1

RURAL - LOGARITHMIC : LOG **FL** = a **+** β LOG **TE**

ROUNDS -	**27**	**32**	**38**	**44**	**4 COMBINED**
a	-0.7186	-0.2613	-0.2645	0.4809	-1.4205
	-2.9610	*-0.4489*	*-0.1547*	*2.3499*	*-8.6810*
β	0.6755	0.4854	0.5954	0.2844	1.1262
	4.6073	*1.5661*	*0.7208*	*3.1254*	*13.5603*
R^2	0.5910	0.1587	0.0384	0.3518	0.7561
D-W	2.4857	2.5304	2.2784	1.6836	2.1506

(The numbers in the italics are computed **t-values**. Generally a value of t greater than 2 is taken as statistically significant at 5 % level).

year 1987-88 (44th round). This implies that the responsiveness to fuel and light expenditure for changes in overall total expenditure is high in the beginning years, and decreased later years. This supports the Engel curve analysis, implying that the proportion spent on a commodity increases at a decreasing rate, and ultimately decreases over time. This also supports the Engel curve analysis as done by Assimakopolous and Domenikos [1991] for Greece.

In the regression equations, given in Table 10.1, the R is very poor for the 38th round, but it is reasonably high for the 27th and 44th rounds, being a cross-section data, the R are not expected to be too high. The result of low R^2 was experienced by the studies done by Assimakopolous and Domenikos [1991] and Hutton [1984], where cross-sectional data was used. The R ranged between 0.43 and 0.709 in case of study by Assimakopolous and Domenikos and between 0.015 and 0.47 by Hutton. From the statistical point of view, the regression coefficients are significant at 5 % level for the 27th round and 44th rounds. The regression equations above show that the amount spent on fuel and light out of total has more or less decreased over time.

2. **URBAN - LOGARITHMIC** - The regressions below, given in Table 10.2, are for state-wise urban areas. In the case of urban areas, unlike the rural areas, it was found that the coefficient on TE (elasticity of expenditure on F&L with respect to TE) increased steadily from 27th round to the 44th round. The elasticity being

highest for the 4 rounds combined, when it was elastic (> 1) with 1.1039. This implies that there is high responsiveness to F&L expenditure for changes in overall TE in the urban areas.

TABLE 10.2

URBAN - LOGARITHMIC : LOG **FL =** a **+** β LOG **TE**

ROUNDS -	**27**	**32**	**38**	**44**	**4 COMBINED**
a	0.5388	-0.4150	-1.2135	3215	-1 .4241
	0.5216	-0.6914	-2.2168	-4.7926	-15.2702
ft	0.0192	0.5755	1.0204	1.0648	1 .1039
	0.0334	1.9269	4.1251	2.4884	25.0996
$\bar{R}^2$		0.1623	0.5336	0.4438	0.9142
D-W	2.3440	2.8440	2.5050	0.6474	1.9451

This proves that in the urban areas, an increase in TE (or income of a household) will result in the purchase of better or efficient fuel. It is expected that from one round to the next, from 1973-74 (27th round) to 1986-87 (44th round) the incomes would increase and with development, the fuel availability and types of fuels at the disposal of a household also would go up. Thus, with an increase in income in the urban areas, there is a tendency for spending more on F&L out of TE by a household. In the equations for urban areas the equation for 4 rounds combined had the highest R^2 with 0.9142, and from the statistical point of view, the coefficients of 32, 38 and 44 rounds, and 4 rounds combined are significant at 5 % level of significance. Thus for the urban areas it was found that fuel and light forms an important part of the total expenditure.

3. **TOTAL - LOGARITHMIC** - For the equations on total India, the

data for rural and urban areas was added round-wise separately. The regression equations in Table 10.3, for 27th to 44th rounds for total India show that the coefficients increase steadily from the 27th round, when the coefficient or elasticity was 0.5512 to 38th round with 0.9736. The 44th round showed a slight decrease in the elasticity of F&L expenditure out of TE with 0.9548. The coefficient for 4 rounds combined showed that the F&L expenditure was elastic with respect to TE, with 1.1297. It shows that in the case of all India expenditure patterns on F&L out of TE, there was an increase on F&L expenditure for the first three rounds, but for

TABLE 10.3

TOTAL - LOGARITHMIC : LOG FL = a + β LOG TE

ROUNDS -	27	32	38	44	4 COMBINED
a	-0.3219	-0.4919	-1.0991	-1.0369	-1.5046
	-0.4507	-0.6832	-2.1190	-1.4214	-16.4278
β	0.5512	0.6637	0.9736	0.9548	1.1297
	1.5681	2.0759	4.5974	3.4644	29.0586
R^2	0.0944	0.1912	0.5899	0.4400	0.9346
D-W	2.3809	2.8367	2.8446	2.1743	2.2005

the 44th round it registered a slight decrease, possibly because a saturation point may have been reached as far as F&L expenditure is concerned. Statistically, the t-values of 32, 38, 44th rounds and 4 rounds combined were found to be significant at 5 % level. The R is very good for the 4 rounds combined equation, but for other rounds, it was low, but being cross-section data, it is expected. The R^2 in this case, ranges between 0.0944 and 0.9346. These regression equations more than the rural and urban separately explains the elasticity of fuel and light expenditure out of total expenditure, where it registered an increase during the first three rounds and more or less remained the same in the last round.

4. **RURAL - SEMI-LOG** - One of the functional forms tried was for semi-log with Log FL = a + β TE. It is one of the alternative methods for studying influence of income on consumption of commodities, as a classical method for the analysis of household budgets, as was done by Assimakopolous and Domenikos [1991]. In the case of rural areas, for 4 rounds and 4 rounds combined,

TABLE 10.4

RURAL - SEMI-LOG LOG FL = a + β TE

ROUNDS -	27	32	38	44	4 COMBINED
a	0.1435	0.4694	0.7473	0.8479	0.2880
	2.4889	3.6825	2.1902	16.6432	6.2725
	0.0055	0.0023	0.0019	0.0015	0.0046
	4.5425	1.4595	0.6545	5.3126	12.1764
Elasticity	0.2534	0.1782	0.2259	0.2748	0.4894
R^2	0.5838	0.1408	0.0319	0.6604	0.7140
D-W	2.4724	2.4981	2.2765	2.1557	1.7679

the expenditure on F&L as shown in Table 10.4, decreased from 27th round to the 44th round though the coefficient for the 4 rounds combined showed an increase. The corresponding elasticities show that for all the rounds, the F&L expenditure was inelastic out of TE. For the 27th round the elasticity was 0.253, which reduced to 0.1782 for the 32nd round, and increased for the next two rounds. The elasticity for 4 rounds combined was 0.4894, meaning that overall, an increase in TE will result in less than proportionate increase in F&L expenditure. The 27th, 44th rounds and 4 rounds combined are statistically significant at 5 % level of significance and the R range between 0.0319 (38th round) and 0.7140 (4 rounds combined). The trend of decreasing elasticity of TE for F&L expenditure follows that which was observed in the case of rural double-logarithmic case as well. The regression equations shown in Table 10.4 show that F&L expenditure was inelastic for all the rounds, that is, an increase in the total expenditure brings about an increase which is less than proportionate than the increase in total expenditure.

5. URBAN - SEMI - LOG - In the case of urban areas, as can be seen in Table 10.5, the coefficients for 27th, 32nd and 38th rounds increased from the previous rounds, but register a decrease once again for the 44th round, with the maximum being once again for 4 rounds combined. For the urban areas, the elasticity increased form 0.00312 for 27th round to 0.2269 in the 32nd round,

TABLE 10.5

RURAL - SEMI-LOG LOG FL = a + β TE

ROUNDS -	27	32	38	44	4 COMBINED
a	0.5398	0.5138	0.5919	0.7931	0.4047
	2.2236	3.9635	5.4966	6.03 5	16.1728
	0.0005	0.0022	0.0028	0.0017	0.0034
	0.1387	1.7732	4.2183	3.4958	22.4009
Elasticity	0.0312	0.2269	0.4588	0.4439	0.5020
R^2	0.0015	0.1328	0.5454	0.4446	0.8946
D-W	2.3354	2.8713	2.5519	2.6361	1.7277

and further increased to 0.4587 for the 38th round, but decreased marginally to 0.4439 for the 44th round. The elasticity for the 4 rounds combined was highest with 0.5020. The t-values are significant at 5 % level of significance for the 38th, 44th rounds, and for 4 rounds combined. The $\bar{R}^2$ again was highest for the 4 rounds combined with 0.8946. The increase in the share of expenditure on F&L out of TE was also observed in the double log form. This proves that with better facilities being available and with increasing incomes of urban households, there is an increase in the amount spent on fuel. This is because the usage of better fuel being more efficient and more convenient for the relatively faster paced life styles of the urban households. Thus, more efficient fuel will leave more time for other economically beneficial activities. The elasticities reveal that the F&L expenditure increased over time in the urban areas, possibly because of a desire to buy more efficient and convenient fuel and also because of better purchasing power of the people.

6. **TOTAL - SEMI-LOG** - In the total semi-log for all India, once again the elasticities of all the rounds was found to be inelastic. The elasticity of TE increased from 0.2278 in the 27th round to 0.2709 in the 32nd round and further increased to 0.4241 for the 38th round. For the 44th round there was a decrease to 0.3999, and for the overall 4 rounds combined, the elasticity was maximum, at 0.5081. In all the cases, shown in Table 10.6, the coefficients are inelastic (that is, < 1). This means that any increase in TE will result in less than proportionate increase in

TABLE 10.6

TOTAL - SEMI-LOG LOG **FL** = a **+** β **TE**

ROUNDS -	**27**	**32**	**38**	**44**	**4 COMBINED**
a	**0.5699**	0.7362	**0.8698**	1 0784	0.6317
	4.0836	5.4129	**9.6220**	9.0605	25.9191
β	**0.0021**	0.0015	**0.0015**	0.0009	0.0020
	1.6505	1.9821	**4.6225**	3.4536	23.5823
Elasticity	0.2280	0.2709	0.4241	0.3999	0.5081
$\bar{R}^2$	0.1096	0.1730	0.5926	0.4784	0.9039
D-W	2.3861	2.8351	2.9183	2.**1813**	1.6346

the expenditure on F&L. The R again is found to be highest for the 4 rounds combined, and ranged between 0.1096 (27th round) and 0.9039 for 4 rounds combined. The R^2 has been high consistently for the 4 rounds combined in all the cases and was found to be low in case of individual rounds. This is the econometrics criteria. For the total also, like the case of urban areas, there is **an** increase in the elasticity over the rounds, meaning F&L was an important part of the household budget and it is one on of the main consumer items.

10.2 FUEL - WISE ESTIMATION

The following set of equations **are** for individual **fuels (4** fuels) out of total expenditure on Fuel and Light. Four fuels, coke, **fuelwood, kerosene and electricity were** chosen. The reason for selecting **these** particular four fuels out of around 10-12 fuels available in NSS was because of two main reasons. Firstly, coke **and** fuelwood are fuels which are **mainly** used by the **rural** households, for cooking exclusively. Even in some sections of urban areas, coke and fuelwood is used, which again is for cooking exclusively. These fuels are never used for lighting. On the other hand, kerosene is used and can be taken as a 'transitional fuel', which is not only used for lighting, but is also used extensively for cooking, both in the rural and the urban areas. It can be found near the mid - way point of the energy ladder for both the rural and the rural areas.

Whether the move is from coke to fuelwood to LPG, or from fuelwood to LPG to electricity, for the rural and urban areas, respectively, kerosene forms the 'middle rung fuel'. Secondly, kerosene is used both for cooking and lighting; and electricity is used almost exclusively for lighting. Thus, there are two fuels (coke and fuelwood) which are used only for cooking, one fuel (kerosene) which is used for both cooking and lighting, and one fuel (electricity) which is used only for lighting. Thus, any changes in the coefficients (or elasticity) will show how the expenditure patterns have changed over the course of 3 rounds and what the combined effect is, which is captured by the 3 rounds combined equation. Whether the fuel used for cooking is more important or the fuel used for lighting is assuming more importance can be captured by these equations. In the second set of equations, only three rounds are taken into consideration, they are 27th, 32nd and 38th rounds, and 3 rounds combined. The data is again for the rural and urban areas, and all India, (rural + urban) combined.

1. **COKE - LOGARITHMIC - RURAL** - In the all India rural areas, for the 27th round, shown in table 10.7, the elasticity of F&L for coke was negative, meaning that any increase in the F&L expenditure would lead to a negative increase (or decrease) in the amount spent on coke. This could be because of two reasons, either the availability of coke was negligible during the survey period (1973-74), or the price of the fuel was prohibitively high. The coefficient (or elasticity) for the 32nd round increased from the 27th round and was 1.0869 and further increased to 1.9478 during the 38th round. For the three rounds combined, it was 1.0393, meaning that over the rounds, in the rural areas, coke was being preferred and purchased. It also means that fuel availability was also more certain than during the 27th round. Statistically, only the 38th round and 3 rounds combined equations were significant at 5 % level, and $\bar{R}^2$ were low for all the rounds.

TABLE 10.7
RURAL - LOGARITHMIC
LOG FL **(COKE)** = a + β LOG F&L

ROUNDS -	**27**	32	38	3 COMBINED
a	7.9514 1.1971	-9.4242 -1.0434	-4.1063 -1.5325	-7.0699 -1.7959
β	-0.7399 -0.9550	1.0869 1.1113	.9478 3.5395	1.0393 2.4527
$\bar{R}^2$	0.0539	0.0136	0.4041	0.0865
D-W	1.6646	0.9433	1.7083	1.2941

2. **FUELWOOD - LOGARITHMIC - RURAL** - In the case of fuelwood, which is the dominant fuel in the rural areas, the coefficients more or less remained the dame throughout the three rounds, with an

increase from 0.6399 in the 27th round to 0.9174 in the 32nd round, to 0.9330 in the 38th round. The coefficient for 3 rounds

TABLE 10.8
RURAL - LOGARITHMIC
LOG FL **(FUELWOOD)** = a + β LOG F&L

ROUNDS -	27	32	38	3 COMBINED
a	2.7121	0.1761	0.1108	1.0290
	2.5400	0.2549	0.1525	2.3033
ft	0.6399	0.9174	0.9330	0.8344
	5.1382	12.2671	12.8505	17.3506
R^2	0.5991	0.8979	0.9061	0.8499
D-W	2.8622	1.9428	2.1192	2.5740

combined was 0.8344, as shown in Table 10.8. The elasticity of F&L expenditure for fuelwood was inelastic, meaning any change in the F&L expenditure will have less than unitary (proportionate) change on the amount spent on fuelwood. This could be because in the rural areas, to substitute one fuel for another is difficult and irrespective of the changes in F&L expenditure, there always will be some expenditure for fuelwood. Statistically, all the equations are significant at 5 % level of significance, and the R are reasonably good for all the equations.

3. <u>KEROSENE - LOGARITHMIC - RURAL</u> - Like in the case of fuelwood **even** for kerosene, as in Table 10.9, there was an increase from one round to the other. During the 27th round, the coefficient **was** 0.7999, which increased to 1.0897 for the 32nd round, with a further increase to 1.1768 for the 38th round. Thus the expenditure on kerosene out of total F&L expenditure was elastic (that is > 1) and when the three rounds are taken together, it is 0.9949. This positive trend can be attributed to the fact that in the rural areas, the availability of kerosene through the Public Distribution System is having a positive impact on the consumption patterns of the fuel.

TABLE 10.9
RURAL - LOGARITHMIC
LOG FL (KEROSENE) = a + β LOG F&L

ROUNDS -	27	32	38	3 COMBINED
a	-0.1062	-2.7004	-3.6401	-1.8086
	-0.0697	-3.5899	-2.0376	-2.6292
ft	0.7999	1.0897	1.1768	0.9949
	4.5017	13.3773	6.5911	13.4366
$\bar{R}^2$	0.5312	0.9128	0.7140	0.7721
D-W	1.6568	1 5083	1.4357	1.4735

The fuel is being used more and more, though it's use has not been able to cut out the consumption of fuelwood, mainly because it is a purchased fuel, and fuelwood is mainly a gathered fuel. Another reason may be because, kerosene is out of the reach of many rural households, especially to be used as a cooking fuel. The use of this fuel is mainly for lighting in the rural areas. But with massive rural electrification programme, this trend may change in **the** future survey rounds. All the equations are significant at 5 **% level of** significance and the R are also relatively good, which range between 0.5312 (27th round) and 0.9128 (32nd round), despite **the** cross-section data.

4. **ELECTRICITY - LOGARITHMIC - RURAL** - In Table 10.10, for

electricity, the coefficient for total F&L expenditure during 1973-74 (27th round) was 0.3475, which increased during the 32nd round (1.5892), but decreased to 0.4750 in the 38th round. The coefficient or the elasticity for three rounds combined was elastic (that is, > 1) with 1.2920. This trend for electricity could be because in the beginning, when the rural electrification

TABLE 10.10
RURAL - LOGARITHMIC
LOG **FL (ELECTRICITY) =** a **+** β LOG **F&L**

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	0.0999	-9.4955	1.9613	-6.9643
	0.0153	-2.9850	0.8633	-2.7595
β	0.3475	1 5892	0.4750	1.2920
	0.4577	4.6137	2.0922	4.7559
$\bar{R}^2$	0.0129	0.5441	0.1657	0.2897
D-W	1.6845	1 6087	1.9035	1.5919

programme was launched, the connections were limited to 'single-bulb' connections, and later it was increased, and was used on a large scale for agricultural purposes. But the usage of electricity by the household sector is limited completely to lighting in the rural areas, and that too because of the high cost of the appliances and getting the connections (the cost of the fuel is firstly less compared to other fuels, secondly, a major number of the connections are 'illegal connections so, the payment is almost nil). All the equations except for 27th round were statistically significant at 5 % level, and R^2 is again low compared to fuelwood or kerosene.

5. **COKE - LOGARITHMIC - URBAN** - In the urban areas, shown in Table

10.11, consumption or expenditure for coke first increased in the 32nd round from 0.4257 in the 27th round to 0.9778, but declined to 0.6375 during the 38th round. This could be because coke remains to be used by the poorer households along with fuelwood and kerosene, for cooking. With the increasing availability and increasing cost of other fuels, coke still remains an important

TABLE 10.11
URBAN - LOGARITHMIC
LOG **FL (COKE) =** a **+** β LOG F&L

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	1.4723	-3.1509	0.3057	-0.1257
	0.8622	-1.2402	0.2160	-0.1230
ft	0.4257	0.9778	0.6375	0.6503
	1.6886	3.0736	3.9842	5.0369
$\bar{R}^2$	0.0982	0.3320	0.4666	0.3150
D-W	1.6321	1.5613	1.6111	1.6489

fuel, though it is inelastic when the three rounds combined is taken where it is 0.6503. The coefficients for 32nd, 38th rounds and 3 rounds combined are statistically significant at 5 % level and the R^2 ranged between 0.0982 and 0.4666.

6. **FUELWOOD - LOGARITHMIC - URBAN** - Like coke, even in the case of fuelwood, in Table 10.12, the coefficients first increased for the 32nd round and then decreased in the 38th round. This again may be because of the reduced availability of fuelwood due to the depletion of forest resources in and around urban areas [Bowonder, Prasad and Unni; 1989]. The high cost of the fuel when seen in the view of the efficiency and convenience of use, it acts as a deterrent to its wider usage in the urban areas, where a number of

TABLE 10.12

URBAN - LOGARITHMIC

LOG **FL (FUELWOOD) = a +** β LOG **F&L**

ROUNDS -	27	32	38	3 COMBINED
a	4.2219 5.2497	2.9718 4.7811	4.1459 6.5908	3.6142 9.0481
ft	0.3138 2.6427	0.5219 6.7066	0.4138 5.8176	0.4445 8.8055
R^2	0.2604	0.7212	0.6589	0.5909
D-W	2.0765	1.7044	2.1249	2.2056

alternative sources of energy are available. Statistically, all the equations are found to be significant at 5 % level of significance and the R are relatively high for all the rounds (equations).

7. **KEROSENE - LOGARITHMIC - URBAN** - In case of kerosene, the 'transitional fuel', the coefficient remained more or less same through all the rounds, as can be seen from Table 10.13. Kerosene is used both for lighting and cooking purposes. the elasticity of F&L for kerosene remained inelastic (<1) when 3 rounds combined is

TABLE 10.13

URBAN - LOGARITHMIC

LOG **FL (KEROSENE) = a +** β LOG **F&L**

ROUNDS -	27	32	38	3 COMBINED
a	2.69603 3.28375	1.9261 2.9551	2.6842 3.5326	2.1677 5.0715
ft	0.42741 3.52562	0.5901 7.2299	0.5325 6.1975	0,5579 10.3293
$\bar{R}^2$	0.40204	0.7510	0.6876	0.6660
D-W	1.62413	2.4121	3.3076	2.1078

taken, which was 0.5579. It means that an increase in F&L expenditure may not result in a proportionate increase in consumption of kerosene. This is so because there may be an increase in the purchase of other fuels (shifting to other fuels). All the equations are statistically significant at 5 % level and $\bar{R}^2$ are relatively high for all the equations.

8. **ELECTRICITY - LOGARITHMIC - URBAN** - The usage of electricity is mostly limited to lighting though it is used for household appliances (like refrigerators, coolers, washing machines, etc.) in the higher income households. As seen in Table 10.14, the elasticity of expenditure for electricity out of total F&L is inelastic for 3 rounds combined (0.5044), which means that there must be some amount of expenditure on electricity irrespective of the cost but an increase in the expenditure on the F&L may not result in a proportionate increase in the amount spent for

TABLE 10.14
URBAN - LOGARITHMIC
LOG **FL (ELECTRICITY) =** a **+** β LOG **F&L**

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	7.2610	5.8801	8.2372	6.9013
	8.5800	8.7763	8.7404	14.6803
(3	0.4124	0.6163	0.3928	0.5044
	3.3002	7.3458	3.6859	8.4899
R^2	0.3678	0.7570	0.4254	0.5728
D-W	2.3457	2.32363	2.1373	2.1222

electricity. Once again, all the equations are statistically significant at 5 % level of significance and the R are relatively high for all the equations.

9. **COKE - LOGARITHMIC - TOTAL** - The regression equations for 'total' once again is a combination of rural and urban areas,

TABLE 10.15
TOTAL - LOGARITHMIC
LOG **FL (COKE)** = a + β LOG F&L

ROUNDS -	27	**32**	38	**3 COMBINED**
a	-3.5609	-12.2366	-5.5381	-6.9214
	-1.0118	-2.3436	-2.1137	-3.4273
	0.9465	1.7793	1.1633	1.2807
	2.3835	3.2488	4.5883	6.0849
	0.2159	0.3598	0.5412	0.4047
D-W	1.2304	] 4788	1.4293	1.4771

round-wise, all India, state-wise. In case of coke, in Table 10.15, the coefficient increased from 27th round to 32nd round, then decreased for the 38th round. The coefficient or elasticity of F&L expenditure for coke in total India was elastic (> 1) with 1.2807. This means that given the present situation of availability and cost, coke still remains a preferred fuel - over fuelwood, as can be seen from the next equations. All the equations are significant at 5 % level of significance. The R are low, but it is expected because of cross-section data.

10. **FUELWOOD - LOGARITHMIC - TOTAL** - From Table 10.16, in the case of fuelwood, it can be seen that the coefficients remained more or less same in all the rounds and for the three rounds combined. It shows that even with the reduced availability and higher cost per calorie of the fuel, it still is demanded and consumed by a major

TABLE 10.16

TOTAL - LOGARITHMIC

LOG FL (FUELWOOD) = a + β LOG F&L

ROUNDS -	27	32	38	3 COMBINED
a	1.1679	0.8850	0.8546	0.8810
	1.4512	1.2235	1.1492	2.4241
β	0.8118	0.8364	0.8496	0.8428
	8.9412	11.0221	11.8077	22.2537
	0.8228	0.8764	0.8906	0.9031
D-W	2.7918	1.8374	2.1079	2.4581

portion of the households. This can be mainly because of the non-availability of other fuels or because fuelwood is still gathered 'free' of cost from the nearby tree-lots. It was 0.8118 in the 27th round, and it registered a slight increase in the 32nd round and 38th rounds. For the 3 rounds combined, the elasticity was 0.8428. The main aspect with regard to the fuelwood consumption is that the inelastic nature did not change drastically over the rounds. Its usage remained more or less the same. All the equations were statistically significant at 5 % level and had very high R , which is exceptional for cross-sectional data.

11. **KEROSENE - LOGARITHMIC - TOTAL** - Like fuelwood, even for kerosene as shown in Table 10.17, the coefficients remained more or less the same through the rounds and the were elastic (> 1) in all the cases. Though there was a slight decrease in the 32nd round from the 27th round (from 1.0930 to 1.0289), it increased to 1.1345 in the 38th round, and, for 3 rounds combined, it was 1.0696. All the equations were statistically significant at 5 %

level of significance with high R for all the equations.

TABLE 10.17
TOTAL - LOGARITHMIC
LOG **FL (KEROSENE) = a +** β LOG **F&L**

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	-2.6209	-2.0161	-3.1335	-2.4271
	-2.3627	-3.6514	-2.3722	-4.9824
β	1.0930	1.0289	1.1345	1.0696
	8.7333	17.7650	8.8752	21.0686
R^2	0.8158	0.9487	0.8206	0.8931
D-W	1.7382	2.0931	1.6480	1.6474

12. **ELECTRICITY - LOGARITHMIC - TOTAL** - As seen from Table 10.18, electricity experienced some ups and down with a decrease in the coefficient in 32nd round from 1.3488 in the 27th round to 1.1270. In the 38th round, it decreased further to 0.8852 and became inelastic. But the overall 3 rounds combined figure is elastic with the elasticity 1.1252, meaning that over the rounds combined an increase in the expenditure on total F&L will result in more than proportionate increase in the amount spent for electricity.

TABLE 10.18
TOTAL - LOGARITHMIC
LOG **FL (ELECTRICITY) = a + *ft* LOG F&L**

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	-1.9834	-0.0075	2.5149	0.0144
	-1.1434	-0.0054	1.0537	0.0161
ft	1.3488	1.1270	0.8852	1.1252
	6.8915	7.7618	3.8327	12.0253
R^2	0.7323	0.7770	0.4461	0.7304
D-W	2.0034	2.3540	1.9270	1.9988

Again all the equations were significant statisticallv at 5 % level of significance and the R^2 were relatively high.

10.3 FUEL & LIGHT AND TOTAL EXPENDITURE WITH FAMILY SIZE

To study the energy ladder concept in a different way, where more of energy is consumed or more efficient fuel is demanded if the family size is large, the variable of Family Size is taken. The size of the family plays a very important role in the amount a household spends and the amount of fuel consumed, the type of fuel used and the amount of money spent on fuel. The number of members is a determinant which decides the overall spending patterns of a family. It was observed from the survey data that in the lower income groups, the number of members per family were large compared to the higher income groups.

In the third set of regression equations, F&L is taken as a function of Total Consumption Expenditure (TCE) and the Family Size (FS) of a household. The regressions are calculated for two rounds, 28th and 38th rounds, all India, state-wise. The expenditure patterns is observed under four monthly per capita expenditure (MPCE) categories. The four MPCE categories are, for the 28th round, Rs. 0-43, Rs. 43-100, Rs. 100-200, and Rs. 200 and above; and for the 38th round, Rs. 0-100, Rs. 100-200, Rs. 200-300, and Rs. 300 and above. The regressions are for the rural and urban and for total - all India. Only the logarithmic and semi-log equations are reported in this chapter, other specifications (linear and semi-log) are reported in the Appendix D. To observe the expenditure patterns of a household expenditure for F&L according to the MPCE categories (or income categories), another set of equations without FS was calculated, which is also reported here. For the equations without FS, only the logarithmic equations are reported.

10.3.1 LOGARITHMIC

1. RURAL 28TH ROUND - LOGARITHMIC - In the rural areas, for the MPCE category 0-43, the elasticity of F&L with respect to TCE was elastic, (1.7589), but for the next expenditure category of 43-100, it became negative, meaning that with an increase in total TCE, the amount spent on F&L will not only increase, but also

TABLE 10.19
RURAL - 28TH ROUND (LOGARITHMIC)
LOG **FL** = a + β LOG TCE + y LOG **FS**

MPCE -	0 - 43	43 - 100	100 - 200	200 & ABOVE
a	-4.05459	21.36446	-1.70743	-0.95435
	-2.75779	1.72712	-5.17024	-2.53565
β	1.75895	-4.89265	0.74021	0.47248
	2.18748	-1.64352	6.89385	4.53136
γ	-0.47625	0.25829	-0.11398	0.28469
	-0.80152	0.68801	-0.68749	1.48696
$\bar{R}^2$	0.61928	0.03932	0.95319	0.97117
D-W	1.40796	1.28275	1.56287	2.12631

actually decrease, as can be observed from Table 10.19. This may be due to various reasons like for that category, increasing the expenditure on F&L may not be as necessary as increasing the expenditure on items like food, or clothing, etc. On the other hand, if the next category (100-200) is taken, then though the elasticity of F&L out of TCE is inelastic, it is better than the previous category. This means that an increase of 1 % in TCE would bring about a 0.74 % increase in the amount spent on F&L, for the income category of 100-200. For the next category of 200 and Above, the elasticity is again inelastic (< 1), meaning any increase in the total expenditure will bring about a less than proportionate change in the amount spent for F&L. Family size, for the 28th round, rural areas did not show any significance, that is, family size did not appear to make a difference in the TCE of the particular expenditure categories.

The elastic nature of F&L expenditure may be because, for the lower income classes, fuel forms a major part of their household budget. On the other hand, with the increase in income, other commodities like food to some extent and other luxurious items are more important. The t-values for the coefficients of TCE, for the categories 0-43, 100-200 and 200 and Above are significant at 5 % level, and none of the t-values for FS are significant. R^2 is relatively good for all the categories except for the 43-100 category.

2. **URBAN - 28TH ROUND - LOGARITHMIC** - In the case of urban areas, for the category 0-43, F&L expenditure is highly elastic (1.5164) out of TCE. Meaning that a 1 % increase in TCE will bring about a 1.516 % increase in the amount spent on F&L. Thus in the urban

TABLE 10.20 URBAN - 28TH ROUND (LOGARITHMIC)

$$\text{LOG } FL = a + \beta \text{ LOG } TCE + \gamma \text{ LOG } FS$$

MPCE -	0 - 43	43 - 100	100 - 200	200 & ABOVE
a	-3.34852	0.22806	-1.60719	-1.70126
	-11.05392	0.02149	-1.44615	-3.36261
3	1.51640	0.23705	0.82860	0.74254
	9.26006	0.94451	3.59201	6.45546
γ	-0.48103	0.14533	-0.44023	-0.10446
	-4.08821	0.49719	-1.46423	-0.49912
$\bar{R}^2$	0.92988	0.01222	0.33921	0.93415
D-W	2.11486	2.23660	1.25346	1.99849

areas, for 0-43 category F&L is highly responsive to any increase in TCE. In case of the category of 43-100, the elasticity is inelastic, but it again increases for the higher income category, though it still is inelastic. For the final category, the elasticity again goes down. This again proves that for the lower income level households, fuel and light assume greater importance and take a larger portion of the total income (expenditure) than compared to the households of higher levels income. In the case of urban areas again, the none of the coefficients for FS were significant, except for the 0-43 category. All the coefficients for TCE (except for 43-100 category) were significant at 5 % level of significance, and R^2 was relatively lower compared to the rural areas, but this is to be expected, as the data is cross-sectional data.

4. **RURAL - 38TH ROUND - LOGARITHMIC** - In case of the 38th round, the categorization was slightly different than that for 28th round. The categories were, 0-100 (low), 100-200 (medium),

200-300 (high) and 300 and above (very high). In case of the elasticity of F&L with respect to TCE, as given in Table 10.21, for the low category it was inelastic (0.5651), but it decreased and became negative in the case of medium category. For the category of 200-300, it became not only positive, but also became elastic (that is, > 1) with 1.363, meaning any increase in TCE will result in more than proportionate increase in the amount spent on F&L. For the very high category, again the elasticity was inelastic, meaning at higher expenditure group, less percentage of the total is spent on F&L. With respect to the coefficients of FS, it was found that, in the case of the first category, an increase in F&L will mean that if the family size does not increase proportionately, that is if the family size is

TABLE 10.21
RURAL - 38TH ROUND (LOGARITHMIC)
LOG **FL = a + 8** LOG TCE **+** γ LOG **FS**

MPCE -	**0 - 100**	**100 - 200**	**200 - 300**	**300 & ABOVE**
a	-1.73759	4.44849	-4.42947	0.06820
	-2.55970	0.95141	-0.23230	0.03915
β	0.56511	-0.59643	1.36325	0.44617
	2.76174	-0.62589	0.39477	1.51522
7	0.64907	0.47026	-0.34139	0.03674
	2.35565	1.65843	-1.49304	0.27513
$\bar{R}^2$	0.56566	0.04357	0.02752	0.03714
D-W	1.62445	1.77108	1.46558	2.06133

growing, then the amount spent on F&L also does not grow proportionately. This trend was observed in the case of the next category as well, but for the category of 200-300, it was negative, which was not expected. The reason for the inelastic nature of elasticity for FS may be because, with the increase in family size, the amount of fuel consumed does not increase proportionately, and the average fuel consumption goes down. For example, if an electric light is used in the night times to illuminate the household, it would be used whether the number of members is 2 or 10, hence, the average expenditure for the light comes down if the number of members is more. Statistically, only the first category coefficients were significant at 5 % level of significance, and the R^2 were not very high in the case of regression for rural areas in the 38th round.

5. **URBAN - 38TH ROUND - LOGARITHMIC** - In case of the urban areas as given in Table 10.22, for the 38th round, the elasticity for the first category was inelastic, and it was negative for all the other categories. This means that in the urban areas, at higher

TABLE 10.22
URBAN - 38TH ROUND (LOGARITHMIC)
LOG **FL** = a + β LOG TCE + γ LOG **FS**

MPCE -	**0 - 100**	**100 - 200**	**200 - 300**	300 & **ABOVE**
a	0.20939 0.20871	42.34975 2.50673	40.23405 1.21466	4.32249 1.39495
β	0.15241 0.53861	-8.04929 -2.35792	-6.70562 -1.11513	-0.20020 -0.39286
γ	0.50353 3.76037	-0.07430 -0.25933	-0.40572 -1.27675	-0.04532 -0.20352
$\bar{R}^2$	0.52835	0.14727	0.04619	0.01187
D-W	1.95803	1.30131	1.41364	2.17818

expenditure classes, F&L does not form a major part of the total nature of elasticity for FS may be because, with the increase in family size, the amount of fuel consumed does not increase proportionately, and the average fuel consumption goes down. For example, if an electric light is used in the night times to illuminate the household, it would be used whether the number of members is 2 or 10, hence, the average expenditure for the light comes down if the number of members is more. Statistically, only the first category coefficients were significant at 5 % level of significance, and the $\bar{R}^2$ were not very high in the case of regression for rural areas in the 38th round.

5. **URBAN - 38TH ROUND - LOGARITHMIC** - In case of the urban areas as given in Table 10.22, for the 38th round, the elasticity for the first category was inelastic, and it was negative for all the other categories. This means that in the urban areas, at higher

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URBAN - 38TH ROUND (LOGARITHMIC)
LOG **FL** = a + β LOG TCE + γ LOG **FS**

MPCE -	**0-100**	**100 - 200**	**200 - 300**	**300 & ABOVE**
a	0.20939	42.34975	40.23405	4.32249
	0.20871	2.50673	1.21466	1.39495
β	0.15241	-8.04929	-6.70562	-0.20020
	0.53861	-2.35792	-1.11513	-0.39286
γ	0.50353	-0.07430	-0.40572	-0.04532
	3.76037	-0.25933	-1.27675	-0.20352
$\bar{R}^2$	0.52835	0.14727	0.04619	0.01187
D-W	1.95803	1.30131	1.41364	2.17818

expenditure classes, F&L does not form a major part of the total expenditure, and it may actually go down, as the household may already be using an efficient fuel and an efficient appliance. This is more obvious for the case of the higher income groups, where the households may already be using an efficient fuel with better cooking appliances. Thus in such a case, there will be almost negligible impact on F&L for an increase in TCE. The same was observed in the case of the coefficients of FS. For the first category the elasticity was inelastic, and for the other, it was negative. Statistically, in the case of TCE, only the category of 100-200 was significant at 5 % level, and for FS, the category of 0-100 was significant at 5 % level. $\bar{R}^2$ were not found to be high for any of the equations.

10.3.2 SEMI-LOG

As was observed in the earlier section, semi-log is one of the alternative methods of finding out the impact of income or expenditure on the household budgets and expenditure patterns. In the present set of equations, with family size and expenditure categories, semi-log in the form of Log F&L = a + β TCE + γ FS was taken. The regression equations for the rural and urban areas for 28 and 38th rounds are presented here.

1. **RURAL - 28TH ROUND - SEMI-LOG** - From Table 10.23, it can be observed that in the rural areas for the 28th round, the coefficients for TCE were positive with an elasticity of 1.9060 (elastic) for the first MPCE category, and for the next, it **was**

TABLE 10.23
RURAL - 28TH ROUND (SEMI-LOG)
LOG **FL** = a + β TCE + γ **FS**

MPCE -	0 - 43	43 - 100	100 - 200	200 & ABOVE
a	-1.41326	6.03045	-4.30815	-3.50561
	-4.86574	2.02238	-9.56979	-8.41552
β	0.09785	-0.76116	0.04165	0.17846
	2.69305	-1.64508	11.87093	7.37623
Elasticity	1.90600	-49.82000	5.69500	40.05000
γ	-0.02689	0.05445	0.03875	0.17355
	-0.23752	0.73209	0.71304	1.14164
Elasticity	-0.13690	0.28230	0.14190	0.47700
$\bar{R}^2$	0.63851	0.03915	0.88805	0.86448
D-W	1.25473	1.30261	1.67299	1.92439

negative, with a big negative elasticity, which was not expected. For the third category (100-200), again the coefficients were positive and the elasticity was once again elastic (5.6950), that is, an increase of 1 % in the TCE, will bring about an increase in the amount spent on F&L by 5.69 %. This inordinate increase in the elasticity for F&L out of TCE may be because of the subsistence level of fuel consumption in the rural areas, an increase in the spending capacity (or an increase in household income) may result in the purchase of better fuel. This also depends upon the occupation of the household, and the higher income categories, in the rural areas mostly belong to either the business classes, or salaried class, in which case, the time spent by the household for fuel collection may be small, hence, any increase in income would go for essentials like firstly, food, then fuel, so that more time can be devoted to productive economic activity. This can be observed even for the last category, the very high income category, where the elasticity is a phenomenal

40.05. Statistically, all the coefficients of TCE, other than the second category (43-100) showed significance at 5 % level. Regarding FS, in the case of first category, the negative elasticity means that as the F&L expenditure increases, the average size of the family goes down. This may be true of the lowest income families, with larger families, the per head average fuel consumption is low, and if the family size is less, then the amount spent on fuel, or the amount of fuel consumed does not reduce much. Other categories of MPCE for the 28th round, in the rural areas also show inelastic nature of the coefficients of FS, meaning, on an *average,* larger family consumes less fuel compared to a smaller family. Statistically, none of the coefficients of FS were found to be significant. Except for the middle income / expenditure category, all the other MPCE classes had relatively good R .

2. **URBAN - 28TH ROUND - SEMI-LOG** - In the case of urban areas of 28th round, all the TCE coefficients had positive sign, and except for the medium class, elasticities of other categories were elastic, as seen from Table 10.24. In case of the low category, in the urban areas, the elasticity of F&L expenditure with respect to TCE was 1.4597, that is, an increase in TCE will result in more than proportionate increase in the amount spent for fuel. Though the medium category was found to be inelastic, other two categories were elastic, with 1.1695 and 4.8758 respectively. Statistically, all the coefficients of TCE, other than 43-100 class were significant at 5 % level. In case of size of family,

again the coefficients were found to be insignificant statistically for all the categories, except for the very high

TABLE 10.24
URBAN - 28TH ROUND (SEMI-LOG)
LOG **FL** = a + β TCE + γ **FS**

MPCE -	**0 - 43**	**43 - 100**	**100 - 200**	200 **& ABOVE**
a	-1.22404	1.07403	1.23717	-3.49859
	-8.61299	0.41812	3.13018	-6.26560
β	0.09777	0.00346	0.00816	0.01807
	3.14933	0.09128	3.53569	8.78153
Elasticity	1.45971	0.22890	1.16950	4.87580
γ	-0.59895	0.03018	-0.12977	0.33894
	-0.56096	0.57587	-1.29897	2.07327
Elasticity	-2.2491	0.16240	-0.38460	0.72090
$\bar{R}^2$	0.80997	0.01631	0.32921	0.82707
D-W	2.26669	2.23754	1.26150	1.42010

income category, which was found to be significant at 5 % level of significance. The elasticity in this case was 0.7209, meaning, the increase in the average size of family is less than proportionate for an increase in F&L. R were relatively good for the first and the last category.

3. **RURAL - 38TH ROUND - SEMI-LOG** - In case of the 38th round, as seen in Table 10.25, the coefficients of TCE were positive, except for the second category (43-100). Positive coefficients mean that with an increase in TCE, the increase in F&L is less than proportionate, but there is an increase, and not a decrease in the actual amount spent on F&L. For the third category (100-200), the elasticity was found to be elastic, that is, more than 1, (1.5173), meaning, any increase in TCE will result in more

TABLE 10.25

RURAL - 38TH ROUND (SEMI-LOG)

$LOG\ FL = a + \beta\ TCE + \gamma\ FS$

MPCE -	0 - **100**	**100 - 200**	**200 - 300**	**300 & ABOVE**
a	0.22882	2.43605	1.42116	2.35016
	0.84574	2.37827	0.40262	7.83714
	0.01491	-0.00481	0.00615	0.00103
	2.83809	-0.65655	0.43453	1.49331
Elasticity	0.80499	-0.66840	1.51733	0.43730
	0.10488	0.09844	-0.82196	0.00660
	2.14927	1.72700	-1.41996	0.16559
Elasticity	0.58940	0.50300	-3.37830	0.02342
R^2	0.54341	0.05312	0.01775	0.02144
D-W	1.68931	1.77614	1.49292	2.04929

than proportionate increase in the amount spent for F&L. For the first and last category the elasticity was found to be inelastic with 0.8049 and 0.4373 elasticity respectively. Only the low category equation was found to be statistically significant at 5 % level. In case of coefficients for FS, the low expenditure category was found to be significant, and the elasticity was inelastic with 0.5894. Surprisingly, the high category was found to be elastic for FS, but it was negatively elastic. R^2 for the equations of 38th round, rural areas were not very high.

4. **<u>URBAN - 38TH ROUND - SEMI-LOG</u>** - Finally, coming to the urban areas for the 38th round, given in Table 10.26, the elasticities of TCE for the 100-200, 200-300 and 300 and above categories showed some unexpected results. The elasticity for the first category was found to be inelastic, with 0.32585, but for the next

three categories, the elasticities were very big and the sign was found to be negative. This kind of elasticity was not expected as far as the urban areas was concerned. Only the second category was found to be statistically significant at 5 % level of significance. Even the elasticities for FS showed negative sign and all the elasticities were found to be inelastic. The first category was found to be statistically significant at 5 % level. The elasticity of 0.45676 for FS for 0-100 category means that for that particular MPCE class, an increase in family size means an increase in the fuel expenditure, which is less than proportionate the increase in the number of people. R was found to be low for all the equations. In this set of equations, the 'Total' (all India) equations, that the sum of rural and urban is not reported

TABLE 10.26
URBAN - 38TH ROUND (SEMI-LOG)
LOG **FL = a +** β TCE **+** γ **FS**

MPCE -	0 - **100**	**100 - 200**	200 - **300**	300 & **ABOVE**
a	0.86171	10.48746	9.98640	3.19026
	3.57469	3.08056	1.65364	6,35160
	0.00627	-0.05695	-0.27628	-0.29132
	1.19790	-2.35189	-1.13193	-0.27316
Elasticity	0.32585	-8.01570	-68.37100	-135.83080
γ	0.08490	-0.01233	-0.10816	-0.35714
	3.81916	-0.23944	-1.20320	-0.51514
Elasticity	0.4676	-0.06497	-0.40340	-0.73571
R^2	0.53552	0.14862	0.03755	0.00452
D-W	1.89991	1.29849	1.39847	2.17324

here, but reported in the Appendix D. Even though the functional form is sound, the data did not confirm the specifications, and the results were not found to be significant, for both the logarithmic case and semi-log case.

10.4. CONCLUSION

This chapter dealt with the regression results, to show that Fuel and Light expenditure is an important part of the Total Expenditure, and the relative share and demand for particular fuels out of total expenditure on fuels. Expenditure (or Income) categories were taken to show the share of fuel and light expenditure out of total consumption expenditure of a household, for different categories. The impact of size of family on the fuel expenditure was also studied.

The results, were presented in three sections, first, fuel and light as a function of total expenditure, second, four types of fuels, as functions of total fuel and light expenditure, and third and finally, fuel and light as a function of total expenditure and size of family, according to monthly per capita expenditure (MPCE) categories.

The main objective was to establish a relation between the income classes and the expenditure patterns on energy. From the regression equations it was found that in the beginning, the demand for fuel was elastic but over time, when it was assumed that the household income increases and the household purchasing capacity increases, the amount spent or. fuel out of total expenditure decreases. Taking into account four main fuels, coke, fuelwood, kerosene and electricity, it was found that there is a shift away from the inefficient, biomass fuels towards efficient and convenient fuels like kerosene and electricity. In this, the income of a household plays an important determining factor. Fuels like fuelwood in spite of being inefficient are demanded and consumed because it is gathered and the 'cost' is only the time spent for its collection. But with an increase in income and changes in the occupation structure of the households, the quality of fuel and the type of energy forms demanded also register a change over time, from fuelwood to kerosene to electricity. This is expected from the energy ladder hypothesis, and this proves the energy ladder concept.

To find the consumption patterns of energy for different income / expenditure categories the income classes were grouped into four categories, respectively for 28th and 38th rounds as 0-43, and 0-100 (low), 43-100 and 100-200 (medium), 100-200 and 200-300 (high) and finally, 200 and above and 300 and above (very high) respectively. Overall the estimates suggest that the elasticity is more as income increases, but it decreases at the very high group, thus supporting the engel curve concept that with an increase in income, there will be an initial increase in **the** amount of a commodity demanded, but eventually the proportion of **the demand** increases at a decreasing rate and become negative at very high income levels.

XI
CONCLUSION AND SUMMARY

11.0 INTRODUCTION

Energy is a crucial input not only for the industrial production process, but also plays an important part of the household activity. Apart from the main task of cooking, energy is essential for lighting and running the various appliances being used in the households. The form in which energy is consumed and used is closely related to the task it is designed to perform. For example, a fuel like fuelwood is best suited for cooking and its use for lighting is severely limited.

For most of the households of the urban and rural poor, the energy requirements are clubbed together as 'cooking and lighting', as some fuels like kerosene are used both for cooking and lighting. Out of the total energy consumed, almost 80 % is used for cooking in the rural areas (Cecelski, Dunkerley and Ramsay; 1985). In the household sector, the energy consumed is both the commercial and non-commercial type. Though, non-commercial fuels are used on a wider scale by the poorer sections of both the rural and urban dwellers. The main biomass fuels used are, fuelwood, twigs and branches, leaves and roots, and other agricultural wastes and animal wastes. Other types of fuels most used are coal, charcoal, kerosene and to some extent, electricity. Of late, in some areas, the usage of biogas is gaining momentum.

The major problem for accounting purposes is when the so called non-commercial fuels like fuelwood and animal wastes, etc., are bought and sold, especially in the urban areas, and not collected as was done earlier. This 'commercial' nature of the non - commercial fuels brings about a blurred distinction between the commercial and non-commercial fuels. The extent of household consumption of energy is based on various factors like, the income of the household, availability of a certain fuel, the size of the family, land-use pattern of the rural areas, the type of appliances used for cooking, and last but not the least, the habits and customs of the consumers. Of the various factors, for the present study, the income (or expenditure) levels of various households and the size of the family were taken as the independent variables, on which the level of energy consumption is dependent.

11.1 HOUSEHOLD SECTOR - ENERGY LADDER

The concept of energy ladder indicates that the pattern of energy use in different households varies according to their income levels and each rung of the ladder corresponds to different and more efficient fuels. Thus the step on which the household stays as far as the energy consumption is concerned, is dependent mainly on its income. The ladder can be from agricultural wastes, cow dung, fuelwood, to coal, kerosene, charcoal to LPG and electricity. The height of the ladder is determined by factors like cost of the appliance used, the fixed cost of the fuel use (for example, for using electricity, its imperative to have electrical wiring done beforehand) and price of the energy source itself. The aim of the households in a way, is to shift from a fuel of lower efficiency to a fuel of higher efficiency, apart from a cheaper fuel to costlier fuel, in terms of money. Thus, from a purely economic point of view, the shift from an inefficient fuel to a more efficient fuel is good, apart from the wood saving which can be achieved if a major percentage of population can shift away from fuelwood usage. But for the present, given the economic status of the majority of the population and the availability situation of alternative fuels, this may not be possible.

The energy ladder, in the present study was studied separately for the rural and the urban areas, and for all India total (rural + urban). It was observed that the energy ladder was more prominent in the urban areas than the rural areas. This could be because, in the urban areas, there is a wide variety of fuel forms available, and the incomes of the households are relatively more compared to the rural areas. Because of the severe shortages or non-availability of biomass fuels in the urban areas, there is an increased consumption of commercial fuels.

To study the energy ladder, it was found that the double - logarithmic functional form is best suited. The results given in the previous chapter show that the regression equations with the double-logarithmic functional form showed better results, over the rounds, for all, rural, urban and all India. In case of the equations with MPCE categories also, the double-logarithmic form was found to be best suited.

11.2 DATABASE, RESULTS AND DATA GAPS

The data used for the present study is sample survey data, given by the National Sample Survey Organization, Central Statistical Organization, Government of India. Survey is conducted for the country as a whole, state-wise, for one year, so as to coincide with the four cropping seasons. The one complete year survey is called as one 'round', and from the time the surveys started, it has been called Round 1, Round 2, and so on.

For the present study, five different rounds of survey data was used to observe the energy consumption patterns by the households across the years (rounds) and across the states. The rounds selected were 27th, 28th, 32nd, 38th and 44th. The survey data was collected for expenditure on Fuel and Light by the households out of their Total Expenditure. It helped to observe the relative importance of energy in the household budget, across the states and across the rounds. This type of data was collected for the

27th, 32nd, 38th and 44th rounds. Another set of data, where the extent of households consumption for selected fuels out of its total expenditure on Fuel and Light was taken. The data was collected for the 27th, 32nd and 38th rounds. The fuels selected were, coke, fuelwood, kerosene, and electricity. Of the four fuels, two are used mainly for cooking (coke and fuelwood), one is used for cooking and lighting (kerosene) and one is used more or less exclusively for lighting (electricity. By observing the consumption of selected fuels out of total expenditure on fuel and light, it can be estimated whether there is any shift from one fuel to another across the rounds, across the states. This is an important indicator which can be used for observing the emergence of an energy ladder in the household sector, across the rounds. From the analysis of results done in the previous chapter it is apparent that there is a shift away from coke in both the rural and urban areas, though the usage of fuelwood remained more or less same across the rounds. On the other hand, the consumption of kerosene had increased for the 32nd round, though its increase was overshadowed by the increase of electricity consumption for the 38th round. This trend of fuel consumption clearly shows that there is a shift from one fuel to another across the rounds.

The steady consumption of fuelwood may be because, for a major portion of the urban and rural poor, no other alternative is feasible, given their economic situation, and more often than not, marketing of fuelwood gives them a source of daily income as well.

Apart from, the fact that fuelwood is available at zero monetary cost, another factor of its continued use is because of the non-availability of any other fuel in the rural areas, at a price which is affordable by all.

The third set of data collected was for 28th and 38th rounds. The data was according to Monthly Per Capita Expenditure categories. Originally there were thirteen categories for each round. But for the sake of convenience and to observe the impact of the increasing income (expenditure) for a few blocks of income categories, the number of categories were brought down to four. For the 28th round, the categories were, Rs. 0-43 (low), Rs.43-100 (medium), Rs. 100-200 (high) and Rs. 200 and above (very high). For the 38th round, the categories were, Rs.0-100 (low), Rs.100-200 (medium), Rs.200-300 (high) and Rs.300 and above (very high). The different categorization for the two rounds was to account for the impact of inflation on the purchasing power of the households, for the ten year gap (that is from the 28th round to the 38th round).

For the two rounds, for four categories each, data for expenditure on Fuel and Light and Total Consumer Expenditure was taken. To study the impact of the size of family on the amount of fuel consumed, the average size of the family across states was taken. It was found that in India, the size of family at the lower levels of income was significantly larger compared to the size of family at the higher income levels. This was observed for more or less all the states, for both the rounds. It was found that the average family size for the 28th round was slightly larger compared to the average family size of the 38th round.

Though it was not expected, from the regression analysis, it was found that the size of the family did not contribute significantly to the amount of fuel consumed, across the different income categories. On the other hand, as was expected, the expenditure on fuel and light initially experienced a decline (where an increase in purchasing power of the household would result in higher consumption of essentials like food), then increased for the high category, and finally for the very high category, declined. This proves that the engel curve approach holds good even for the consumption of energy sources, where, an increase in income brings about an initial increase in the amount of a commodity consumed, followed by a decline in the same.

Though the data was taken from the official published sources, there were certain data gaps, and certain categories of data crucial for the analysis were not included, for want of availability. Firstly, category of expenditure is assumed to be same as income, which may not be the case. Even in the poorer sections of households, there is some amount of saving done and some amount spent for items/events not covered in the survey. For example, money spent for performing the marriage, or funeral ceremonies, or festivals is not covered under the survey, thus the total expenditure given by the survey data will not be equal to the actual total expenditure, and hence, total expenditure cannot be equal to total income. The method of collection of data is either by the interview method or by questionnaire. More often than not, the respondents are the male head of the household, and as far as the extent of consumption of energy is concerned is guessed, rather than the actual figure. This is so because in the rural areas mainly, the responsibility of collection of fuel (fuelwood, animal wastes, twigs and branches, etc.) is with the female members and children of the household. Thus the data given by the respondent may be misleading. Another shortcoming of the data is regarding the assumption of increase in the monetary income across the rounds. It was assumed that the income of a household increase over time. This may be true as far as the monetary income is concerned, but whether the real income has increased or not is debatable. With the impact of inflation on both the incomes and cost of items consumed by the households, any increase in income may not mean an actual increase in the household income.

11.3 SUMMARY

In the present study, various issues related to the study of energy ladder and energy usage in the rural and urban was analyzed in detail. Special emphasis was given to fuelwood because of its unique nature, where it is being used in both the rural as well as the urban areas, inspite of its dwindling supply. A special emphasis on fuelwood was also felt necessary because this fuel is more often than not, collected at no monetary cost to the collector. Thus any shift in fuel consumption necessarily means that either that particular household has improved economically, or the supply of fuelwood is so bad that there is no alternative but to shift to other fuels.

To study the fuel shifts, what makes a household shift from one source of fuel to another, and what is the importance of expenditure on fuel and light in the overall household budget, the various issues were studied under the following chapters. The first chapter gives an introduction to the thesis, enumerating the objectives. The second chapter talked about the Land-use pattern and the fuelwood demand, where the different alternative uses of land were analyzed. The third chapter dealt with the Economics of Rural Energy Crisis, where the various issues related to the fuelwood consumption were dealt with. The relation between rural household energy and fuelwood was also studied in detail. Alternative sources of energy which can be used by the household sector like solar, wind, biogas, etc were also outlined. The fourth chapter dealt with the pricing of energy resources, with special emphasis on pricing of fuelwood and its non-price cost, and the substitution possibilities in the rural areas, for fuelwood. Mostly, the cost of fuelwood, wherever it is monetized, does not include the cost of labour used for its collection. The possibilities of energy substitution in the household and inter-fuel substitution vis-a-vis fuelwood is also studied. The fifth chapter talked about the efficiency factors. The various issues related in efficiency like fuel efficiency and cooking appliance efficiency were dealt with in detail. The sixth chapter dealt with the main issue of the study, that is, energy ladder, and the related studies in the area. Seventh chapter gives an outline of the area of study, that is India, the economic situation, the major sectors, energy situation and forests in India. The next chapter details the data used and its analysis. Ninth chapter talks about the methodological aspects like ordinary least squares method, regression analysis and engel curve approach used for the present study, and the tenth chapter gives a detailed analysis of the regression results, and its implications.

11.4 CONCLUSION

This study deals mainly with how Fuel and Light expenditure is an important part of the Total Expenditure, and the relative share and demand for particular fuels out of total expenditure on fuels. For this energy ladder approach was used. Energy ladder approach talks basically about the shifts in fuel source by the households **from** one fuel to another because of an improvement in the economic status of that household. For this, fuel Expenditure (or Income) categories were taken to show the share of fuel and light expenditure out of total consumption expenditure of a household, for different categories. The impact of size of family on the fuel expenditure was also studied.

The main objective of the study was to establish a consumption pattern between the income classes and the expenditure on energy. From the analysis it was found that in the beginning, the demand for fuel was elastic but over time, with an improvement in the economic status of the household, the amount spent on fuel out of total expenditure decreases. Taking into account four main fuels, coke, fuelwood, kerosene and electricity, it was found that there is a shift away from the inefficient, biomass fuels towards efficient and convenient fuels like kerosene and electricity. In this, the income of a household plays an important determining factor. Fuels like fuelwood inspite of being inefficient are demanded and consumed because it is gathered and the 'cost' is only the time spent for its collection, and also mainly because there is no alternative available in most of the rural areas. But with an increase in income and changes in the occupation structure of the households, the quality of fuel and the type of energy sources demanded also changes over time, from fuelwood to kerosene to electricity. Thus the study was successful in establishing the fact that the energy ladder does exist in the rural and urban areas, given the fact that there is availability of alternative fuels and there is an increase in the income of the households.

11.5 POLICY RECOMMENDATIONS AND IMPLICATIONS

For any developing country one major policy issue is that the rural households face serious to severe fuelwood shortages. The question about how to encourage households to make fuel substitution is very important Much of the policy work undertaken has assumed that an energy ladder exists. But most of the households are so constrained that they have no choice but to remain dependent upon fuelwood for the time being. As a result, policy efforts have focussed on rural afforestation and ignored any possibilities of inter-fuel substitution, particularly those which involve a move away from fuelwood and a move up the energy ladder.

A number of recommendations can be made for policy formulation point of view from the present study.

1. From the policy point of view it is very essential to know the type of fuel being used in a particular area. For example, a state like Assam, which has abundant forest resources would need a separate type of policy compared to a state like Bihar where the area under forest is very less. The policy regarding conservation of fuelwood and forest resources will not have much relevance for a state like Bihar, which has almost negligible forests, whereas it is crucial for a state like Assam. Thus estimation of household fuels consumption in different areas should be the primary policy requirement.

2. As even commercial types of fuels are available (though erratically) in the rural areas, it is evident that the people are ready to shift away from the traditional forms of fuels like fuelwood. Thus this can can be used to wean the households away from fuelwood use.

3. Encouragement to non-commercial, potential types of renewable fuels like solar, biogas and wind energy should be given, as they are not only non-polluting in nature, even remote areas can become self-sufficient as far as fuel needs are concerned. Though subsidies are given for usage of solar cookers, the maintenance of the same is very important, which is overlooked.

4. In this respect the crucial nature of improved stove programme should be emphasized. This programme in a way can be viewed as an alternative 'source of fuel' in the sense that, by the employment of improved stoves, almost 50 - 60 % of fuel can be saved compared to traditional stove use. The effective dissemination of the improved stoves may go a long way in improving the fuel availability situation, especially in the rural areas.

5. Regarding the usage of potential, renewable sources of energy, biogas assumes much importance. The unique nature of this source of energy is that the feed-stock for getting the biogas (energy source) is available in abundance within the village itself, and more so because in the rural areas, most of the household maintain some milch or farm animals, which can provide adequate amount of animal wastes to feed the biogas

plant.

6. The policies for energy consumption, conservation and usage should not be clubbed with other major programmes, where it is only a small part of the other project. The important role of energy in the household use makes its imperative for a separate programme which will look into the consumption, conservation and possible shifts to other fuels. If energy is made a part of any other programme, say on rural development, the other socio-economic factors assume importance over energy, where its importance is overlooked.
7. From the present study on energy ladder, it can be observed that with the increasing household incomes, people are inclined to shift away from the traditional sources of energy to more efficient, commercial fuels. In this move away from traditional fuels, it becomes crucial that alternatives, at least cost to the consumers is made available within comfortable distance.
8. An important offshoot of this shift is that there will be increasing demand for alternative fuels, which generally mean some commercial sources of fuel. This could mean that prices of the already expensive commercial fuels may go up further, which may again force the consumers to shift back to the traditional fuels. To avoid this from happening, if encouragement is given for shift towards potential, renewable sources of fuel like wind energy, solar, biogas, then there is development of a relatively pollution free fuel, at least cost

to the consumers and mainly, which is available within the village itself.

9. Last but not the least, effective implementation of the existing programmes and any future new programmes is imperative for it to have any impact on the overall energy consumption situation.

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The implications from the above mentioned recommendations are many. First of all, a shift away from traditional, biomass fuels like fuelwood, is that, it will leave the degraded forests free to regenerate and replenish, which is crucial for the environmental well being of the country. The shift to better, efficient fuels has a positive impact on the household, in the sense that, not only is it more convenient to use, it will be cleaner to use. The time saved (which otherwise would have gone for fuel collection) can be effectively used for other productive purposes. This also means that the health of the users would not suffer, as earlier, because of the usage of fuels which emit large quantities of smoke. The implementation of the above mentioned recommendations thus, may radically change the rural and urban household energy use and will have an equally radical impact on the lives of the users.

11.6 SHORTCOMINGS OF THE STUDY

The main shortcoming of the present study is that, the prices of the fuel sources have not been included. The relative prices of each fuel would have given a better understanding as to why there is a shift from one fuel to another. The choice of a particular fuel, depends on prices to a great extent, apart from availability of that fuel. For example, if fuelwood bought from the market, and is not collected 'free of cost', then there is a tendency for the consumers to shift away from fuelwood to any other more efficient fuel like coal or kerosene.

Another shortcoming of the study is that the mode of procurement of fuel was not taken into account, which would have given the idea as to what percentage of the households depend upon 'bought' fuel and how many depend on collected or gathered fuel. This is very important from the policy point of view, especially fuelwood or forest policies. This is important because one of the major reasons for degradation of accessible forests (adjacent to the human settlements mainly) is the wood pilferages, which end up either in the fuelwood markets, or in the hearth.

The assumption of the existence of an energy ladder is a question by itself. In most of the areas, especially the rural areas, the types of fuel available is very limited. At best fuelwood, animal wastes and crop wastes are available, with erratic supply of kerosene. Even with the electrification, the usage of this fuel source for household purposes (mainly cooking) is almost negligible.

A P P E N D I X

APPENDIX A - RAW DATA

TABLE 1
PER CAPITA FUEL AND LIGHT ACROSS THE ROUNDS

STATES	27 ROUND		32 ROUND		38 ROUND		44 ROUND	
	RURAL	URBAN	RURAL	URBAN	RURAL	URBAN	RURAL	URBAN
ANDHRA PR.	1.99	2.94	3.74	5.33	6.89	9.65	10.65	13.64
ASSAM	3.02	3.93	4.34	6.26	8.85	11.53	12.53	18.46
BIHAR	1.94	3.04	3.34	3.88	6.26	8.95	11.23	13.73
GUJARAT	2.60	3.56	11.40	6.21	9.60	11.44	13.87	19.86
HARAYANA	3.68	4.36	4.66	5.82	9.74	12.63	15.39	18.58
KARNATAKA	2.59	3.55	5.24	6.13	9.71	11.83	13.03	16.63
KERALA	2.47	3.22	4.28	5.04	8.45	10.05	13.76	16.91
MADHYA PR.	2.37	3.55	3.42	4.87	7.12	10.64	12.34	19.94
MAHARASHTRA	2.39	3.73	4.15	7.15	9.77	12.96	12.94	17.90
ORISSA	2.22	3.30	3.57	3.69	6.33	10.35	11.73	22.58
PUNJAB	3.32	4.59	6.03	6.83	11.62	14.93	18.94	17.75
RAJASTHAN	2.63	3.45	4.65	6.04	7.50	10.79	14.72	15.73
TAMIL NADU	2.52	3.46	4.13	5.63	7.58	10.31	11.20	16.10
UTTAR PR.	2.55	7.74	4.19	5.58	8.18	10.01	12.35	19.56
WEST BENGAL	1.84	3.44	3.42	5.42	6.93	11.38	12.31	21.98

TABLE 2
PER CAPITA TOTAL EXPENDITURE ACROSS THE ROUNDS

STATES	27 ROUND		32 ROUND		38 ROUND		44 ROUND	
	RURAL	URBAN	RURAL	URBAN	RURAL	URBAN	RURAL	URBAN
A.P.	72.65	97.12	37.79	56.32	60.66	101.57	183.14	245.25
ASSAM	59.84	112.70	41.67	60.75	115.58	159.55	159.66	227.87
BIHAR	62.35	89.39	41.20	59.91	113.03	160.48	152.89	227.87
GUJ.	76.93	108.87	51.70	57.58	93.76	139.58	171.55	276.03
HAR.	104.63	108.37	70.07	69.88	119.25	164.06	244.65	249.77
K'TAKA	65.77	88.50	44.53	57.89	149.14	183.97	157.55	280.01
KERALA	77.36	83.09	42.19	58.27	118.12	168.11	217.97	234.34
M.P.	65.10	137.97	40.72	61.88	145.24	178.31	152.89	311.76
M'TRA	83.30	118.69	41.55	74.84	101.71	148.39	171.07	256.36
ORISSA	53.19	87.59	34.96	62.35	110.98	187.56	147.34	298.50
P'JAB	126.68	125.73	74.62	77.88	97.48	151.35	264.71	264.12
R'TAHN	115.49	108.18	51.98	63.87	170.30	184.38	218.79	251.34
T.N.	65.20	87.11	37.70	54.02	127.52	159.96	170.93	238.22
U.P	72.68	92.26	42.12	53.55	112.19	164.15	164.73	268.67
W.B.	60.66	101.57	38.45	68.23	104.25	137.84	169.98	286.89

APPENDIX B

RURAL - 27 TH ROUND (Rs. '00000)

TOTAL VALUE OF CONSUMPTION OF SOURCES OF ENERGY FOR 365 DAYS

STATES	COKE	FUELWOOD	KEROSENE	ELECTRI	OTHERS	TOTAL
Andhra Pr.	0.00	6176.00	1809.00	88.00	882.00	8955.00
	0.00	*68.97*	*20.20*	*0.98*	*9.85*	
Assam	17.00	3733.00	1010.00	0.00	223.00	4983.00
	0.34	*74.91*	*20.27*	*0.00*	*4.48*	
Bihar	701.00	4399.00	2486.00	0.00	5864.00	13450.00
	5.20	*32.71*	*18.48*	*0.00*	*43.60*	
Gujarat	24.00	4098.00	1391.00	171.00	1216.00	6900.00
	0.35	*59.39*	*20.16*	*2.48*	*17.62*	
Haryana	32.00	1789.00	368.00	137.00	1589.00	3915.00
	0.82	*45.70*	*9.40*	*3.50*	*40.59*	
Himachal Pr	4.00	2060.00	150.00	73.00	101.00	2388.00
	0.17	*86.26*	*6.28*	*3.06*	*4.23*	
Jammu & K.	10.00	1385.00	135.00	53.00	533.00	2116.00
	0.47	*65.45*	*6.38*	*2.50*	*25.19*	
Karnataka	0.00	5380.00	1177.00	196.00	617.00	7370.00
	0.00	*73.00*	*15.97*	*2.66*	*8.37*	
Kerala	0.00	4069.00	877.00	270.00	359.00	5575.00
	0.00	*72.99*	*15.73*	*4.84*	*6.44*	
Madhya Pr.	0.00	6631.00	1547.00	44.00	2432.00	10654.00
	0.00	*62.24*	*14.52*	*0.41*	*22.83*	
Maharashtra	88.00	7332.00	1800.00	88.00	1361.00	10669.00
	0.82	*68.72*	*16.87*	*0.82*	*12.76*	
Orissa	25.00	3973.00	886.00	25.00	81.00	4990.00
	0.50	*79.62*	*17.76*	*0.50*	*1.62*	
Punjab	13.00	1675.00	558.00	247.00	1884.00	4377.00
	0.30	*38.27*	*12.75*	*5.64*	*43.04*	
Rajasthan	54.00	3488.00	676.00	27.00	2947.00	7192.00
	0.75	*48.50*	*9.40*	*0.38*	*40.98*	
Tamil Nadu	0.00	6918.00	1477.00	324.00	505.00	9224.00
	0.00	*75.00*	*16.01*	*3.51*	*5.47*	
Tripura	14.00	368.00	71.00	0.00	26.00	479.00
	2.92	*76.83*	*14.82*	*0.00*	*5.43*	
Uttar Pr.	0.00	13273.00	3438.00	95.00	7830.00	24636.00
	0.00	*53.88*	*13.96*	*0.39*	*31.78*	
W. Bengal	966.00	3696.00	1680.00	0.00	1681.00	8023.00
	12.04	*46.07*	*20.94*	*0.00*	*20.95*	
All India	1971.00	83178.00	21626. 0	1866.00	29435.00	138076.00
	1.43	*60.24*	*15.66*	*1.35*	*21.32*	

* The figures in *italics* are percentages.

RURAL - 32 TH ROUND

TOTAL VALUE OF CONSUMPTION OF SOURCES OF ENERGY FOR 365 DAYS

STATES	COKE	FUELWOOD	KEROSE E	ELECTRI	OTHERS	TOTAL
Andhra Pr.	0.00	11322.00	3067. 0	541.00	2165.00	17095.00
	0.00	*66.23*	*17.94*	*3.16*	*12.66*	
Assam	0.00	6280.00	1946. 0	140.00	422.00	8788.00
	0.00	*71.46*	*22.14*	*1.59*	*4.80*	
Bihar	1085.00	9430.00	4410. 0	68.00	8005.00	22998.00
	4.72	*41.00*	*19.18*	*0.30*	*34.81*	
Gujarat	231.00	6114.00	2440. 0	488.00	5210.00	14483.00
	1.59	*42.22*	*16.85*	*3.37*	*35.97*	
Haryana	33.00	1687.00	701. 0	230.00	2508.00	5159.00
	0.64	*32.70*	*13.59*	*4.46*	*48.61*	
Himachal Pr	9.00	2409.00	221. 0	177.00	204.00	3020.00
	0.30	*79.77*	*7.32*	*5.86*	*6.75*	
Jammu & K.	0.00	1735.00	231. 0	53.00	994.00	3013.00
	0.00	*57.58*	*7.67*	*1.76*	*32.99*	
Karnataka	0.00	9048.00	2183. 0	373.00	1005.00	12609.00
	0.00	*71.76*	*17.31*	*2.96*	*7.97*	
Kerala	0.00	7256.00	1682. 0	553.00	913.00	10404.00
	0.00	*69.74*	*16.17*	*5.32*	*8.78*	
Madhya Pr.	0.00	9338.00	2906. 0	191.00	4001.00	16436.00
	0.00	*56.81*	*17.68*	*1.16*	*24.34*	
Maharashtra	0.00	11481.00	3782. 0	720.00	2973.00	18956.00
	0.00	*60.57*	*19.95*	*3.80*	*15.68*	
Orissa	0.00	7234.00	1593. 0	108.00	837.00	9772.00
	0.00	*74.03*	*16.30*	*1.11*	*8.57*	
Punjab	66.00	2567.00	953. 0	542.00	3903.00	8031.00
	0.82	*31.96*	*11.87*	*6.75*	*48.60*	
Rajasthan	0.00	8503.00	1559. 0	206.00	3560.00	13828.00
	0.00	*61.49*	*11.27*	*1.49*	*25.74*	
Tamil Nadu	0.00	10839.00	2490. 0	806.00	1135.00	15270.00
	0.00	*70.98*	*16.31*	*5.28*	*7.43*	
Tripura	0.00	449.00	132. 0	0.00	39.00	620.00
	0.00	*72.42*	*21.29*	*0.00*	*6.29*	
Uttar Pr.	197.00	18058.00	5723. 0	296.00	17565.00	41839.00
	0.47	*43.16*	*13.68*	*0.71*	*41.98*	
W. Bengal	2594.00	6532.00	3457. 0	185.00	3354.00	16122.00
	16.09	*40.52*	*21.44*	*1.15*	*20.80*	
All India	4275.00	132485.00	40271. 0	5836.00	55840.00	238707.00
	1.79	*55.50*	*16.87*	*2.44*	*23.39*	

The figures in *italics* are percentages,

RURAL - 38 TH ROUND

TOTAL VALUE OF CONSUMPTION OF SOURCES OF ENERGY FOR 365 DAYS

STATES	COKE	FUELWOOD	KEROSENE	ELECTRI	OTHERS	TOTAL
Andhra Pr.	199.00	22894.00	5662.00	1569.00	4871.00	35195.00
	0.57	*65.05*	*16.09*	*4.46*	*13.84*	
Assam	139.00	14892.00	4151.00	218.00	926.00	20326.00
	0.68	*73.27*	*20.42*	*1.07*	*4.56*	
Bihar	1714.00	18076.00	8177.00	247.00	15637.00	43851.00
	3.91	*41.22*	*18.65*	*0.56*	*35.66*	
Gujarat	262.00	15090.00	4402.00	2195.00	3378.00	25327.00
	1.03	*59.58*	*17.38*	*8.67*	*13.34*	
Haryana	31.00	4144.00	1412.00	1085.00	5829.00	12501.00
	0.25	*33.15*	*11.30*	*8.68*	*46.63*	
Himachal Pr	54.00	5185.00	467.00	549.00	457.00	6712.00
	0.80	*77.25*	*6.96*	*8.18*	*6.81*	
Jammu & K.	18.00	3691.00	499.00	633.00	1405.00	6246.00
	0.29	*59.09*	*7.99*	*10.13*	*22.49*	
Karnataka	165.00	23496.00	4382.00	1044.00	2912.00	31999.00
	0.52	*73.43*	*13.69*	*3.26*	*9.10*	
Kerala	222.00	15900.00	2664.00	2008.00	1060.00	21854.00
	1.02	*72.76*	*12.19*	*9.19*	*4.85*	
Madhya Pr.	410.00	22565.00	5233.00	956.00	8207.00	37371.00
	1.10	*60.38*	*14.00*	*2.56*	*21.96*	
Maharashtra	321.00	29520.00	7122.00	2779.00	7235.00	46977.00
	0.68	*62.84*	*15.16*	*5.92*	*15.40*	
Orissa	151.00	15128.00	3118.00	683.00	2143.00	21223.00
	0.71	*71.28*	*14.69*	*3.22*	*10.10*	
Punjab	125.00	6449.00	1613.00	2287.00	7090.00	17564.00
	0.71	*36.72*	*9.18*	*13.02*	*40.37*	
Rajasthan	383.00	15313.00	3079.00	597.00	6507.00	25879.00
	1.48	*59.17*	*11.90*	*2.31*	*25.14*	
Tamil Nadu	222.00	21853.00	4382.00	2221.00	1842.00	30520.00
	0.73	*71.60*	*14.36*	*7.28*	*6.04*	
Tripura	79.00	1112.00	294.00	85.00	98.00	1668.00
	4.74	*66.67*	*17.63*	*5.10*	*5.88*	
Uttar Pr.	535.00	37788.00	11458.00	614.00	42512.00	92907.00
	0.58	*40.67*	*12.33*	*0.66*	*45.76*	
W. Bengal	4588.00	14350.00	61092.00	525.00	4541.00	85096.00
	5.39	*16.86*	*71.79*	*0.62*	*5.34*	
All India	10019.00	190100.00	74816. 0	20830.0	228076.0	523841.00
	1.91	*36.29*	*14.28*	*3.98*	*43.54*	

* The figures in *italics* are percentages.

URBAN - 27 TH ROUND

TOTAL VALUE OF CONSUMPTION OF SOURCES OF ENERGY FOR 365 DAYS

STATES	CQKE	FUELWOOD	KEROSENE	ELECTRI	OTHERS	TOTAL
Andhra Pr.	106.00	1562.00	549.00	443.00	433.00	3093.00
	3.43	*50.50*	*17.75*	*14.32*	*14.0*	
Assam	10.00	407.00	132.00	70.00	46.00	665.00
	1.50	*61.20*	*19.85*	*10.53*	*6.92*	
Bihar	850.00	368.00	290.00	312.00	340.00	2160.00
	39.35	*17.04*	*13.43*	*14.44*	*15.74*	
Gujarat	410.00	476.00	962.00	543.00	1143.00	3534.00
	11.60	*13.47*	*27.22*	*15.37*	*32.34*	
Haryana	228.00	257.00	120.00	196.00	185.00	986.00
	23.12	*26.06*	*12.17*	*19.88*	*18.76*	
Himachal Pr	47.00	89.00	31.00	46.00	20.00	233.00
	20.17	*38.20*	*13.30*	*19.74*	*8.58*	
Jammu & K.	0.00	24.00	10.00	8.00	11.00	53.00
	0.00	*45.28*	*18.87*	*15.09*	*20.75*	
Karnataka	27.00	1845.00	540.00	441.00	324.00	3177.00
	0.85	*58.07*	*17.00*	*13.88*	*10.20*	
Kerala	9.00	828.00	200.00	231.00	105.00	1373.00
	0.66	*60.31*	*14.57*	*16.82*	*7.65*	
Madhya Pr.	310.00	1325.00	413.00	430.00	572.00	3050.00
	10.16	*43.44*	*13.54*	*14.10*	*18.75*	
Maharashtra	278.00	1622.00	2406.00	332.00	2779.00	7417.00
	3.75	*21.87*	*32.44*	*4.48*	*37.47*	
Orissa	91.00	422.00	113.00	88.00	48.00	762.00
	11.94	*55.38*	*14.83*	*11.55*	*6.30*	
Punjab	323.00	453.00	356.00	400.00	327.00	1859.00
	17.37	*24.37*	*19.15*	*21.52*	*17.59*	
Rajasthan	121.00	816.00	295.00	307.00	464.00	2003.00
	6.04	*40.74*	*14.73*	*15.33*	*23.17*	
Tamil Nadu	16.00	3016.00	1032.00	844.00	486.00	5394.00
	0.30	*55.91*	*19.13*	*15.65*	*9.01*	
Tripura	0.00	64.00	16.00	6.00	3.00	89.00
	0.00	*71.91*	*17.98*	*6.74*	*3.37*	
Uttar Pr.	716.00	2413.00	152.00	794.00	1266.00	5341.00
	13.41	*45.18*	*2.85*	*14.87*	*23.70*	
W. Bengal	1893.00	345.00	1188.00	1022.00	305.00	4753.00
	39.83	*7.26*	*24.99*	*21.50*	*6.42*	
All India	5790.00	17369.00	9098. 0	8271.00	8235.00	49213.00
	12.13	*35.29*	*18.49*	*16.81*	*16.73*	

* The figures in *italics* are percentages

URBAN - 32 TH ROUND
TOTAL VALUE OF CONSUMPTION OF SOURCES OF ENERGY FOR 365 DAYS

STATES	COKE	FUELWOOD	KEROSENE	ELECTR1	OTHERS	TOTAL
Andhra Pr.	192.00	3471.00	1591.00	1029.00	1097.00	7380.00
	2.60	*47.03*	*21.56*	*13.94*	*14.86*	
Assam	41.00	789.00	343.00	163.00	114.00	1450.00
	2.83	*54.41*	*23.66*	*11.24*	*7.86*	
Bihar	1633.00	928.00	657.00	657.00	803.00	4678.00
	34.91	*19.84*	*14.04*	*14.04*	*17.17*	
Gujarat	1009.00	1241.00	2261.00	206.00	2541.00	7258.00
	13.90	*17.10*	*31.15*	*2.84*	*35.01*	
Haryana	267.00	448.00	344.00	322.00	404.00	1785.00
	24.96	*25.10*	*19.27*	*18.04*	*22.63*	
Himachal Pr	32.00	106.00	82.00	75.00	30.00	325.00
	9.85	*32.62*	*25.23*	*23.08*	*9.23*	
Jammu & K.	0.00	378.00	257.00	57.00	169.00	861.00
	0.00	*43.90*	*29.85*	*6.62*	*19.63*	
Karnataka	23.00	3874.00	1575.00	688.00	526.00	6686.00
	0.34	*57.94*	*23.56*	*10.29*	*7.87*	
Kerala	0.00	1801.00	321.00	393.00	311.00	2826.00
	0.00	*63.73*	*11.36*	*13.91*	*11.00*	
Madhya Pr.	570.00	2401.00	1079.00	800.00	1129.00	5979.00
	9.53	*40.16*	*18.05*	*13.38*	*18.88*	
Maharashtra	655.00	3010.00	6700.00	3690.00	3472.00	17527.00
	3.74	*17.17*	*38.23*	*21.05*	*19.81*	
Orissa	115.00	1115.00	231.00	126.00	159.00	1746.00
	6.59	*63.86*	*13.23*	*7.22*	*9.11*	
Punjab	405.00	760.00	856.00	755.00	738.00	3514.00
	11.53	*21.63*	*24.36*	*21.49*	*21.00*	
Rajasthan	282.00	2000.00	863.00	753.00	895.00	4793.00
	5.88	*41.73*	*18.01*	*15.71*	*18.67*	
Tamil Nadu	36.00	5057.00	2495.00	1584.00	1013.00	10185.00
	0.35	*49.65*	*24.50*	*15.55*	*9.95*	
Tripura	2.00	108.00	35.00	26.00	8.00	179.00
	1.12	*60.34*	*19.55*	*14.53*	*4.47*	
Uttar Pr.	1597.00	4857.00	1641.00	1813.00	2267.00	12175.00
	13.12	*39.89*	*13.48*	*14.89*	*18.62*	
W. Bengal	3769.00	650.00	1451.00	1801.00	1468.00	9139.00
	41.24	*7.11*	*15.88*	*19.71*	*16.06*	
All India	11531.00	33705.00	24836. 0	17740.0	18094.00	105906.00
	10.89	*31.83*	*23.45*	*16.75*	*17.08*	

* The figures in *italics* are percentages

URBAN - 38 TH ROUND

TOTAL VALUE OF CONSUMPTION OF SOURCES OF ENERGY FOR 365 DAYS

STATES	COKE	FUELWOOD	KEROSENE	ELECTRI	OTHERS	TOTAL
Andhra Pr.	480.00	6494.00	4000.00	2676.00	2409.00	16059.00
	2.99	*40.44*	*24.91*	*16.66*	*15.00*	
Assam	98.00	1772.00	585.00	389.00	312.00	3156.00
	3.11	*56.15*	*18.54*	*12.33*	*9.89*	
Bihar	4104.00	2207.00	1543.00	1143.00	1614.00	10611.00
	38.68	*20.80*	*14.54*	*10.77*	*15.21*	
Gujarat	1557.00	2751.00	4624.00	4090.00	2824.00	15846.00
	9.83	*17.36*	*29.18*	*25.81*	*17.82*	
Haryana	485.00	1082.00	237.00	1093.00	2052.00	4949.00
	9.80	*21.86*	*4.79*	*22.09*	*41.46*	
Himachal Pr	26.00	230.00	177.00	172.00	101.00	706.00
	3.68	*32.58*	*25.07*	*24.36*	*14.31*	
Jammu & K.	6.00	799.00	665.00	444.00	531.00	2445.00
	0.25	*32.68*	*27.20*	*18.16*	*21.72*	
Karnataka	122.00	1044.00	4348.00	2650.00	8867.00	17031.00
	0.72	*6.13*	*25.53*	*15.56*	*52.06*	
Kerala	117.00	3515.00	826.00	1158.00	770.00	6386.00
	1.83	*55.04*	*12.93*	*18.13*	*12.06*	
Madhya Pr.	1796.00	6117.00	2448.00	2381.00	2584.00	15326.00
	11.72	*39.91*	*15.97*	*15.54*	*16.86*	
Maha.tra	1025.00	7111.00	11991.00	10570.00	6853.00	37550.00
	2.73	*18.94*	*31.93*	*28.15*	*18.25*	
Orissa	299.00	2615.00	540.00	640.00	391.00	4485.00
	6.67	*58.31*	*12.04*	*14.27*	*8.72*	
Punjab	375.00	1618.00	2220.00	2933.00	2070.00	9216.00
	4.07	*17.56*	*24.09*	*31.83*	*22.46*	
Rajasthan	635.00	4495.00	1896.00	1676.00	1918.00	10620.00
	5.98	*42.33*	*17.85*	*15.78*	*18.06*	
Tamil Nadu	224.00	9083.00	5615.00	3823.00	2432.00	21177.00
	1.06	*42.89*	*26.51*	*18.05*	*11.48*	
Tripura	5.00	203.00	41.00	63.00	24.00	336.00
	1.49	*60.42*	*12.20*	*18.75*	*7.14*	
Uttar Pr.	2786.00	11600.00	4729.00	4568.00	6413.00	30096.00
	9.26	*38.54*	*15.71*	*15.18*	*21.31*	
W. Bengal	8398.00	1403.00	3397.00	4387.00	3667.00	21252.00
	39.52	*6.60*	*15.98*	*20.64*	*17.25*	
All India	23209.00	73571.00	54070.00	48848.0	41431.00	241129.00
	9.63	*30.51*	*22.42*	*20.26*	*17.18*	

The figures in *italics* are percentages

APPENDIX C

DATA ON FUEL EXPENDITURE BY MPCE CATEGORIES

TABLE 1 : RURAL - 28TH ROUND

STATES	0-43			43-100		
	FS	FL	TCP	FS	FL	TCP
ANDHRA PRADESH	5.22	1.45	22.33	4.30	3.14	65.70
ASSAM	6.74	1.76	21.18	5.20	4.04	64.37
BIHAR	5.87	1.81	22.36	5.38	3.03	65.82
GUJARAT	6.20	1.73	22.77	5.15	3.81	65.84
HARYANA	5.17	1.69	19.02	6.59	4.05	66.34
HIMACHAL PR.	5.34	1.76	18.43	5.24	6.09	66.46
JAMMU & KASHMIR	5.07	2.24	19.31	5.35	5.45	64.55
KARNATAKA	6.37	1.80	21.63	5.44	3.81	65.73
KERALA	6.32	1.78	22.54	5.45	3.42	66.15
MADHYA PRADESH	6.50	1.63	22.41	4.92	2.90	65.30
MAHARASHTRA	5.44	1.84	22.61	5.15	3.56	64.53
MANIPUR	3.71	0.38	14.61	5.49	3.11	65.71
MEGHAYALA	5.49	0.91	17.75	5.10	3.90	65.90
ORISSA	5.18	1.79	22.41	4.78	3.87	65.22
PUNJAB	4.79	1.69	18.70	6.05	3.97	66.62
RAJASTHAN	4.67	1.55	19.47	5.50	3.52	65.05
TAMIL NADU	5.38	2.01	22.56	3.85	3.81	65.70
TRIPURA	5.19	1.62	19.49	5.09	3.88	65.24
UTTAR PRADESH	5.98	1.89	22.24	4.99	3.31	65.12
WEST BENGAL	5.65	1.40	22.32	5.63	2.80	66.31
DELHI	0.81	0.39	4.96	5.31	5.53	62.46
GOA	3.65	1.53	17.05	4.42	3.76	65.27
PONDICHERRY	2.38	0.84	11.85	4.88	3.95	66.07

TABLE 2

STATES	100-200			200 & ABOVE		
	FS	FL	TCP	FS	FL	TCP
ANDHRA PRADESH	0.85	7.08	366.40	3.51	4.25	144.91
ASSAM	0.01	0.01	0.01	4.19	6.47	136.14
BIHAR	2.86	8.33	314.44	4.56	5.13	144.98
GUJARAT	3.00	7.33	285.44	4.05	4.58	144.74
HARYANA	3.86	5.05	258.02	5.09	6.70	148.20
HIMACHAL PR.	5.85	7.22	240.79	3.09	9.32	144.98
JAMMU & KASHMIR	3.40	9.71	233.16	3.40	8.35	144.18
KARNATAKA	3.80	7.89	294.21	3.89	6.22	143.32
KERALA	2.88	9.30	262.48	4.16	5.52	147.94
MADHYA PRADESH	2.63	0.80	261.00	3.69	6.01	145.33
MAHARASHTRA	2.60	7.65	271.29	3.95	4.95	140.78
MANIPUR	0.01	0.01	0.01	1.56	8.37	142.06
MEGHAYALA	5.23	3.25	254.25	1.90	8.51	133.29
ORISSA	2.60	5.75	223.29	2.45	9.63	142.98
PUNJAB	4.34	7.35	253.65	4.54	5.93	141.87
RAJASTHAN	3.88	6.65	277.43	4.57	5.16	144.21
TAMIL NADU	3.00	7.67	273.68	3.07	6.52	141.74
TRIPURA	1.00	2.00	265.00	2.67	4.59	137.17
UTTAR PRADESH	2.59	7.26	265.11	3.61	5.05	145.37
WEST BENGAL	5.75	6.52	329.35	3.83	4.95	142.91
DELHI	1.00	4.00	232.00	0.01	0.01	0.01
GOA	0.04	0.04	0.04	6.00	4.07	158.11
PONDICHERRY	0.04	0.04	0.04	10.75	10.18	129.74

TABLE 3

URBAN - 28TH ROUND

STATES	0-43			43-100		
	FS	FL	TCP	FS	FL	TCP
ANDHRA PRADESH	4.94	1.51	19.52	4.75	3.75	66.03
ASSAM	3.39	1.10	14.14	5.39	4.34	66.33
BIHAR	5.35	1.18	18.25	5.70	3.42	67.28
GUJARAT	4.90	1.17	16.36	5.38	4.49	66.00
HARYANA	4.07	1.44	15.09	5.33	5.25	66.70
HIMACHAL PR.	10.25	0.56	3.75	5.24	5.76	66.59
JAMMU & KASHMIR	4.36	1.20	17.65	5.45	3.79	66.15
KARNATAKA	5.20	1.40	19.52	5.51	4.48	66.03
KERALA	5.72	1.51	20.62	5.77	3.57	65.21
MADHYA PRADESH	5.01	1.68	19.55	5.54	4.15	67.06
MAHARASHTRA	5.14	1.48	22.36	5.33	4.27	65.59
MANIPUR	11.04	0.39	4.98	6.50	4.87	65.39
MEGHAYALA	10.88	0.31	4.84	7.00	5.01	66.60
ORISSA	3.02	1.20	17.36	4.67	3.79	65.89
PUNJAB	1.76	0.81	8.82	5.50	4.92	65.91
RAJASTHAN	4.15	1.43	16.00	5.62	4.03	65.10
TAMIL NADU	4.84	1.47	21.53	4.47	4.51	66.75
TRIPURA	10.63	0.55	4.93	5.28	4.62	66.69
UTTAR PRADESH	6.48	1.65	22.72	4.78	4.48	66.01
WEST BENGAL	5.94	1.47	21.90	4.95	3.93	67.35
DELHI	4.82	1.50	17.33	4.67	4.98	66.35
GOA	11.25	0.21	3.80	5.44	3.73	67. 17
PONDICHERRY	3.22	1.06	12.38	5.50	4.31	64.04

TABLE 4

STATES	100-200			200 & ABOVE		
	FS	FL	TCF»	FS	**FL**	TCP
ANDHRA PRADESH	2.99	6.30	149.52			
ASSAM	2.27	7.48	147.44	1.47	8.41	283.87
BIHAR	2.96	6.62	141.30	1.55	9.00	269.36
GUJARAT	2.65	7.87	146.07	3. 13	8.27	241.21
HARYANA	2.92	8.95	143.05	2.23	9.86	255.72
HIMACHAL PR.	2.33	12.45	151.55	1.20	16.00	248.58
JAMMU & KASHMIR	2.88	9.24	146.16	1.00	8.21	291.63
KARNATAKA	3.20	8.01	149.52	2.57	11.53	244.59
KERALA	3.73	5.67	145.64	3.46	13.21	276.07
MADHYA PRADESH	3.15	6.40	147.57	2.29	5.59	269.20
MAHARASHTRA	3.07	6.76	141.39	2.16	8.93	279.71
MANIPUR	2.50	9.13	135.49	1.00	8.00	290.00
MEGHAYALA	3.12	10.28	158.63	1.54	**11.47**	297.25
ORISSA	2.50	9.24	152.52	1.32	52.62	398.68
PUNJAB	3.17	8.55	147.81	1.83	12.03	320.54
RAJASTHAN	2.94	7.34	147.90	2.66	**12.15**	280.56
TAMIL NADU	3.03	8.05	145.78	3.27	**11.24**	290.53
TRIPURA	2.88	5.36	152.01	2.67	15.63	267.41
UTTAR PRADESH	2.93	7.52	148.62	2.10	9.47	229.28
WEST BENGAL	2.82	6.36	145.93	2.68	9.30	265.48
DELHI	3.63	8.57	146.26	3.15	13.80	346.37
GOA	4.00	8. 10	144.34	0.01	0.01	0.01
PONDICHERRY	2.50	4. 10	61.90	3.00	10.50	241.34

TABLE 5

RURAL - 38TH ROUND

STATES	0-100			100-200		
	FS	FL	TCP	FS	FL	TCP
ANDHRA PRADESH	4.93	4.37	56.00	4.28	8.11	139.64
ASSAM	5.51	5.01	53.00	4.91	10.59	119.44
BIHAR	5.65	4.83	56.68	4.96	7.84	138.83
GUJARAT	6.52	5.29	57.18	5.24	9.71	140.04
HARYANA	6.83	5.74	56.86	6.19	9.90	140.48
HIMACHAL PR.	5.80	6.75	53.64	5 32	13.11	140.25
JAMMU & KASHMIR	7.55	6.76	57.78	5 45	11.58	139.49
KARNATAKA	5.78	6.57	56.74	5.35	11.10	139.94
KERALA	6.48	5.25	56.96	5 14	8.85	140.39
MADHYA PRADESH	5.90	5.13	56.43	5 08	8.98	139.90
MAHARASHTRA	5.24	6.29	56.56	4,77	10.72	140.17
MANIPUR	5.04	5.60	53 54	5.31	10.07	138.88
ORISSA	5.21	5.19	56.44	4.74	9.37	138.53
PUNJAB	6.40	5.60	56.80	5.92	11 16	140.13
RAJASTHAN	5.92	5.29	56.80	5.64	8.70	140,05
TAMIL NADU	4.86	5.26	56,36	3.93	9 20	139.97
UTTAR PRADESH	5.81	5.87	56.84	4.91	9 86	139,71
WEST BENGAL	5.47	4.65	56.66	5.23	8.03	139.46
ANDAMAN & NIC.	5.07	3.50	54 34	5.02.	6 89	140,50
DELHI	4.28	2.61	24,28	5.97	11.72	141.79
GOA	4.60	4.43	42.24	5.04	10.,32	139.42
PONDICHERRY	4.76	3.96	55.65	4.02	9,47	140,28

TABLE 6

	200-300			300 & ABOVE		
	FS	FL	TCP	1	FL	TCP
ANDHRA PRADESH	3.61	10.24	246.12	3.47	14.27	432.77
ASSAM	3.30	16.04	243.81	3.15	17.68	368.53
BIHAR	4.16	10.40	250.21	3.34	14.45	440.72
GUJARAT	4.16	12.94	246.72	4.09	14.53	443.58
HARYANA	5.35	13.06	247.51	4.65	16.03	397.58
HIMACHAL PR.	3.49	22.58	248.16	2.83	25.07	457.19
JAMMU & KASHMIR	4.40	16.21	247.97	5.07	15.91	381.11
KARNATAKA	4.86	13.69	248.64	4.24	18.90	449.62
KERALA	4.55	11.79	246.83	3.86	16.88	534.87
MADHYA PRADESH	4.25	12.52	247.42	4.03	16.49	422.78
MAHARASHTRA	4.34	13.11	246.22	3.58	16.30	412.02
MANIPUR	3.46	15.66	243.31	3.10	16.66	357.76
ORISSA	3.93	15.59	250.29	2.93	18.04	384.00
PUNJAB	5.20	14.49	245.98	4.67	18.34	436.89
RAJASTHAN	4.48	11.30	246.65	3.79	16.35	494.56
TAMIL NADU	3.62	12.49	246.89	2.96	16.88	467.48
UTTAR PRADESH	3.88	13.44	246.08	3.69	19.16	444.15
WEST BENGAL	4.92	11.33	246.35	3.92	16.26	398.85
ANDAMAN & NIC.	3.03	12.38	248.68	2.00	13.97	406.70
DELHI	2.74	16.56	250.42	4.03	16.03	429.23
GOA	4.27	13.79	246.17	2.67	19.02	447.50
PONDICHERRY	4.38	12.01	237.36	2.13	12.32	331.71

APPENDIX D

I. REGRESSIONS WITH FUEL AND LIGHT AND TOTAL EXPENDITURE

FUEL AND LIGHT AS A FUNCTION OF TOTAL EXPENDITURE - FOR 4 ROUNDS

RURAL - LINEAR FL = a + 8 TE

ROUNDS -	27	32	38	44	4 COMBINED
a	0.9277	2.8660	1.8632	4.2441	-0.5144
	2.8946	1.4472	1.1287	2.6610	-1.2845
β	0.0350	0.0237	0.0542	0.0485	0.0722
	5.1852	0.9612	3.9581	5.6729	21.7176
R	0.6490	0.0664	0.5116	0.6901	0.8886
D-W	2.5262	2.3717	2.9128	2.2266	2.4347

URBAN - LINEAR

ROUNDS -	**27**	**32**	**38**	**44**	**4 COMBINED**
a	4.4819	2.7841	-0.8367	-1.0018	-1.0887
	1.6138	1.8148	-0.2859	-0.1918	-2.7348
β	-0.0099	0.0272	0.0732	0.0726	0.0727
	-0.2263	1.8509	4.1178	3.6465	30.3729
R^2		0.1477	0.5326	0.4676	0.9398
D-W	2.3253	3.0106	2.4559	2.5507	2.1856

TOTAL - LINEAR

ROUNDS -	27	32	38	44	4 COMBINED
a	3.1647	4.1179	0.0106	2.0712	-2.0402
	1.3438	1.1215	0.0026	0.2593	-3.2471
β	0.0298	0.0342	0.0688	0.0653	0.0742
	1.3891	1.7068	4.7012	3.6453	33.6867
R^2	0.0623	0.1202	0.6012	0.4674	0.9505
D-W	2.3554	2.7065	2.8436	2.1277	2.2880

RURAL - QUADRATIC FL = a + β TE + TE^2

ROUNDS -	27	32	38	44	4 COMBINED
a	0.5076	-4.9325	-0.7398	29.2739	-1.1219
	0.2486	-0.4877	-0.0698	3.0145	-1.4987
β	0.0514	0.2111	0.0954	-0.2082	0.0846
	0.6515	0.8815	0.5732	-2.1047	6.3658
y	-0.0001	-0.0010	-0.0002	0.0006	-0.0001
	-0.2086	-0.7868	-0.2487	2.6019	-0.9607
R^2	0.6211	0.1122	0.4736	0.7854	0.8885
D-W	2.5405	2.4622	2.8825	2.8459	2.4154

URBAN - QUADRATIC

ROUNDS -	**27**	**32**	**38**	**44**	**4 COMBINED**
a	53.4532	-16.5092	28.4626	-0.3343	-0.2969
	2.2476	-1.7919	0.9477	-0.0057	-0.3355
fi	-1.5289	0.3925	-0.2888	0.0675	0.0605
	-2.0811	2.2688	-0.7810	0.1526	4.8928
y	0.0116	-0.0017	0.0011	0.00001	0.00003
	2.0704	-2.1175	0.9802	0.0114	1.0012
R^2	0.1438	0.3278	0.5312	0.4233	0.9398
D-W	2.5873	2.6808	2.6531	2.5494	2.2610

TOTAL - QUADRATIC

ROUNDS -	**27**	**32**	**38**	**44**	**4 COMBINED**
a	20.5450	-13.1539	15.0060	-1.2964	-1.1806
	1.1103	-0.5514	0.4478	-0.0179	-0.8258
β	-0.2653	0.2184	-0.0352	0.0804	0.0665
	-0.8494	0.8663	-0.1525	0.2509	5.6419
γ	0.0012	-0.0005	0.0002	-0.00002	0.00001
	0.9470	-0.7330	0.4512	-0.0471	0.6700
R^2	0.0548	0.2181	0.5751	0.4232	0.9501
D-W	2.4778	2.7049	2.9542	2.1257	2.3076

RURAL - INVERSE FL = a + **β** TE + **γ** 1/TE

ROUNDS -	27	32	38	44	4 COMBINED
a	1.5878	18.8117	13.0370	-42.4278	0.2257
	0.4282	1.0402	0.6412	-2.1053	0.1582
β	0.0289	-0.0673	0.0107	0.1648	0.0689
	0.8282	-0.6375	0.1331	3.2549	9.8279
γ	-16.6611	-649.0411	-695.4018	4507.8860	-30.4501
	-0.1787	-0.8871	-0.5515	2.3213	-0.5407
R^2	0.6208	0.1238	0.4840	0.7683	0.8872
D-W	2.5404	2.4022	2.7937	2.9343	2.4216

URBAN - INVERSE

ROUNDS -	**27**	**32**	**38**	**44**	**4 COMBINED**
a	-98.8267	39.0705	-55.2996	-15.2396	-4.0574
	-2.1858	1.9478	-0.9356	-0.1286	-2.5836
β	0.7850	-0.1425	0.2409	0.0994	0.0824
	2.2458	-1.5068	1.3193	0.4437	15.0249
y	3312.0070	-1896.5870	4385.7520	1871.6510	170.6001
	2.2882	-1.8135	0.9226	0.1202	1.9511
R^2	0.1909	0.2753	0.5272	0.4239	0.9426
D-W	2.7016	2.8016	2.6324	2.5387	2.3486

TOTAL - INVERSE

ROUNDS -	27	32	38	44	4 COMBINED
a	-32.2366	48.1672	-21.6831	7.1961	-5.3370
	-0.9170	0.9986	-0.3289	0.0499	-2.1210
β	0.1771	-0.0812	0.1063	0.0596	0.0805
	1.2005	-0.6364	0.9277	0.3680	15.6013
y	2066.8360	-4080.9380	3100.1650	-1139.7880	323.1748
	1.0092	-0.9159	0.3298	-0.0356	1.3524
R^2	0.0636	0.1092	0.5718	0.4231	0.9512
D-W	2.5136	2.6479	2.9322	2.1258	2.3593

RURAL - SEMI-LOG FL = a + β LOG TE

ROUNDS -	27	32	38	44	4 COMBINED
	-4.4970	-4.9360	-24.7510	-7.2232	-24.4182
	-3.2953	-0.5440	-3.0053	1.0846	-11.7075
β	4.2590	5.1408	15.9736	9.1465	16.1519
R^2	5.1661	1.0641	4.0156	3.0626	15.2580
	0.6473	0.0801	0.5193	0.3744	0.7971
	2.5608	2.3952	2.8504	1.7101	1.6535

URBAN - **SEMI-LOG**

ROUNDS -	27	32	38	44	4 COMBINED
a	7.7789	-8.6712	-48.5519	-88.6248	-38.1741
	0.6603	-1.2220	-3.2538	-3.0182	-15.8156
β	-2.1870	7.1006	26.9889	44.1342	22.6904
	-0.3330	2.0110	4.0026	3.6303	19.9347
R^2	0.	0.2373	0.5176	0.4652	0.8704
D-W	2.3346	2.9914	2.4222	2.5624	1.1417

II. REGRESSIONS WITH FOUR TYPES OF FUELS

FOR THREE ROUNDS AND FOR FOUR FUELS - LINEAR

RURAL - COKE

ROUNDS -	27	32	38	3 COMBINED
a	119.7368	250.8366	168.7696	43.67119
	(1.719796)	(1.524874)	(0.3797685)	(0.31236)
β	-0.0000159	-0.00003498	0.001282140	0.00615
	(-0.4551528)	(-0.3126216)	(1.003762)	(2.47989)
R^2	0.0127823	0.0060712	0.059241	0.88563
D-W	1.45652	1.106858	1.43937	1.82076

RURAL - FUELWOOD

ROUNDS -	27	32	38	3 COMBINED
a	4699.339	7725.067	3853.255	1628.735
	(6.199814	7.191116	2.244341	2.985
β	-0.0003198	-0.00102224	0.04249427	0.466
	(-0.8361141	-1.399018	8.611172	19.415
R	0.041864	0.05330729	0.811430	0.876
D-W	2.361457	1.726234	1.450367	1.5584

RURAL - KEROSENE

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	1235.017	2336.251	1841.360	28.35678
	(5.455449	6.198563	0.3286535	0.019063
β	-0.0000536	-0.00030035	0.01871776	0.2143999
	(-0.4689169	-1.171586	1.162316	3.276103
R^2	0.01355634	0.0214484	0.02022819	0.15515
D-W	1.7851621	1.2450234	1.245023	1.3164

RURAL - ELECTRICITY

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	1023.114	3409.007	10250.74	216.7667
	(3.882740	5.864150	2.914772	1.840137
β	-0.000002781	-0.0005353	0.00359239	0.01829
	(-0.02091606	-1.353817	0.3553891	3.530989
R^2	0.00002743	0.1027779	0.00783201	0.17789
D-W	2.501457	2.5998478	2.48205416	1.78979

FOR THREE ROUNDS AND FOR FOUR FUELS - LINEAR

URBAN - COKE

ROUNDS -	27	32	38	3 COMBINED
a	119515.5	5568.141	123854.500000	152.6270
	(1.661483	2.157867	2.180009	0.68687
β	-178.9967	0.1530343	-4.555454	0.08340
	(-1.166897	0.3318739	-1.264554	3.87193
R^2	0.0784286	0.0068367	0.090863	0.20886
D-W	2.2320342	0.7640391	0.034041	1.42957

URBAN - **FUELWOOD**

ROUNDS -	27	32	38	3 COMBINED
a	1186999.00000	570307.50000	1120544.0000	472.5425
	(2.79697	1.14387	1.461437	1.801434
β	-1830.67000	-44.07781	-47.05266	0.241595
	(-2.02285	-0.49472	-0.9678202	9.501163
R^2	0.15389	0.01507	0.0553046	0.62747
D-W	2.32283	2.17938	2.1922526	2.40569

URBAN - KEROSENE

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	76421.670000	62565.770000	67065.290000	-181.6574
	(1.533698	1.408463	1.729358	-1.24496
β	-110.40860	-2.184683	-0.5812842	0.25074
	(-1.039064	-0.2752118	-0.2363933	17.72737
R^2	0.063213	0.0047115	0.00348046	0.8552
D-W	1.956039	2.2254942	2.21759672	2.00488

URBAN - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	638198.6000000	110827.200000	110056.100000	26427.340
	(1.8700500	2.423929	2.123527	1.73684
β	-928.756200	9.764573	15.905480	11.42006
	(-1.276190	1.195079	4.840052	7.74259
R^2	0.081948	0.024570	0.568814	0.52656
D-W	2.000569	2.315709	2.833570	1.88850

FOR THREE ROUNDS AND FOR FOUR FUELS - LINEAR

TOTAL - COKE

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	58595.1000000	6529.83300000	167399.9000000	
	(1.0632930	2.54101800	2.4500230	
β	-0.000150	-0.00069113	-0.3148413	0.042236
	(-0.0054240	-0.39551610	-1.6683730	3.734378
R^2	0.0000018	0.00968240	0.0949489	0.19630
D-W	2.1507305	2.05412890	1.9611581	1.683856

TOTAL - **FUELWOOD**

ROUNDS -	27	32	38	3 COMBINED
a	263587.3000000	513534.800000	1477821.000000	1753.839
	(0.9379889	1.094694	1.566870	2.789506
β	0.4200032	-0.104662	-2.904332	0.415503
	(2.9621500	-0.328106	-1.114920	21.42539
R^2	0.3138060	0.006683	0.0720899	0.89630
D-W	2.1365203	2.143372	2.2797467	1.75452

TOTAL - KEROSENE

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	-4509.8500000	64778.4800000	93244.460000	-271.7304
	(-0.2012745	1.5644110	1.967671	-0.18687
β	0.0616492	-0.0118495	-0.085803	0.23017
	(5.4530030	-0.4208445	-0.655569	5.13178
R^2	0.6501604	0.0109482	0.026158	0.32342
D-W	1.9995239	2.2233063	2.237190	1.48013

TOTAL - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	21217.630000	150984.300000	154643.100000	14098.9500
	(0.129950	3.438034	1.654928	0.8533
β	0.417470	-0.024444	0.479696	3.8990
	(5.067410	-0.818576	1.858667	7.6501
R^2	0.592117	0.040196	0.126173	0.52047
D-W	2.023992	2.470779	2.586685	2.02398

FOR THREE ROUNDS AND FOR FOUR FUELS - QUADRATIC

$$FL(i) = a + \beta\ FL + \gamma\ FL^2$$

RURAL - COKE

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	-96.73657	-252.0485	-429.8661	-147.3046
	-0.6515996	-0.6332522	-0.6479869	-0.8274713
β	0.0480076	0.056999	0.05285086	0.036668
	1.501599	1.224665	1.484582	2.608197
γ	-0.00000168	-0.000001042	-0.00000045	-0.0000003059
	-1.300394	-0.9525456	-1.202239	-1.687097
R^2	0.01989745	0.1059274	0.02751353	0.119814
D-W	1.27851094	1.1598027	1.1151701	1.6533702

RURAL - FUELWOOD

ROUNDS -	27	32	38	3 COMBINED
a	1432.972	11.49282	-699.2755	43.67482
	1.806641	0.01106659	-0.3208879	0.0701234
β	0.3863856	0.6524673	0.7293605	0.6438544
	2.262084	5.372845	6.236866	13.08982
γ	0.0000034	-0.00000549	-0.00000341	-0.0000025387
	0.4948344	-1.924303	-2.783256	-4.002236
R	0.7708766	0.855011	0.867359	0.
D-W	2.7002	1.4661622	1.700947	1.8127565

RURAL - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	173.3949	-444.9082	-4281.652	-1676.845
	0.7551730	-1.867682	-0.5037127	-0.8781153
3	0.1489307	0.2413296	0.5966100	0.4056068
	3.011951	8.663668	1.307920	2.689540
γ	-0.00000048	-0.0000021	-0.00000459	-0.0000027
	-0.2412093	-3.309139	-0.9596918	-1.404299
R^2	0.7783876	0.935942	0.0153671	0.170651
D-W	1.49738	1.412007	0.9717261	1.03739

RURAL - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	93.63097	53.94181	403.6986	-71.44582
	1.565552	0.3903847	0.7971460	-0.5087076
β	0.00295294	0.032939	0.04514239	0.0506174
	0.2292746	2.038648	1.661056	4.563581
γ	-0.000000154	-0.000000677	-0.000000465	-0.0000004616
	-0.2949607	-1.785393	-1.634668	-3.227227
R^2	0.0068963	0.1173465	0.0455681	0.303916
D-W	2.5580046	2.93262	2.780191	2.128254

FOR THREE ROUNDS AND FOR FOUR FUELS - QUADRATIC

FLU) = a + β FL + γ FL^2 URBAN - COKE

ROUNDS -	27	32	38	3 COMBINED
a	48.78267	-171.7639	-497.7277	-102.8938
	0.2916915	-0.4282710	-0.5114319	-0.3900154
3	0.2004222	0.2320221	0.2354053	0.1699620
	1.446224	1.846037	1.711098	3.116361
γ	-0.00001961	-0.000009795	-0.000004669	-0.00000308
	-0.9146324	-1.260902	-1.209939	-1.721817
R^2	0.0982184	0.1539809	0.12233107	0.23766148
D-W	1.1195250	0.9879423	1.16396865	1.39368655

URBAN - FUELWOOD

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	309.7937	9.746240	379.0825	328.6794
	1.209047	0.0193936	0.3285643	1.032426
β	0.2973949	0.4893186	0.2845695	0.2903302
	1.400670	3.106973	1.744768	4.411456
y	-0.000007099	-0.000016359	-0.0000015162	-0.000001735
	-0.2160585	-1.680650	-0.3314413	-0.8033479
R	0.3856521	0.53253506	0.49087941	0.62491636
D-W	2.19299832	1.66011503	2.22851407	2.36551397

URBAN - KEROSENE

ROUNDS -	27	32	**38**	3 COMBINED
a	146.9014	252.1965	134.3050	56.25670
	1.251681	1.041090	0.2493364	0.3347097
β	-0.012359	0.019289	0.1279790	0.1701479
	-0.127081	0.254094	1.680719	4.896932
y	0.000036	0.000018	0.000003971	0.00000286986
	2.439767	3.859353	1.859290	2.516415
R^2	0.72768375	0.88418394	0.86226469	0.86875268
D-W	2.01330909	1.49858334	1.77506347	1.87769539

URBAN - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	7333.116	10640.89	-48385.00	-24420.14
	1.094752	0.863322	-1.125229	-1.794860
β	22.25469	5.806823	36.37610	28.64531
	4.009410	1.503343	5.984240	10.18449
y	-0.00210512	0.000815	-0.0008409	-0.00061335
	-2.450867	3.417410	-4.932396	-6.643852
R^2	0.63454133	0.91488395	0.6923162	0.74123973
D-W	2.07957399	2.15766343	1.4576948	1.84009877

FOR THREE ROUNDS AND FOR FOUR FUELS - QUADRATIC TOTAL

TOTAL - COKE

ROUNDS -	27	32	38	3 COMBINED
a	-187.6843	-472.9738	-1187.507	-369.3512
	-0.4793454	-0.5446947	-0.6648231	-0.7903133
β	0.09494	0.0971676	0.1081753	0.07683
	1.396229	1.246637	1.517875	2.787247
y	-0.00000213	-0.000001006	-0.00000058	-0.0000003745
	-0.9212228	-0.6795620	-1.007848	-1.373869
R^2	0.06926354	0.0773186	0.0926295	0.20979398
D-W	1.10487298	1.0839904	1.1418474	1.52953969

TOTAL - **FUELWOOD**

ROUNDS -	27	32	38	3 COMBINED
a	1281.517	846.6871	1312.734	888.6801
	1.309445	0.5516302	0.4579613	1.120734
β	0.4075638	0.4916695	0.5006756	0.4896936
	2.397870	3.568623	4.377702	10.47044
y	0.00000197	-0.00000185	-0.000000938	-0.000000803
	0.3399828	-0.7068045	-1.003379	-1.736535
R^2	0.7836595	0.79399567	0.85078151	0.90016123
D-W	2.46601131		1.6071715	1.86924520

TOTAL - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	-181.7914	-756.7380	-5830.021	-2016.491
	-0.5461212	-1.165376	-0.7389345	-1.091823
β	0.2616160	0.2819191	0.5680293	0.3797950
	4.525297	4.836678	1.804447	3.486493
y	-0.00000428	-0.0000020	-0.00000302	-0.0000016196
	-2.172990	-1.841076	-1.172800	-1.503565
R^2	0.76613591	0.82167434	0.17040257	0.33943466
D-W	1.8947494	2.34142350	1.09930159	1.18925754

TOTAL - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	-1831.141	-29861.39	8387.836	-14806.42
	-0.148296	-0.7968987	0.1066361	-0.7238107
β	5.550033	7.177146	6.082125	6.377771
	2.588023	2.133768	1.937972	5.286003
y	-0.000102	-0.0000405	-0.0000263	-0.00002683
	-1.392052	-0.6333177	-1.028412	-2.248972
R^2	0.451730	0.5035256	0.2891662	0.5551807
D-W	1.6812445	2.2678389	1.80233824	1.91149838

FOR THREE ROUNDS AND FOR FOUR FUELS - INVERSE

FLU) **= a + β (FL) + y** (1/FL)

RURAL - COKE

ROUNDS -	27	32	38	3 COMBINED
a	77.67206	60.3943500	282.586800	68.959670
	0.505419	0.1688392	0.461065	0.395653
β	0.006690	0.0142197	0.010673	0.014588
	0.470320	0.7192537	0.700202	2.155758
y	-47628.080000	-74866.3500000	-644257.400000	-68107.390000
	-0.315601	-0.1478485	-0.279287	-0.247120
R^2	0.043766	0.0532251	0.064107	0.071803
D-W	1.670074	1.4179353	1.425553	1.813309

RURAL - FUELWOOD

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	920.84450	2142.7270	5869.1840	1942.7820
	117613	2.1952	2.6188	2.8715
β	0.48152	0.4063	0.3869	0.4578
	6.64311	7.5315	6.9413	17.4299
y	313620.10000	-1480002.0000	-11411088.0000	-845796.5000
	0.40791	-1.0711	-1.3528	-0.7906
R^2	0.76969	0.8321	0.8207	0.8755
D-W	2.81042	1.2949	1.4552	1.5864

RURAL - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	63.3296	235.8393	3353.7480000	48.267300
	0.2880	0.8718	0.4341508	0.026013
β	0.14840	0.1511	0.1586255	0.213876
	7.28962	10.1028	0.8257024	2.968844
y	206633.40000	-225412.5000	-8560812.0000000	-53623.370000
	0.95693	-0.5886	-0.2944471	-0.018276
R^2	0.79033	0.8917	0.0831611	0.138588
D-W	1.42889	1.6495	1.2125451	1.315571

RURAL - ELECTRICITY

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	135.4415	346.3947	1489.6630	296.0144
	2.3307	2.7732	3.2988	2.0314
3	-0.0027	0.0013	-0.0052	0.0162
	-0.4929	0.1885	-0.4611	2.8657
y	-39954.3500	-248492.2000	-2629789.0000	-213431.3000
	-0.7001	-1.4053	-1.5473	-0.9263
R^2	0.0328	0.0543	0.0303	0.1756
D-W	2.4927	2.6322	2.5860	1.8382

URBAN - COKE

ROUNDS -	27	32	38	3 COMBINED
a	86.6887	195.6310	321.7943	156.9845
	0.4971	0.4803	0.3728	0.6465
3	0.0883	0.0778	0.0758	0.0831
	1.7189	1.4628	1.4693	3.6914
y	971.5054	-6271.0030	-2053.5170	-235.1586
	0.3815	-0.2528	-0.1517	-0.0469
R^2	0.0571	0.0683	0.0381	0.1934
D-W	1.1006	0.9335	1.2039	1.4293

URBAN - FUELWOOD

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	142.2446	698.5098	720.9502	451.6521
	0.5891	1.3320	0.7360	1.5761
β	0.2968	0.2237	0.2291	0.2429
	4.1707	3.2697	3.9130	9.1405
y	5704.9300	-18449.3200	-3384.5430	1127.3830
	1.6181	-0.5777	-0.2204	0.1906
R	0.4753	0.4566	0.4888	0.6204
D-W	2.0111	1.9552	2.2575	1.6287

URBAN - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	-74.10140	-517.90050	-670.98060	-249.59300
	-0.55427	-1.62609	-1.34814	-1.58459
β	0.23053	0.31409	0.26897	0.25501
	5.85173	7.55803	9.04281	17.45847
y	2612.61900	21239.11000	5631.92200	3666.26100
	1.33846	1.09510	0.72169	1.12760
R^2	0.66020	0.78627	0.83621	0.85605
D-W	2.14807	1.75001	1.90110	1.96511

URBAN - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	9976.91100	-24790.55000	106170.70000	27173.60000
	1.30277	-1.62117	1.82711	1.63436
β	10.53797	19.16641	7.29171	11.37316
	4.66979	9.60592	2.09974	7.37633
y	146336.90000	1034943.00000	-619084.00000	-40273.43000
	1.30876	1.11142	-0.67948	-0.11735
R^2	0.54065	0.86013	0.21737	0.51741
D-W	1.62292	2.49519	1.97807	1.89019

TOTAL - COKE

ROUNDS -	27	32	38	3 COMBINED
a	134.8820	-51.3729	248.6186	69.8872
	0.3526	-0.0623	0.1504	0.1541
β	0.0326	0.0473	0.0389	0.0416
	1.1779	1.4469	1.3207	3.3490
y	-121903.6000	-31728.3900	-856729.8000	-125891.6000
	-0.2405	-0.2427	-0.1328	-0.1367
R^2	0.0204	0.0489	0.0323	0.1808
D-W	1.3774	1.2738	1.3990	1.6822

TOTAL - FUELWOOD

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	1383.2880	2234.7910	4677.9980	2201.7710
	1.4925	1.5547	1.7986	2.8586
β	0.4434	0.3805	0.3750	0.4072
	6.6046	6.6887	8.0973	19.3167
y	-660381.4000	-1581886.0000	-7964193.0000	-1574265.0000
	-0.5379	-0.6945	-0.7848	-1.0065
R	0.7861	0.7938	0.8470	0.8963
D-W	2.4497	1.4268	1.3573	1.7173

TOTAL - KEROSENE

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	547.6183	141.8966	1655.1340	-299.1510
	1.5430	0.2110	0.2243	-0.1663
3	0.1322	0.1794	0.2104	0.2307
	5.1427	6.7410	1.6010	4.6854
y	-404206.2000	-174817.3000	-5040869.0000	96370.3600
	-0.8597	-0.1641	-0.1751	0.0264
R^2	0.7070	0.7818	0.0962	0.3102
D-W	1.9633	2.2372	.	1.4807

TOTAL - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	17729.4000	-18540.2100	101769.2000	21022.8500
	1.4533	-0.5226	1.4229	1.0319
β	2.3539	5.3477	2.5660	3.7704
	2.6639	3.8084	2.0148	6.7622
y	-13915930.0000	12728284.0000	-216185045.0000	-24334160.0000
	-0.8611	0.2264	-0.7747	-0.5882
R^2	0.4101	0.4920	0.2683	0.5144
D-W	1.7559	2.2832	1.8431	2.0169

SEMI LOG (1) FL(i) **= a +** β LOG (FL) **RURAL - COKE**

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	-463.2620	-1283.2470	-2873.8680	-1703.3420
	-0.8249	-0.8519	-1.0129	-2.0656
|3	67.0906	165.1636	341.9573	216.3421
	1.0242	1.0126	1.2060	2.4372
R^2	0.0029	0.0015	0.0261	0.0854
D-W	1.6110	1.3108	1.3463	**1.6019**

RURAL - FUELWOOD

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	-13720.0400	-28911.8200	-75053.2300	-44126.5200
	-3.0602	-5.0827	-5.7080	-8.1067
β	2135.2240	3934.5750	9132.6150	5783.8150
	4.0830	6.3875	6.9498	9.8709
R^2	0.4797		0.7356	0.6453
D-W	2.3336	1.3407	1.4319	1.7969

RURAL - KEROSENE

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	-4094.5520	-10311.9200	-39524.3600	-21481.6800
	-3.0656	-5.2858	-1.1019	-2.3967
β	621.1118	1361.0620	**4685.8350**	2710.6800
	3.9868	6.4426	1.3071	2.8095
R	0.4670	0.7044	0.0965	0.1151
D-W	1.3817	1.0533	1.0690	0.9632

RURAL - ELECTRICITY

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	50.4404	-676.5347	-1673.0940	-2211.8870
	0.2319	-1.2974	-0.7700	-3.2926
β	6.0683	107.9627	280.9938	295.6195
	0.2391	1.9120	1.2941	4.0879
R	0.0036	0.1351	0.0382	0.2287
D-W	2.4486	2.7042	2.4981	1.9469

FLU) = a + β LOG (FL)

URBAN - COKE

ROUNDS -	27	32	38	3 COMBINED
a	-164.9435	-928.3435	-1315.9530	-976.3718
	-0.5094	-1.0220	-0.6860	-1.5926
|3	72.9744	195.5602	299.9967	223.2595
	1.5264	1.7194	1.3831	2.8817
R^2	0.0726	0.1032	0.0510	0.1211
D-W	1.0153	0.8078	0.9973	1.1370

URBAN - FUELWOOD

ROUNDS -	27	32	38	3 COMBINED
a	-295.1194	-2340.2330	-3099.5990	-2440.4330
	-0.5279	-1.8348	-1.1699	-2.6359
β	187.9181	537.3445	778.3456	599.5422
	2.2763	3.3646	2.5980	5.1243
R	0.1974	0.3778	0.2527	0.3228
D-W	2.3194	1.8141	1.9699	2.0095

URBAN - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	-448.7356	-2276.2690	-3358.7680	-2459.6200
	-1.2246	-1.7081	-1.4277	-2.9459
β	146.5744	456.0588	716.0947	523.8567
	2.7090	2.7330	2.6918	4.9648
R	0.2716	0.2757	0.2687	0.3085
D-W	1.6950	2.3896	2.6744	2.3114

URBAN - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	-17292.3300	-147494.9000	-143658.7000	-136875.0000
	-1.0424	-1.9595	-1.1551	-2.9157
β	8357.3590	29677.1200	39101.8900	31720.5100
	3.4120	3.1487	2.7805	5.3471
R^2	0.3850	0.3440	0.2836	0.3424
D-W	2.0822	2.0411	1.8353	1.6899

FL(i) = a + β LOG (FL) **TOTAL** - COKE

ROUNDS -	27	32	38	3 COMBINED
a	-2098.7230	-4314.2110	-10179.6800	-6143.0250
	-1.3455	-1.3155	-1.3678	-2.7754
β	284.6076	542.2105	1163.2470	750.5384
	1.6172	1.5761	1.6152	3.2538
R^2	0.0868	0.0803	0.0865	0.1532
D-W	1.2309	1.0285	1.1818	1.3729

TOTAL - FUELWOOD

ROUNDS -	27	32	38	3 COMBINED
a	-22267.1600	-33735.8100	-85537.1400	-55912.5400
	-4.2227	-4.4293	-4.8389	-8.2312
β	3135.7570	4516.5820	10213.9900	7057.9670
	5.2706	5.6531	5.9710	9.9703
R^2	0.6117	0.6455	0.6709	0.6499
D-W	1.8705	1.4142	1.4426	1.7098

TOTAL - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	-7695.2620	-15528.6400		-31802.7900
	-4.7881	-4.2814		-3.4764
β	1064.1230	2003.3830	6261.9430	3866.4020
	5.8684	5.2657	1.9397	4.0555
R	0.6630	0.6112	0.1398	0.2257
D-W	1.6579	2.0273	1.1236	1.0362

TOTAL - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	-156689.4000	-426341.3000	-774005.8000	-577058.4000
	-3.1809	-2.6151	-2.4406	-5.4969
β	21890.3500	53773.3400	93925.7800	71481.9100
	3.9387	3.1444	3.0605	6.5338
R^2	0.4605	0.3433	0.3298	0.4403
D-W	1.2917	2.0371	1.5641	1.7138

THREE ROUNDS - FOUR FUELS - SEMI LOG

LOG FL (i) = a + β (FL) RURAL - COKE

ROUNDS -	27	32	38	3 COMBINED
a	2.71599	-1.39373	4.24323	0.97339
	2.24567	-0.89598	9.63519	1.52087
β	-0.00015	0.00015	0.00004	
	-1.11696	1.52527	3.04071	3.36405
R^2	0.01436	0.07238	0.32662	0.16294
D-W	1.55616	1.01769	1.83809	1.48051

RURAL - FUELWOOD

ROUNDS -	27	32	38	3 COMBINED
a	7.42680	7.59810	8.46549	7.93675
	33.94085	30.18405	34.59828	63.14764
β	0.00010	0.00008	0.00003	0.00005
	4.25841	4.84931	4.70847	8.75704
R^2	0.50196	0.56979	0.55462	0.58814
D-W	2.15236	1.55061	1.55273	1.92069

RURAL - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	5.75679	6.07241	6.86488	6.41976
	19.47630	21.97454	18.08144	38.83121
β	0.00013	0.00009	0.00004	0.00006
	4.07039	5.43658	3.93187	8.00888
R^2	0.47802	0.62684	0.45962	0.54366
D-W	1.47244	1.36375	1.64245	1.74134

RURAL - ELECTRICITY

ROUNDS -	**27**	**32**	**38**	**3 COMBINED**
a	2.93016	4.03324	6.47815	3.90559
	2.43356	5.04993	16.57682	8.27868
β	0.00002	0.00008	0.00001	0.00006
	0.13677	1.62842	0.68013	3.09943
R^2	0.00117	0.08856	0.02809	0.13970
D-W	1.75405	d-w	2.04928	1.63013

URBAN - COKE

ROUNDS -	27	32	38	3 COMBINED
a	3.13173	2.57382	4.16405	3.64811
	4.04452	2.63025	6.72766	8.93142
β	0.00047	0.00035	0.00013	0.00017
	1.94053	2.50461	3.30646	4.31831
R^2	0.13992	0.23675	0.36879	0.24979
D-W	1.65404	1.59549	1.46993	1.63821

URBAN - **FUELWOOD**

ROUNDS -	27	32	38	3 COMBINED
a	5.42553	6.07483	6.70630	6.21426
	15.67669	19.80688	21.15353	35.00863
β	0.00036	0.00018	0.00008	0.00011
	3.27997	4.06429	3.96602	6.61281
R^2	0.36468	0.47722	0.46422	0.44635
D-W	1.95449	1.89279	2.10825	2.11229

URBAN - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	4.36312	5.20961	5.74203	5.34012
	12.79257	22.41478	19.48769	30.16483
β	0.00047	0.00024	0.00012	0.00016
	4.41815	7.32931	6.51919	9.11059
R	0.52140	0.75616	0.70940	0.60742
D-W	1.41366	1.59353	1.51891	1.58504

URBAN - ELECTRICITY

ROUNDS	27 .	32	38	3 COMBINED
a	8.95436	9.35494	11.04187	9.96396
	23.25431	35.33001	22.84277	44.08525
fi	0.00042	0.24263	0.00004	0.00011
	3.46469	6.49304	1.47746	5.13199
R^2	0.39294	0.70770	0.06506	0.32344
D-W	2.11137	2.13445	2.19725	2.06231

TOTAL - COKE

ROUNDS -	27	32	38	3 COMBINED
a	3.69564	2.09766	4.91180	3.97416
	5.95531	2.04143	10.24300	10.73568
|3	0.00012	0.00014	0.00004	0.00006
	2.18763	2.98537	3.85379	4.96263
R	0.18213	0.31761	0.44898	0.30834
D-W	1.22286	1.51482	1.51473	1.57728

TOTAL - FUELWOOD

ROUNDS -	27	32	38	3 COMBINED
a	7.48353	7.75051	8.58344	8.10432
	34.60607	31.66977	36.61560	65.20392
β	0.00009	0.00006	0.00002	0.00003
	4.85857	5.25788	5.25519	9.12617
R^2	0.57077	0.61049	0.61024	0.60824
D-W	1.97138	1.54958	1.51941	2.00063

TOTAL - KEROSENE

ROUNDS -	27	32	38	3 COMBINED
a	5.91826	6.40224	7.16606	6.74381
	19.27062	24.88809	21.22133	41.87765
β	0.00012	0.00007	0.00003	0.00004
	4.45857	6.28559	4.94425	8.90010
R^2	0.52618	0.69374	0.57968	0.59607
D-W	1.37840	1.32092	1.71782	1.72458

TOTAL - ELECTRICITY

ROUNDS -	27	32	38	3 COMBINED
a	8.66026	9.14031	10.78694	9.78705
	19.15487	26.86661	22.00649	42.11162
β	0.00013	0.00008	0.00002	0.00004
	3.44366	5.46417	.	5.73138
R^2	0.38978	0.62928	0.16225	0.37536
D-W	1.85546	2.02567	2.10038	2.01687

III. REGRESSIONS WITH FAMILY SIZE AND TOTAL CON. EXPD.

RURAL - 28TH ROUND

FL = a + β TCE + y FS

Y CAT. -	0 - 43	43 - 100	100 - 200	200 & ABOVE
a	-0.17939	23.56881	0.87018	0.84143
	-0.56596	1.87628	0.43975	0.60322
β	-0.09465	-0.31994	0.03424	0.02131
	2.38685	-1.64145	2.22026	2.63133
y	-0.02379	0.23719	0.14409	0.34059
	-0.19251	0.75707	0.60318	0.66909
R^2	0.58155	0.03964	0.20238	0.46070
D-W	1.31333	1.29424	1.38756	2.31168

$FL = a + \beta \, LOG \, TCE + y \, LOG \, FS$

Y CAT. -	0 - 4 3	43 - 100	100 - 200	200 & ABOVE
a	-2.65817	88.11527	2.01808	3.48272
	-1.61649	1.69197	0.95046	1.40712
β	1.67382	-20.60302	1.04555	0.77553
	1.86113	-1.64389	1.51455	1.13104
y	-0.45047	1.15139	-0.62670	0.08649
	-0.67783	0.72848	-0.58791	0.06870
R	0.53710	0.04097	0.28652	0.55758
D-W	1.42081	1.27452	1.41590	2.11801

URBAN

$FL = a + \beta \, TCE + y \, FS$

Y CAT. -	0 - 4 3	43 - 100	100 - 200	200 & ABOVE
a	0.17182	1.48844	3.65865	-6.77240
	2.01577	0.13143	1.15417	-0.98832
β	0.06084	0.03190	0.52791	0.09034
	3.26711	0.19066	2.85131	3.57694
y	0.01664	0.14265	-1.17089	-2.65959
	0.25980	0.61740	-1.46136	-1.32566
R^2	0.88637	0.01919	0.23807	0.32929
D-W	2.26760	2.17742	1.17000	2.24530

$FL = a + \beta \, LOG \, TCE + y \, LOG \, FS$

Y CAT. -	0 - 4 3	43 - 100	100 - 200	200 & ABOVE
a	-1.03021	-5.82312	-14.38361	-9.33765
	-3.88459	-0.12448	-1.60960	-0.79538
β	0.92233	2.15074	5.32209	4.72999
	6.43345	0.19437	2.86931	1.77216
y	-0.17319	0.69961	-3.91809	-6.49927
	-1.68125	0.54289	-1.62072	-1.33836
R^2	0.91067	0.01511	0.24560	0.08683
D-W	1.73892	2.17713	1.17686	2.10079

RURAL - **38TH** ROUND

$FL = a + \beta \, TCE + y \, FS$

Y CAT. -	0 - 100	100 - 200	200 - 300	300 & ABOVE
a	-0.81491	10.68434	-6.72667	9.53193
	-0.60289	1.08283	-0.12772	1.77469
3	0.05137	-0.04267	0.10440	0.17790
	1.95697	-0.60409	0.49406	1.43935
y	0.57322	0.98448	-1.29531	-0.08076
	2.35128	1.79291	-1.49970	-0.11305
R^2	0.46261	0.06081	0.03228	0.00499
D-W	1.62486	1.80814	1.45573	2.02228

FL = a • β LOG TCE + y LOG FS

Y CAT. -	0 - 100	100 - 200	200 - 300	300 & ABOVE
a	-8.31987	28.10527	-107.77920	-30.25969
	-2.42619	0.62430	-0.37844	-0.96690
β	1.88679	-5.27132	23.40639	7.79588
	1.82530	-0.57453	0.45380	1.47397
y	3.49419	4.73046	-5.31473	-0.05820
	2.51034	1.73265	-1.55619	-0.02426
R	0.47735	0.05226	0.03996	0.01537
D-W	1.57117	1.80035	1.43446	2.03661

FL = a + β TCE + **y** FS

Y CAT. -	0-100	100 - 200	200 - 300	300 & ABOVE
a	1.57566	100.97160	141.07360	28.03067
	1.32633	2.50858	1.45855	2.60620
β	0.02252	-0.63215	-0.47535	-0.11400
	0.87338	-2.20814	-1.21596	-0.49921
y	0.46522	-0.15238	-2.05071	-0.42923
	4.24643	-0.25022	-1.42434	-0.28913
R^2	0.56002	0.12545	0.07171	0.02095
D-W	1.98312	1.23016	1.46711	2.21808

FL = a + β LOG TCE + **y** LOG FS

Y CAT. -	0-100	100 - 200	200 - 300	300 & ABOVE
a	-0.44339	455.12450	660.34800	67.33700
	-0.08869	2.27929	1.24623	1.02068
0	0.29873	-89.41882	-115.13200	-7.07695
	0.21187	-2.21623	-1.19687	-0.65228
y	2.72657	-0.95259	-7.65581	-2.26242
	4.08651	-0.28130	-1.50603	-0.47723
R^2	0.54329	0.12465	0.08226	0.03928
D-W	2.01224	1.23239	1.48397	2.22503

TOTAL - 28TH ROUND

FL = a + 0 TCE + y FS

Y CAT. -	0-43	43 - 100	100 - 200	200 & ABOVE
a	0.15929	10227.25000	9628.61400	-2.57055
	0.52782	3.93675	3.01731	-0.40497
0	0.07230	-0.00406	-6.55843	0.05199
	3.68877	-0.16316	-0.27486	2.96490
y	0.00552	-0.05970	-722.88180	-1.21112
	0.05719	-0.20749	-1.95341	-0.84484
R^2	0.77520	0.00435	0.11980	0.31628
D-W	1 08272	2.16489	2.01271	1.61242

FL = a + β LOG TCE + y LOG FS

Y CAT. -	0 - 4 3	43 - 100	100 - 200	200 & ABOVE
a	-5.64721	11423.30000	10722.16000	11.17385
	-5.21621	0.69826	3.24329	1.17539
β	2.44136	102.61690	235.20310	0.62763
	4.59621	0.07164	0.31525	0.29208
y	-0.11134	-377.76360	-4315.18400	3.51832
	-0.21824	-0.80185	-1.82724	0.93650
R	0.81324	0.03122	0.09710	0.14992
D-W	1.07865	1.97479	2.01524	1.86662

LOG FL = a + |3 LOG TCE + y LOG FS

Y CAT. -	0 - 4 3	43 - 100	100 - 200	200 & ABOVE
a	-3.06727	12.38378	11.53761	-0.83670
	-4.50210	2.11492	6.43441	-2.80670
β	1.22243	-0.24608	0.53214	0.56552
	3.65707	-0.47997	1.31498	8.39238
y	-0.14584	-0.10349	-3.91345	0.15990
	-0.45427	-0.61376	-3.05525	1.35726
R^2	0.70079	0.03066	0.26231	0.94452
D-W	1.13245	2.13900	2.28566	1.82487

LOG FL = a + β TCE + γ FS

Y CAT. -	0 - 4 3	43 - 100	100 - 200	200 & ABOVE
a	-0.22143	9.63112	10.07872	-0.90675
	-1.17898	10.61622	6.08204	-1.65873
β	0.03484	-0.00001	0.00991	0.00773
	2.85642	-0.49432	0.79963	5.11902
y	-0.00626	-0.00008	-0.69340	-0.07685
	-0.10426	-0.79737	-3.60826	-0.62249
R^2	0.64779	0.05168	0.34080	0.66343
D-W	1.10806	2.22322	2.37749	2.45339

TOTAL - 28TH ROUND - TOTAL

FL = a + β TCE + y FS

Y CAT. -	0 - 4 3	43 - 100	100 - 200	200 & ABOVE
a	0.15929	10227.25000	9628.61400	-2.57055
	0.52782	3.93675	3.01731	-0.40497
β	0.07230	-0.00406	-6.55843	0.05199
	3.68877	-0.16316	-0.27486	2.96490
y	0.00552	-0.05970	-722.88180	-1.21112
	0.05719	-0.20749	-1.95341	-0.84484
R^2	0.77520	0.00435	0.11980	0.31628
D-W	1.08272	2.16489	2.01271	1.61242

FL = a + β LOG TCE + γ LOG FS

Y CAT. -	0 - 100	100 - 200	200 - 300	300 & ABOVE
a	-5.64721	11423.30000	10722.16000	11.17385
	-5.21621	0.69826	3.24329	1.17539
β	2.44136	102.61690	235.20310	0.62763
	4.59621	0.07164	0.31525	0.29208
y	-0.11134	-377.76360	-4315.18400	3.51832
	-0.21824	-0.80185	-1.82724	0.93650
R	0.81324	0.03122	0.09710	0.14992
D-W	1.07865	1.97479	2.01524	1.86662

LOG FL = a + β LOG TCE + **y** LOG FS

Y CAT. -	0 - 100	100 - 200	200 - 300	300 & ABOVE
a	-3.06727	12.38378	11.53761	-0.83670
	-4.50210	2.11492	6.43441	-2.80670
β	1.22243	-0.24608	0.53214	0.56552
	3.65707	-0.47997	1.31498	8.39238
y	-0.14584	-0.10349	-3.91345	0.15990
	-0.45427	-0.61376	-3.05525	1.35726
R^2	0.70079	0.03066	0.26231	0.94452
DW	1.13245	2.13900	2.28566	1.82487

LOG FL = a + β TCE + γ FS

Y CAT. -	0 - 100	100 - 200	200 - 300	300 & ABOVE
a	-0.22143	9.63112	10.07872	-0.90675
	-1.17898	10.61622	6.08204	-1.65873
β	0.03484	-0.00001	0.00991	0.00773
	2.85642	-0.49432	0.79963	5.11902
y	-0.00626	-0.00008	-0.69340	-0.07685
	-0.10426	-0.79737	-3.60826	-0.62249
R^2	0.64779	0.05168	0.34080	0.66343
DW	1.10806	2.22322	2.37749	2.45339

TOTAL - 38TH ROUND

LOG **FL** = **a** + **|3** LOG TCE + **y** LOG **FS**

Y CAT. -	0 - 100	100 - 200	200 - 300	300 & ABOVE
a	-0.38777	13.00391	11.02066	12.65791
	-0.34993	3.44748	4.29444	5.87462
β	0.20870	0.03203	0.00613	-0.16319
	0.71948	0.11235	0.02888	-0.92742
y	0.82887	-1.02326	0.13941	0.34146
	3.78313	-0.75544	0.21449	0.59837
R^2	0.58677	0.02936	0.00255	0.05795
DW	2.04045	1.71346	1.81450	1.77262

LOG **FL = a + β** TCE **+ y FS**

Y CAT. -	**0 - 100**	**100 - 200**	**200 - 300**	**300 & ABOVE**
a	1.19704	12.26268	11.19223	11.19019
	4.74481	9.02535	16.05532	17.29097
β	0.00316	0.00001	0.00001	-0.16071
	1.07984	0.41641	0.20611	-0.62098
γ	0.09614	-0.14565	0.01629	0.63268
	3.61199	-0.79956	0.14701	0.53894
R^2	0.56653	0.03444	0.00352	0.03379
D-W	2.04752	1.63833	1.81386	1.82542

FL = a + β TCE + y FS

Y CAT. -	**0 - 100**	**100 - 200**	**200 - 300**	**300 & ABOVE**
a	0.004628	185872.70000	85610.79000	85221.93000
	0.001848	1.85406	1.56593	1.61415
β	0.023770	0.21843	0.00352	-0.11970
	0.817019	0.89509	0.01717	-0.56694
y	0.951436	-15388.11000	457.88390	3932.87900
	3.600113	-1.144862	0.05269	0.41065
R^2	0.540927	0.080439	0.00017	0.02474
D-W	1.993830	1.555179	1.86873	1.87660

LOG FL = a + β LOG TCE + y LOG FS

Y CAT. -	**0 - 100**	**100 - 200**	**200 - 300**	**300 & ABOVE**
a	-13.09819	174745.60000	102261.10000	200759.40000
	-1.18916	0.62117	0.50891	1.14142
β	0.34063	10906.50000	-2507.65600	-12590.33000
	0.46498	0.51295	-0.15086	-0.87653
y	8.20048	-102852.40000	8354.20900	22170.05000
	3.76560	-1.01813	0.16414	0.47594
R^2	0.56141	0.05558	0.00237	0.04799
D-W	1.97741	1.68002	1.89181	1.83903

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