CHAPTER I

INTRODUCTION

Energy is one of the most familiar concepts and it is a basic natural resource without which the existence of humankind is impossible. Energy is a term derived from a Greek language 'energos', 'energia', and 'energon', all connected with the idea of activity or work. The term 'energy' was first used by the English physicist Thomas Young. The Bible claims that energy in the form of light is God's gift. According to William Blake, 'energy is the eternal delight' and Einstein that 'energy is equal to mass multiplied by the velocity of light squared'.

To the common man, energy is a commodity; to the engineer, it is the heat; to the physicist and chemist, it is a 'matter' which works through electromagnetic constant in the process of lighting, to the biologist, it is the ability to do work; to the sociologist, it is a synergy by which the action or behaviour of any system is determined in a way that cannot be predicted by the behaviour of the individual; to the psychologist, it is a libidinal force or emotional energy; to the economist, it is a key ingredient to the economic processes and is an intermediate good, whose demand falls under the category of derived demand; and to the energy economist, it is an input used in the production processes. Thus, energy is commodity, heat, matter, ability, synergy, libidinal force, ingredient, input and simply, the capacity to do work (Odum, 1971; Clarence and Barnhart, 1981; Webster Dictionary, 1991).

Technically, energy is a property of matter and have many forms. Energy occurs in several well-defined forms as 'kinetic' and 'potential'. The manifestation
of internal energy is fuel, steam, petroleum or compressed gas. According to the
First Law of Thermodynamics, the gain of internal energy in any given process is
equal to the difference between the heat gained by the system and the work done
by the system; on other systems, it is external to it. Kinetic energy refers to the
capacity for doing work that matter possesses because it is in motion. Potential
energy, as contrasted with kinetic energy is the capacity to do work that a body or
system has by virtue of its position or configuration. Kinetic and potential energy
are also related to the form in which energy is found. The forms of energy include:

**Chemical energy**: Energy stored in a substance and released when the
substance changes from or combines with another substance. Food and
fuels such as coal and oil store chemical energy.

**Mechanical energy**: Energy of motion used to get work done, like using
wind to turn a wind mill, bicycle wheels turning to cause motion, gears
turning to make machines work.

**Electrical energy**: Energy produced by an electrical current, creating
motion, light or heat. A generator can produce electrical energy.

**Radiant (nuclear) energy**: Energy produced by splitting uranium atoms in
a process called nuclear fission. Some day, nuclear fusion (joining atoms
at extremely high temperatures) may also be used to generate electricity.

**Thermal (Heat) energy**: Energy that causes a rise in temperature, like
energy from a fire.

**Gravitational energy**: Energy of motion caused by gravitys pull, such as
a waterfall or water going into a dam, from its catchment.

Yet another simple distinction is that of 'primary' and 'secondary' energy.
Primary energy is the 'energy recovered from nature'. In other words, primary
energy refers to energy in the form of natural resources. Examples are oil, natural
gas, freshly mined, water flowing into a dam and natural uranium. But when
primary energy undergoes conversion, it becomes the secondary energy.
Secondary energy forms are those to which primary energy is usually converted.
to-, in order to be used by the consumers. Examples are gasoline and electricity. While priman/ energy has a very little value in application, secondary energy can be used over a broad spectrum of applications.

Final energy is what consumers use and pay for; that is, secondary energy less losses through various transportation modes. Final energy refers to the form in which energy is consumed once it has reached to the user - the energy in a motor, a stove, a computer or a light. Useful energy is that which is finally delivered through the energy utilisation and conversion equipments. It provides the analysts an estimate of the ultimate energy that is actually available from a given energy source. Useful energy is thus the energy ultimately stored in a product or used for a service - a well lit room or a moving car. The term 'energy' is therefore employed not only to mean chemical energy, but also mechanical, electrical, radiant (nuclear), thermal (heat) and gravitational. The six sources play a vital role in the economic development of a nation, because energy helps in the cultivation of crops, keeps people alive, keeps our houses warm or cool, runs industries, transports goods and people, fuels economic development, and sustains economic systems and progress. Economic growth, social mobility and cultural expression are unthinkable without energy. It enables us to cook food, pump water, communicate and travel from place to place. Energy is thus the very basis from the ancient days till date. Human material progress is largely depended upon the energy.

Smil and Knowland (1980) consider energy as the prime mover of economic growth and development which has complex linkages in its systems. Reddy (1981) clearly explains the catalytic role of energy in development with two propositions: development means growth and growth requires energy. Further energy is directly related to the most pressing social issues that affect sustainable
development. Energy impinges on poverty, jobs and incomes, access to social services, gender disparities, population, agricultural production and food, security, health, land degradation, climate change and environmental quality and economic and security issues.

Energy must be viewed, therefore, as a means of contributing to the solution of major global problems. In fact, the global goal for energy can be stated very simply: sustainable development (Reddy, 1997). David Pimental and Maria Pimental (1979) state that finding, controlling and using energy has enabled man to progress from a primitive life to a settled civilised state. Thus energy is related to almost every major aspect of modern human activity. Basic needs of men are food, shelter and clothing. Equally important with these life essentials is the adequate supply of energy. Energy plays an implicit role in obtaining "essentials. Over centuries, man has tried to use energy in one form or the other. In the initial stages, his prime source of energy was his own muscle power. Later on, he domesticated the animals for draft purposes. He then progressed to wood fuel and wind power. Still later, engines were developed, fuelled by coal, petroleum and nuclear energy. The advancement in energy use has enabled man to march towards civilisation (Table 1.1).

Man would have remained on the level of savagery indefinitely, if he had not learned to augment the amount of energy under his control (White, 1943). Energy is thus the very basis of our existence and covers, in reality, the entire gamut of human life. If energy is short, everything is short. Even though one form of energy can be converted into another, there is, indeed, no real substitute for energy.
In economics, the term 'energy' was not recognised by Adam Smith (1723-1790), Malthus (1766-1834) and Ricardo (1722-1823). In the classical Economic Theories of Growth, energy was not even a distinct input in production. Today, energy is only one of the factors limiting world development, although it is essential for the growth of production and productivity. However, energy could be used as an index of capital - the factor which is most vital for development. In economic parlance, energy caters both to the direct consumption and to the production of goods. As consumer good, energy consumption tends to vary with the changes in income and consumer preferences. As an input to production, its availability and increasing quantity is a sine-qua-non of the rising national income.

Energy economists think that energy is an index of economic development. In the overall economic development of a nation, energy is essential to ensure adequate and sustained supply of energy for every sector of the economy. Energy is perhaps the item of which historians remember the last half of the Twentieth Century. We are at the beginning of a new era of change, an era of possibly greater fundamental significance than even the industrial revolution. For several
centuries, the mankind has grown lazy, lulled into complacency by the case with which multitudes could be fed, housed and transported using abundant supplies of energy which were readily available (Smith, 1981).

The industrial revolution has changed the situation by allowing humans to draw upon stored sources of energy such as firewood, fossil fuels and nuclear energy for achieving industrial growth and economic development. This has necessitated the demand for energy without increasing the worldwide energy supply. On the other, it has encouraged the fast diminishing of non-renewable resources of energy causing energy imbalances among nations.

At this critical juncture, the people of the world use energy either abundantly or mismanage the equivalence of 100 times as much energy, much more than what is needed for survival. Further, the severe hike in the prices of petroleum products has aggravated the problem of energy crisis. In the last three decades, different shocks of energy crisis have occurred: the first oil shock during 1973-74 (as a consequence of Arab-Israel War), the second oil shock during 1979-80 (over Iran-Iraq War) and the recent Gulf crisis of 1994. The rising of petroleum costs has severely paralysed the industrial and developing economics and turned the world into an oil inflamed world today.

All these factors have resulted in the uneven geographical distribution of resources among nations with more demand but low supply in energy commodities. Thus, the tragic events have caused energy imbalances among the developing and the oil importing developing countries, more so, than between the developed and developing countries (Funk and Roberts, 1983). The developed countries have simply managed their situation without relying on other countries for energy goods. The critical factors have forced the oil importing developing
countries to plan and save energy by the greater use of alternative sources of energy.

Under such circumstances, the Government of India has paid much attention to the energy sector in the Five Year and Annual Plans since the launching of the planning era in the post-independence India. The progress in energy has been spectacular in the Five Year Plans, which has had a 30 per cent allocation of the total outlay for energy.

Energy is one of the most important sectors included in 'infrastructure' along with other sectors such as transport, telecommunications, water supply and others. Efficient infrastructure is a pre-requisite for mobilising economic development (Parikh, 1997). During the Fifth Five Year Plan non-conventional and renewable sources of energy began to receive greater attention from the energy planners.

Energy is an important factor in improving the living standards of a country where higher quantities of energy should be consumed. For instance, a starving Indian farmer consumes almost nothing when compared to his American counterpart who consumes energy several times higher quantities than the average Indian farmer. The consumption of energy including commercial and non-commercial sources in India is only 3 per cent of the United States. Howe et al (1979) have viewed that the tremendous disparity between the rich and poor nations in kinds and amount of energy consumption reflects the extent of material under development in the poor nations.

Therefore, the difference between an affluent and a poor society can be seen in terms of energy and energy use patterns. In urban India, the national per
capita energy consumption is roughly, as is understood from the World Development Report (1995), an equivalent of 450 kg of coal while the per capita for the rural areas is an equivalent of 300 kg of coal in 1990.

Statement of the Problem

Energy use in rural areas has distinctive characteristics and may be regarded as a separate entity from that of urban scene (Racherla, 1989), because more than 90 per cent of the present energy consumption in the rural areas of the developing countries consists of non-commercial energy sources (firewood, dung and crop residues). Other sources of energy like the human power is also involved in the rural energy system, but this involvement heavily depends on how much of cost is incurred with regard to various activities concerned.

In a developing country like India, there is a need to improve the use of natural resources, and in particular, their scarce resources such as those of energy and water. The rural sector in India largely uses non-commercial energy sources; their production and consumption data are quite scanty. Villages use firewood, charcoal, agricultural wastes and crop residues, human and animal power for different productive activities. Most of the energy consumed in rural areas goes to growing crops and cooking of food (FAO, 1980). Many reports and the energy experts have pointed out that the commercial energy accounted for about 20 per cent and non-commercial energy over 80 per cent in India (Working Group on Energy Policy, 1979; Chakraborty et al, 1989). As energy is the life blood of the economy, management of energy at present and conservation of energy for the future, with an optimum level of present use are very often discussed by the energy economists. Conservation necessitates the management which include policies and planning in an integrated manner.
Treatment of energy consumption has centred around energy use in the household and other sectors independently of each other. However, energy use in different activities like agriculture, industry, commercial, transport and service may be combined so that an integrated energy conceptualisation emerges. Hence, energy consumption in some of the rural sectors may be considered. Rural household sector uses commercial energy (electricity: 87 per cent and kerosene: 13 per cent) and non-commercial energy (firewood: 42 per cent, agricultural waste: 29 per cent, animal dung: 24 per cent and other sources: 5 per cent). The only sector of village life where commercial energy has completely replaced by non-commercial energy is domestic lighting (Ramaswamy, 1993). The commercial energy used in the household sector shows that the share of electricity has increased and the share of coal and oil has declined. Many households in rural areas do not have access to a wide range of commercial sources. Even now, kerosene and LPG are usually rationed and electricity supply is subject to interruption.

Though many state governments in India have claimed that they have provided cent per cent electrification for all villages, it is noted that hardly 10-12 per cent of the households in these electrified villages has electricity. This is mainly due to the lack of purchasing power of the households. Further, the number of unelectrified houses in the country is increasing at a rate of about one million a year. This is due to the number of households increasing at the rate of 2.9 million a year, where as the number of electrified houses is increasing only at the rate of 2.1 million (Reddy, 1990). However, it may be noted that electrification of villages does not automatically improve the economic conditions of the people.

Cooking in Indian villages is done almost entirely with non-commercial energy which is burnt in primitive chulhas at just 12-20 per cent thermal efficiency.
with huge emission of smoke and grit that affects the health, particularly of women and children. Besides, women and children spend more time for collecting firewood with walking, on an average, a distance of 12 km (Ramasamy, 1991). Even though almost 50 per cent of India's energy consumption comes from non-commercial sources, planners, scientists, academicians and even government are striving hard to find solution for consumers for commercial sources of energy only.

The pattern of energy consumption in the household sector is determined by several factors. The factors that have a major impact on the amount of energy consumed by households and the fuels used include income, settlement size, family size, population density, price or personal costs of obtaining fuels, availability of and accessibility to modern fuels, and efficiency of equipment used. Most of these factors are interrelated and have major implications for the policies aimed at solving problems of household energy.

Agriculture remains the mainstay of life of the Indian village economy. Farmers need adequate energy supply at the right time and in proper form (Stout, 1990). Energy is required for tillage, planting, fertilizing, cultivating, irrigating, spraying, harvesting and drying. Further, the level of energy consumption by the equipments depends on the availability of agronomic socio-economic funding. In India, due to the increased crop intensity, modern agriculture necessitated higher energy inputs for field operations as well as agro-processing. The animal power has been supplemented by tractors, diesel-powered engines and electrical motors. Agricultural sector acts as a producer as well as consumer of energy. As producer, it produces different non-commercial forms of energy such as agricultural waste, animal waste, rice husk, wheat husk, waste from canning and processing units. As a consumer, it uses three forms of energy, namely, (i) animate energy
which is constituted by man (human energy) and animal (animal energy); (ii) inanimate energy (mechanical) which is constituted by machinery (oil or electricity), and (iii) chemical energy which is constituted by fertilizers, farmyard manure and pesticides. India is the fourth largest consumer of fertilizer in the world; yet, its per hectare consumption of fertilizer is 73 kg/ha is much below that of countries like the Netherlands (560 kg/ha), Korea (474 kg/ha) and Japan (407 kg/ha). Thus, it is a well known fact that agriculture is highly dependent upon non-commercial forms of energy (77 per cent from animal and human) and commercial forms of energy (23 per cent - chemical fertiliser: 14 per cent; electricity: 6 per cent and diesel: 3 per cent).

Indian agriculture uses higher percentage of animal and human energy because of an abundant and cheap supply of labour and animal power. The share of agricultural sector in the total commercial energy consumption by different sectors in India has increased from 1.7 per cent in 1953-54 to 9.0 per cent in 1990-91. Unfortunately, the yield increases do not reflect the use of energy in Indian agriculture.

The industrial sector is a major energy consuming sector in India and uses 50 per cent of the total commercial energy in the country. Of the commercial sources of energy consumed by the industries, coal and lignite constitute about 50 per cent, oil and natural gas around 40 per cent, hydroelectric power about 3 per cent and nuclear power 1 per cent. In general Indian industry is highly energy intensive and its energy efficiency is well below that of other industrialised countries. Therefore, there is scope for improvement of energy efficiency and energy conservation in industries. Most of the rural industrial activities such as pottery, brick making, metal work, carpentry and blacksmithy are entirely dependent on traditional and non-commercial sources of energy. No precise data
regarding the quantum of utilisation of such sources of energy is available. Some of the modern rural industries are run using electricity as a power source for operating engines.

Transport has played a significant role in the overall development of the national economy. Transportation in villages is based entirely on animal and human power. These modes of transportation are time consuming but economical. Bullocks, camels, mules, donkeys, and elephants are some of the animals which supply energy in different regions of the country. Animal power is a significant resource for a number of applications in agriculture and transportation. It is estimated that there are 15 million bullock carts in the country carrying about 165 million tonnes (mt) of originating traffic with an average distance of 10 km. These carts remain an optimal means of transport within a limited radius. The total investment in bullock cart comes to Rs.30,000 million and provides direct and indirect employment to 30 million persons.

Draught Animal Power (DAP) constitutes nearly 70 per cent of the rural energy input in the fields of transportation and irrigation. The quantum of freight carried by DAP has been estimated at 3,120 million tonne km in the rural areas, and 1,170 tonne km in the urban areas. It is estimated that more than 55 per cent of the land is cultivated by DAP (with 2 ha command area per pair). Eighty million work animals provide approximately 40 million horse power for cultivation and transportation. This is equivalent, in energy terms, to nearly the total installed capacity for generation of electricity in the entire country today (IIM, 1984). It is noticed that the transportation in India is a major energy consuming sector, particularly oil. The rapid urbanisation, along with the conglomeration of industrial and commercial activities, has consequently increased the transport demand. In recent years, transportation in the rural areas has increasingly demanded the use
of commercial energy. Tractors are used for transportation purposes rather than for ploughing. The changing rural landscape, with new technological practices, consumes a high rate of non-commercial and commercial energy.

The commercial and services sector are characterised by various end-use activities which include cooking, lighting, space heating and cooling, refrigeration, and pumping. For all these end-uses, the readily available data on energy consumption cannot be disaggregated, either by end-use or by the type of establishment. Hospitals, educational establishments, business enterprises, hotels, restaurants, government buildings, offices and other energy-consuming centres which are not included under agriculture, industry, transport and residential sectors comprise the commercial and services sectors. Rural commercial sector such as small hotels, petty shops and cycle shops consume both commercial and non-commercial energy. Rural service sector such as Balwadies, Tamil Nadu Integrated Nutrition Programmes (TINP), schools, banks, mini-health centres, and post and telegraph offices are dependent on human energy, electricity, firewood and kerosene.

Hitherto, we have been looking at a macro picture of energy consumption in various sectors of economy. It has also become clear that all the sectors, discussed above, are in existence in India. But, adequate efforts have not been made to study them at the micro scales. Although many research institutions have taken up research on a sectoral basis, sometimes some sectors in combination, no concerted effort has been made on the study of energy uses and energy management systems, particularly of the rural economy. It is to fill-in this gap in energy system studies that the present study envisages a sectoral study of energy use in rural areas, taking six of the Service Villages of the Gandhigram Rural Institute (GRI). The study focuses on the nature of energy uses, energy availability
in the villages, their consumption patterns by sectors, their use and misuse of energy resources and all related materials, in the context of rural energy development spectrum. Particularly, the study looks at the energy management system in the different sectors of our concern: domestic, agricultural, industrial, transport, commercial and services.

The Objectives

The study is primarily concerned with three relevant objectives. They are:

1. to examine and analyse the existing pattern of energy consumption in the six economic sectors of rural economy, namely, household, agriculture, industry, transport, commercial, and services sectors through an in-depth and sample-based energy use survey;

2. to identify the major determinants of energy consumption and estimate the energy use variations in the six sectors of the rural economy, from an analysis of the survey data collected from six GRI service villages in Dindigul District, Tamil Nadu; and

3. to formulate an Integrated Energy Management System, including the introduction of the scope for energy substitutes in the different sectors of the rural economy and to propose a 'socially acceptable and environmentally sound' energy policy for the rural areas of the economy.

Meaning of Concepts and Terms

Energy Management

Energy Management is not only a day-to-day affair but also a part of operational activity of energy end use sectors of household, agriculture, industry,
transport, commercial and services. It needs a constant update of knowledge on energy efficient gadgets. Energy management shall not be looked at as a saving of energy, but shall be looked at as a tool for enhancing productivity. Hence energy management is a vital and important factor for optimum utilisation of energy sources as well as for efficient and smooth economic activities in the different sectors of the economy. The basic principle of energy management is to register energy consumption and make use of it for forecasting the energy requirement. For the best energy management, certain planning must be done which would ensure no loss of energy at any stage of energy flow from production to the transmission and utilisation. The basic principles of energy management include energy conservation; that is, using available energy resources more efficiently, and energy substitution, replacing more fuels by cheaper ones (Kettani, 1990).

Energy management is an attractive concept because it suggests an initial approach to the problem. The concept will not improve use efficiency, unless it provides a basis for saving energy (Smith, 1981). At the most elementary level, energy management may be thought of as a 'task energy use'; for example, the provision of as much energy as is needed, when it is needed, where it is needed and with quality and quantity required. Implicit in task energy use is the concept of meeting energy requirements without waste in any process. By approximately 'cascading' energy use, the maximum utilisation of the energy quality is obtained. This is in itself a fundamental aspect of energy management. In its most elementary development, energy management involves the utilisation of the minimum quantity of energy for the task at an appropriate quality. For example, to make hot water, high grade fuels such as oil or natural gas is often used but, in a strict case of energy management, low quality 'waste' heat could be employed for water heating.
In this context, the following basic approaches can be used to reduce the quantity of energy required. They are:

Reduce Use : By self denial, by regulation or economic pressures;

Increase Efficiency : By better housekeeping and operational procedures or with more efficient equipment or materials; and

Substitute Energy : Replacement of high cost energy by low cost energy.

It is clearly understood that management is defined as 'the direction, control and organisation of business, money, equipment, energy and people towards a profitable goal'. Thus energy management is the most judicious task of energy use. According to Khaneja (1992):

**Judicious and efficient utilisation of presently available energy source is the only option left to bridge the gap between demand and availability. And such option is known as energy management.**

According to the International Labour Organisation (ILO), both management and energy are interconnected concepts with development. Development is a matter of human energies., and the generation and direction (utilisation) of all other sources of energy is the task of management. Thus the concept of energy management is a balancing element in the use process of energy demand and supply (ILO, 1991).

According to Tunnah (1990), energy management is a discipline - an organised and structured effort directed towards energy efficiency without reducing living standards or production. This direct involvement rationalises different choices to achieve efficient and wise use of energy. Effective energy management requires good data on a systematic and continuing basis, with reference to types
and quantities of energy used in each stage of the productive activities of different sectors. Data collected can be analysed to identify energy conservation opportunities that are technically and economically feasible.

**Commercial Energy and Non-Commercial Energy**

Commercial energy comprises of those energy forms for which there is a large international and domestic market, and which supply the needs of a modern industrial economy. It is an energy form sold in the course of commerce or provided by a public utility. Examples are petroleum fuels, natural gas, electricity, coal and hydro-electricity.

Non-commercial energy comprises of those fuels commonly used in the non-industrial or traditional sector of the economy, such as fuelwood, charcoal, crop residues, and animal dung. Traditional energy forms are still important in most developing countries, providing in many cases more than half the energy consumed. Those energy forms are generally used in 'traditional' or pre-industrial societies. They are largely synonymous with biomass fuels. The term non-commercial is somewhat misleading since these commodities often have a cash value and enter into commerce, but their procurement and availability do not depend on the application of modern technology.

**Conventional Energy and Non-Conventional Energy**

In general, all those energy sources (coal, petroleum, electricity, hydro-power and nuclear power) which are in every day use in most countries are regarded as conventional. Energy sources have hitherto provided the bulk of the requirements for modern industrial society. When talking about world energy
consumption, the convention is to break energy down into five broad convenient sources: coal-oil, gas, hydro-electrical and nuclear. There are sources of commercial energy, providing the basic starting point for most energy uses in the industrialised countries, and the modern industrialised sector in the economies of developing countries. Those energy sources which are not widely used at the present time are regarded as 'non-conventional'. That is, non-conventional energy sources refer to energy gained directly from other sources such as solar, wind, wave tidal, oil shale, geothermal, ocean thermal, tarsands - also known as renewable energy forms.

**Renewable Energy and Non-Renewable Energy**

The production and consumption of a renewable energy resource can be seen as a self-sustaining circular process in which the resource base and the supply potential do not get eroded by continuous use. Examples of renewable energy resources are hydroelectric power and solar energy.

By contrast, the production and consumption of a non-renewable energy resource is a process of depletion, the resource base and the supply potential declining with use. Typical examples are oil and natural gas.

**Capital Energy and Income Energy**

Capital energy sources are finite in quantity and cannot be replaced once used. Income energy sources are regenerative and limited by the rate of use rather than supply.
Conversion Factors for Various Energy Fuels

To measure the aggregate energy consumption or production, it is necessary to express the various constituent forms of energy in terms of common unit of measurement. The Energy Survey of India Committee (1965), Fuel Policy Committee (1974), and the Working Group on Energy Policy (1979) have uniformly used the practice of measuring common units in different fuels specified as Million Tonnes of Coal Replacement' (MTCR). Some of the international reports have widely used the term Million Tonnes of Oil Equivalent (MTOE). A distinction is made between coal (or oil) equivalent and coal (or oil) replacement. Coal equivalent expresses the heat content of all fuels in terms of coal.

Petroleum, for example, usually has about one-and a half times the heat content of coal, so 1.0 tonne of petroleum would become almost 1.5 tonnes of coal equivalent. Coal replacement refers to the amount of fuel, such as petroleum that would be needed to perform a given function performed by coal.

To take an example from India, 2 million tonnes (mt) coal equivalent of petroleum products used by the railway becomes over 9 mt of coal replacement because of the higher efficiency of diesel compared with steam locomotive (Dunkerly, 1990). Both MTCR and MTOE are suitable for macro studies using mainly secondary data. Hence, the researcher felt that for a micro energy study of this kind, Kilowatt hour (Kwh) is used as common unit of measurement for different energy sources that are produced and consumed in rural areas. Conversion factors for various energy kinds are given in Table 1.2 below.
Table 1.2: Energy Conversion Factors

<table>
<thead>
<tr>
<th>Input</th>
<th>Unit</th>
<th>Equivalence (kwh/unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man</td>
<td>hour</td>
<td>0.55</td>
</tr>
<tr>
<td>Woman</td>
<td>hour</td>
<td>0.44</td>
</tr>
<tr>
<td>Human (Average)</td>
<td>hour</td>
<td>0.50</td>
</tr>
<tr>
<td>Kerosene</td>
<td>1 litre</td>
<td>9.16</td>
</tr>
<tr>
<td>Electricity</td>
<td>1 Unit</td>
<td>0.99</td>
</tr>
<tr>
<td>Animal (pair)</td>
<td>hour</td>
<td>2.79</td>
</tr>
<tr>
<td>Firewood</td>
<td>kg</td>
<td>4.90</td>
</tr>
<tr>
<td>Dung</td>
<td>kg</td>
<td>2.78</td>
</tr>
<tr>
<td>Residue</td>
<td>kg</td>
<td>0.36</td>
</tr>
<tr>
<td>Diesel</td>
<td>litre</td>
<td>10.70</td>
</tr>
<tr>
<td>Petrol</td>
<td>litre</td>
<td>9.14</td>
</tr>
<tr>
<td>Charcoal</td>
<td>kg</td>
<td>7.02</td>
</tr>
<tr>
<td>LPG</td>
<td>kg</td>
<td>7.20</td>
</tr>
<tr>
<td>Farmyard manure</td>
<td>kg</td>
<td>0.84</td>
</tr>
<tr>
<td>Electric Motor</td>
<td>hour</td>
<td>17.96</td>
</tr>
<tr>
<td>Pesticide (Average)</td>
<td>kg</td>
<td>56.86</td>
</tr>
<tr>
<td>Fertilizer (Average)</td>
<td>kg</td>
<td>10.19</td>
</tr>
</tbody>
</table>


The Methodology

The data analysed in the study pertain to 1997; they have been collected through an extensive field survey, using a schedule of questions. This study is about energy consumption in the rural areas with special reference to the six villages (Chettiapatti, Kalikkampatti, Sirunaickenpatti, Ulagampatti, Kuttathupatti and Silvarpatti, in Dindigul district of Tamil Nadu), out of the 37 service villages which the GRI has adopted for rural development and extension activities. They are collectively designated as the ‘service villages’, which are spread over in three blocks, namely, (i) Athoor, (ii) Dindigul, and (iii) Reddiarchatram of Dindigul district.
Within these blocks, the socio-economic milieus of the villages are more or less homogeneous. Further, the selected villages are situated in specific locations and thus the researcher has adopted the purposive and contiguous area sampling approach for the selection of these villages. In fact, the two villages each chosen from the three blocks have been so chosen, purposively and contiguously.

This study is essentially diagnostic in nature, based on the primary data which are supported by the secondary data available in various government documents, reports and journals. Data collection was carried out by adopting the following. A simple random technique has been used to collect primary data from 10 per cent of the total households in the six service villages. The socio-economic profiles of the respondents, their income, energy use and cropping patterns, housing conditions, human activities in the household sector and the workwise energy use pattern in agricultural sector have been taken from them by using well structured and pre-tested interview schedule (Appendix 1.1). In the case of other sectors (industry, transport, commerce and services), the researcher has used the well known social survey (census) method to collect the relevant information from the village respondents, using the structured and pre-tested interview schedule.

A total of 534 samples from all the sectors (152 from household and agricultural (farmers), 48 from households (landless labourers), 22 from industry, 161 from transport, 86 from commerce and 65 from services) have been interviewed for gathering information on energy use in all the six sectors of the rural economy. The household and agricultural (152) and household (48) sectors account for 10 per cent of the total households. Respondents from other sectors include all people in industry, transport, commerce and services in the six villages of the study. Table 1.3 gives information on the distribution of respondents by villages and sectors.
### Table 1.3: Sample Respondents by Villages and Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Athoor</th>
<th>Chet</th>
<th>Kal</th>
<th>Dindigul</th>
<th>Siru</th>
<th>Ula</th>
<th>Reddiarchatram</th>
<th>Total</th>
</tr>
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<tbody>
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<td>35</td>
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<tr>
<td>Household (labour)</td>
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<td></td>
<td>24</td>
<td>3</td>
<td>10</td>
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<tr>
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<td>3</td>
<td></td>
<td>6</td>
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<td>23</td>
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<td>40</td>
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<td>14</td>
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<td></td>
<td>25</td>
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<td>18</td>
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<td>Services</td>
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<td>9</td>
<td>8</td>
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<td>13</td>
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<tr>
<td><strong>TOTAL</strong></td>
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<td>100</td>
<td>96</td>
<td>64</td>
<td></td>
<td>534</td>
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Note: Chet = Chettiapatti, Kal = Kalikkampatti, Siru = Sirunaickenpatti, Ula = Ulagampatti, Kut = Kuttathupatti and Silv = Silvarpatti.

Secondary data pertaining to all sample villages were collected from the Department of Statistics, Census of India and the records of the Village Administrative Office. A careful library search and research has enabled the researcher to use the available books, periodicals and journals, government reports and documents to assemble ideas and theoretical perspectives on the energy use and consumption in the various sectors towards economic development. Secondary and documentary sources have been referred to and data there on collected for simple analysis and interpretations. Consultations and participatory dialogues have been used in the understanding of the energy uses in the rural areas and towards developing an Integrated Energy Management System for rural areas which is, both simple and practical. A considerable amount of thinking has gone into it to keep the system viable, within the rural milieu to which it is suggested. Correspondingly, policy imperatives of an integrated energy management system have been considered, concertedly, and thus suggestions have been made towards making the existing policy worthwhile and effective.
The field survey data have been coded, tabled, edited and item-selected for analysis and interpretation. A select set of 18 variables has been entered into a computerised database so that the dataset could be used in the application of intercorrelational (Spearman Correlation) analysis. The same dataset has been subjected to a Principal Components Analysis (PCA), extracting three components. The data entered in the correlational and principal components analysis have been first subjected to standardisation (to make unit based measures, unitless) and then to statistical procedures. All the variables have been quantitative and they have neither been scaled nor ranked. Much of the other data gathered in the field, through interview schedule and participant observation, have been checked for their completeness, correctness, consistency and uniformity and then frequency counted for ratio analysis. The classified data have been put into one-way and two-way tables for analysis and interpretation. Tables, diagrams and graphs have been extensively summarised for use in the text. They form the supports for the statement made in the text.

The Scope of the Study

Rural transformation or rural development is a strategy designed to improve the condition of the rural people of this country, living in 567 thousand villages which cover 76.3 per cent of the total population of India. Rural areas are considered as the backbone of the country. There is, however, a lopsided development in the Indian economy. Industries are confined mostly to urban and semi-urban areas, resulting in the migration of people from rural to urban areas, which in turn leads to urban explosion and other social problems. It is noticed that there are for larger requirements for rural development than we could think of, among them energy occupies a key place in the rural sectors.
The purpose of this study is to analyse the various aspects of use of different energy sources and access to their supply in the rural areas. Actual problems of the rural people, with regard to energy, have been assessed through the field study, as even the data obtained from the secondary sources being useful in lending a snapshot view of the energy situation in rural areas and spur an interest in further research in the area of rural development. This study would be important not only to plan the different sources of energy with augmentation in locally available energy production, but also be helpful in managing and conserving the available energy sources in rural areas. As such the study would prove to be useful in planning and execution of the IREP Programmes in Rural India.

This study looks critically at the energy (use) policy (State, Union) and its implications for consumption in various sectors of the rural economy (patterns of consumption and processes facilitating growth in demand and supply) in order that an Integrated Energy Management System (because the systems in use are neither integrated nor balanced) may be suggested for a socially acceptable and environmentally sound energy (use) policy for the rural areas. It must be mentioned in the study that an energy (use) policy at the state and national levels exist but is implemented poorly for several reasons which are social, cultural, economic and environmental. Further, the study of this kind would help to "develop an integrated energy management system and suggest policy imperative for rural areas and for the future.

Limitations of the Study

This study is confined only to a select set of six villages in Dindigui "District of Tamil Nadu. There are several energy technologies and sources which have been in use, but this study is confined to a select few which are quite common in
the rural areas. While the six villages are a sample of certain regional economic mosaic, the inferences drawn from this study cannot be used in generalisations. Data for the present study were collected through structured interview schedule by meeting the households for a single point of time for many of the variables. This fact results in one limitation, namely, that there may be a data error as they are recall data, as emerging from the respondents' memories. In view of these constraints and restraints of this study, an attempt has been made to maintain the quality of work.

The Organisation of the Thesis

This thesis is organised into seven chapters. The first chapter provides a brief introduction, the objectives, methodology, and the scope and limitations of the study. The second chapter constructs the profiles of rural energy and its development programmes in India. The third chapter presents a review and appraisal of literature. A background of the study area profile and its socio-economic milieu is given in the fourth chapter. The fifth chapter brings out a detailed analysis on energy consumption in the select six sectors of the rural economy. Major findings and an integrated energy system (appropriate, viable and feasible) are presented in the sixth chapter. And the seventh chapter deals with the summary and conclusions.

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