CHAPTER 1
INTRODUCTION

1.1 PREAMBLE

Human society cannot survive without a continuous use, and hence supply, of energy. The original source of energy for social activities was human energy—the energy of human muscle provided the mechanical power necessary at the dawn of civilisation. Then came the control and use of fire from the combustion of wood, and with this, the ability to exploit chemical transformations brought about by heat energy, and thereby to cook food, heat dwellings, and extract metals (bronze and iron). The energy of flowing water and wind was also harnessed. The energy of draught animals began to play a role in agriculture, transport, and even industry. Finally, in rapid succession, human societies acquired control over coal, steam, oil, electricity and gas. Thus from one perspective, history of human civilization is the story of the control over energy sources for the benefit of society.

Modern economies are energy dependent, and their tendency has been to see the provision of sufficient energy as the central problem of the energy sector. Indeed, the magnitude of energy consumed per capita became an indicator of a country’s ‘modernisation’ and progress. Energy concerns have long been driven by one simple preoccupation: increasing the supply of energy. Over the past few decades, however, serious doubts have arisen about the wisdom of pursuing a supply-obsessed approach. Attention is shifting towards a more balanced view that also looks at the demand side of energy. But access to, and the use of, energy continues to be a necessary and vital component of development.

In the supply-driven approach, the appetite for energy often exceeded the capacity of local sources of supply. The energy supplies of some countries had to be brought from halfway round the world. Efforts to establish control over oil wells and oil sea routes have generated persistent tensions and political problems. This situation has also shaped national policies for foreign affairs, economics, science, and technology—and influenced the political map of the world. The security of energy supplies was a major geostrategic issue throughout the 20th century (Reddy, 2000).
At the same time, the magnitude and intensity of energy production and use began to have deleterious impacts on the environment. By the late 1960s the gravity of the environmental problems arising from toxic substances had become clear. Awareness of the environmental issue of acid rain followed. The problems of urban air pollution have been known for a long time. Climate change discussions intensified in the mid-1970s. All these problems are directly related to the quality and quantity of fuel combustion.

Then came the oil shocks of 1973 and 1979, along with price increases that led to economic disruption at international, national and local levels. The oil shocks thrust the energy problem into the range of awareness of individuals. Some oil-importing developing countries suffered serious balance of payments problems, and in some cases landed in debt traps. The development of indigenous fossil fuel resources and power generation faced the hurdle of capital availability. More recently, the accumulation of greenhouse gases in the atmosphere resulting from energy consumption has focussed attention on the threat of climate change, with the possibility of far-reaching consequences. In parallel, the lack of control over energy resources has highlighted the importance of national and local self-reliance (as distinct from self-sufficiency).

Thus, quite apart from the critical issues related to the supply of fossil fuels, the political, social, and economic institutions dealing with energy have failed to overcome a new series of grave problems—problems of economics (access to capital), empowerment (self-reliance), equity, and the environment (Reddy, 2000). Many of the human made threats to the species and the biosphere, indeed to civilisation’s future, are energy-related. Awareness of the energy dimensions of these issues has arisen more recently, but the underlying energy bases of the issues are still imperfectly appreciated by decision makers, perhaps because this understanding has not been disseminated widely.

Energy strategies have impacts on major issues related to poverty, women, population, urbanisation, and lifestyles. Data on infant mortality, illiteracy, life expectancy, and total fertility as a function of energy use are shown in figure 1.1, which is not meant to suggest that there is a causal relation between the parameters represented.
These linkages imply that energy has to be tackled in such a way that social problems are at least not aggravated—which is what conventional energy strategies tend to do, because they are so preoccupied with energy supplies that they ignore these problems completely or deal with them inadequately.

![Figure 1.1 Infant mortality, Illiteracy, Life expectancy and Total fertility as a function of energy](image)

(Note: Data on commercial energy use are for 1994; data on social indicators are for 1995)

Because of its linkages to social problems, energy can contribute to their solution. Unfortunately, energy and the major problems of today’s world are not being dealt with, in an integrated way by national and international policy-makers.

Satisfaction of social needs by energy is best achieved by treating neither energy supply nor energy consumption as ends in themselves. After all, what human beings want is not oil or
coal, or even gasoline or electricity per se, but the services that those energy sources provide. Thus, it is important to focus on the demand side of the energy system, the end uses of energy and the services that energy provides.

In fact, one can identify a rather small set of the most important of these energy services. They include the basic services of cooking, heating, lighting, space conditioning, and safe storage of food. In addition, the provision of clean water and sanitation, which is facilitated by energy, affects public health in cities as well as rural areas. Societies also require services such as transportation, motive power for industry and agriculture, heat for materials processing (steel, cement, and so on), and energy for commerce, communication and other economic and social activities.

The demand-side, end-use-oriented energy services approach stresses another difference. The end user cares less about the original sources or fuels used to provide the service than about crucial attributes of the final energy carrier from a social standpoint. Among the most important attributes are energy’s accessibility (particularly for the poor, women, and those in remote areas), affordability, adequacy, quality, reliability, safety, and impact (particularly on the immediate environment).

Energy issues tend to get sidelined in many international forums. Such major global issues as poverty, women, population, urbanisation, lifestyles, under nutrition, environment, economics, and security tend to get higher priority than energy. But missing from most discussions of these issues is the important linkage between each of them and global and local energy systems. It is too little appreciated that achieving progress in these other arenas can be greatly assisted by manipulation of energy systems.

Even when this linkage is mentioned, the discussion focuses on how these global issues determine energy consumption patterns. Energy is treated as the dependent variable. Very little attention is directed at understanding whether current energy patterns are aggravating these issues and almost no attention is given to how alternative energy strategies can contribute to their solution.
Thus, a fresh conceptual framework is required. The framework depicted in figure 1.2, concerns the linkage between energy, on the one hand, and poverty, women, population, urbanisation, and lifestyles, on the other.

![Figure 1.2 Energy linkages (Source: Reddy, 2000)](image)

1.2 DEMAND FOR ENERGY SERVICES

The structure and size of the energy system are driven by the demand for energy services. Energy services, in turn, are determined by several driving forces. They include (Rogner and Popescu, 2000):

- Economic structure, economic activity, income levels and distribution, access to capital, relative prices, and market conditions.
- Demographics such as population, age distribution, labour force participation rate, family sizes, and degree of urbanisation.
- Geography, including climatic conditions and distances between major metropolitan centres.
- Technology base, age of existing infrastructure, level of innovation, access to research and development, technical skills, and technology diffusion.
- Natural resource endowment and access to indigenous energy resources.
- Lifestyles, settlement patterns, mobility, individual and social preferences, and cultural mores.
• Policy factors that influence economic trends, energy, the environment, standards and codes, subsidies, and social welfare.
• Laws, institutions, and regulations

The structure and level of demand for energy services, together with the performance of end-use technologies, largely determine the magnitude of final energy demand. The amount of final energy per unit of economic output (usually in terms of gross domestic product - GDP), known as the final energy intensity, is often used to measure the effectiveness of energy use and the consumption patterns of different economies. Economies with a large share of services in GDP and a large share of electricity in the final energy mix, usually have lower final energy intensities than do economies based on materials and smokestack-based industries and fuelled by coal and oil (Rogner and Popescu, 2000). The final energy demand mix, the structure and efficiency of energy supply (resource extraction, conversion, transmission, and distribution), domestic resource availability, supply security, and national energy considerations then determine primary energy use.

Energy use by developing countries has increased three to four times as quickly as that by OECD (Organisation for Economic Co-operation and Development) countries—the result of life-style changes made possible by rising incomes and higher population growth. As a result, the share of developing countries in global commercial energy use increased from 13% in 1970 to almost 30% in 1998 (Rogner and Popescu, 2000). On a per capita basis, however, the increase in primary energy use has not resulted in more equitable access to energy services between developed and developing countries. Table 1.1 provides energy data and trends related to this, disaggregated by country and region.
Table 1.1 Primary Energy Use Per Capita by region 1971-97
(Source: Rogner and Popescu, 2000)

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<td>North America</td>
<td>266</td>
<td>276</td>
<td>286</td>
<td>296</td>
<td>277</td>
<td>3.7</td>
<td>2.4</td>
<td>0.6</td>
<td>0.3</td>
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<tr>
<td>Latin America</td>
<td>36</td>
<td>42</td>
<td>40</td>
<td>47</td>
<td>47</td>
<td>15.4</td>
<td>27.7</td>
<td>2.1</td>
<td>3.6</td>
</tr>
<tr>
<td>OECD Europe(^a)</td>
<td>118</td>
<td>134</td>
<td>134</td>
<td>137</td>
<td>141</td>
<td>3.3</td>
<td>19.9</td>
<td>0.5</td>
<td>2.0</td>
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<tr>
<td>Non-OECD Europe(^b)</td>
<td>76</td>
<td>108</td>
<td>112</td>
<td>108</td>
<td>84</td>
<td>-21.8</td>
<td>10.6</td>
<td>-3.4</td>
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<td>Former Soviet Union</td>
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<td>178</td>
<td>192</td>
<td>195</td>
<td>129</td>
<td>-33.9</td>
<td>-4.2</td>
<td>-5.7</td>
<td>-0.6</td>
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<td>Middle East</td>
<td>65</td>
<td>61</td>
<td>72</td>
<td>77</td>
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<td>23.0</td>
<td>175.9</td>
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<td>Africa</td>
<td>23</td>
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<td>27</td>
<td>27</td>
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<td>0.1</td>
<td>17.1</td>
<td>0.0</td>
<td>2.3</td>
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<tr>
<td>China</td>
<td>20</td>
<td>25</td>
<td>28</td>
<td>32</td>
<td>38</td>
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<td>Asia(^c)</td>
<td>16</td>
<td>17</td>
<td>19</td>
<td>21</td>
<td>26</td>
<td>18.0</td>
<td>66.3</td>
<td>2.6</td>
<td>7.6</td>
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<td>Pacific OECD(^d)</td>
<td>94</td>
<td>113</td>
<td>117</td>
<td>142</td>
<td>174</td>
<td>23.2</td>
<td>85.1</td>
<td>3.0</td>
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<td>World total</td>
<td>62</td>
<td>69</td>
<td>69</td>
<td>70</td>
<td>70</td>
<td>-0.1</td>
<td>12.3</td>
<td>0.0</td>
<td>1.7</td>
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<td>OECD countries</td>
<td>161</td>
<td>177</td>
<td>173</td>
<td>181</td>
<td>194</td>
<td>7.0</td>
<td>20.4</td>
<td>1.0</td>
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<td>Transition economies</td>
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<td>166</td>
<td>177</td>
<td>180</td>
<td>121</td>
<td>-32.4</td>
<td>-2.0</td>
<td>-5.4</td>
<td>-0.3</td>
</tr>
<tr>
<td>Developing countries</td>
<td>20</td>
<td>25</td>
<td>27</td>
<td>29</td>
<td>34</td>
<td>16.0</td>
<td>66.2</td>
<td>2.1</td>
<td>7.5</td>
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</table>

\(^a\) Includes Czech Republic, Hungary and Poland.  
\(^b\) Excludes the former Soviet Union.  
\(^c\) Excludes China.  
\(^d\) Includes Republic of Korea.

1.3 TRENDS TOWARDS INCREASED ENERGY USE AND SUSTAINABLE DEVELOPMENT

Increasing income levels tend to lead to a higher use of energy services by citizens of modern society. Some saturation effects occur, but they do not have a dominant effect on energy consumption. The effects of energy-efficiency improvements, especially in space heating and large appliances, may be more important. Nevertheless, lifestyles in industrialised countries still evolve towards higher levels of energy use as shown in Table 1.2 and Figure 1.3.

In its 1987 report, *Our Common Future*, the World Commission on Environment and Development defines sustainable development as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Rogner and Popescu, 2000). The report further describes sustainable development as “a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and
enhance both current and future potentials to meet human needs and aspirations”. In its broadest sense, the report notes, “the strategy for sustainable development aims to promote harmony among human beings and between humanity and nature”.

Table 1.2 Global primary energy demand (Million tons of oil equivalent) (Current and projected) (Source: World energy Outlook, 2007)

<table>
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</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1786</td>
<td>2292</td>
<td>2892</td>
<td>3988</td>
<td>4994</td>
<td>2.2%</td>
</tr>
<tr>
<td>Oil</td>
<td>3106</td>
<td>3647</td>
<td>4000</td>
<td>4720</td>
<td>5585</td>
<td>1.3%</td>
</tr>
<tr>
<td>Gas</td>
<td>1237</td>
<td>2089</td>
<td>2354</td>
<td>3044</td>
<td>3948</td>
<td>2.1%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>186</td>
<td>675</td>
<td>721</td>
<td>804</td>
<td>854</td>
<td>0.7%</td>
</tr>
<tr>
<td>Hydro</td>
<td>147</td>
<td>226</td>
<td>251</td>
<td>327</td>
<td>416</td>
<td>2.0%</td>
</tr>
<tr>
<td>Biomass and waste</td>
<td>753</td>
<td>1041</td>
<td>1149</td>
<td>1334</td>
<td>1615</td>
<td>1.4%</td>
</tr>
<tr>
<td>Other renewables</td>
<td>12</td>
<td>53</td>
<td>61</td>
<td>145</td>
<td>308</td>
<td>6.7%</td>
</tr>
<tr>
<td>Total</td>
<td>7228</td>
<td>10023</td>
<td>11429</td>
<td>14361</td>
<td>17721</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

* Average annual rate of growth.

Figure 1.3 Global primary energy demand (Source: World energy Outlook, 2007)
The relationship between energy production and use and sustainable development has two important features. One is the importance of adequate energy services for satisfying basic human needs, improving social welfare, and achieving economic development—in short, energy as a source of prosperity. The other is that the production and use of energy should not endanger the quality of life of current and future generations and should not exceed the carrying capacity of ecosystems.

Throughout the 20th century, the ready availability of commercial energy fuelled global economic development. But much of the developing world continues to rely on non-commercial energy sources, mainly fuel-wood, and has limited access to modern energy such as electricity and liquid fuels. Lack of capital and technological capacity hinders the development of adequate supplies, with deleterious effects on economic and social development.

Because they affect affordability and economic competitiveness, energy prices need to be taken into account when analysing options for sustainable energy development. Moreover, energy supplies should be secure and reliable. For that reason, attention should be given to:

- The dependence on energy supplies from politically unstable regions or unevenly distributed locations.
- The possible disruption of energy supplies due to severe accidents.
- The socio cultural environment in which energy systems operate.
- The eventual exhaustion of finite energy resources such as coal, crude oil, natural gas, and uranium, for which alternative options must be developed.

Finally, the development and introduction of sustainable energy technology must occur in a socially acceptable manner, with a broad range of citizens participating in decision-making.

As noted, to be considered sustainable, energy systems must not overload the carrying capacity of ecosystems. Nor should the use of finite resources compromise the ability of future generations to meet their energy service requirements. Efficient use of resources, clean conversion processes, and the timely development of inexhaustible supply options—such as
renewable forms or nuclear energy based on breeding or fusion—are therefore the principal strategies for sustainable energy development.

1.4 ENERGY USAGE IN THE RESIDENTIAL SECTOR

The energy use in the residential sector is an important area for campaigns for energy conservation. Household energy conservation has been a topic of interest within applied social and environmental psychological research for a number of decades. Energy saving in the home creates benefits for the household itself in the form of lower energy bills, and for the community at large in the form of lower imports of oil from the OPEC (Organisation of the Petroleum Exporting Countries) countries. In the 1970s, the backdrop to conservation research was the energy crisis, raising concern about a possible depletion of fossil fuels. Currently, environmental problems such as global warming and threats to biodiversity are the main reasons for studying energy conservation.

Several major research works indicate the growing attention that has been focused on household energy consumption and conservation. A primary purpose of this body of research is to understand the factors influencing energy-consuming behaviors (Ritchie et al, 1981). The underlying rationale is to be able to bring about energy conservation by stimulating behaviors that are more energy efficient and/or by stimulating a reduction of energy-consuming behaviors.

Households constitute an important target group, being major contributors to the emission of greenhouse gases and, consequently, global warming. The pivotal question remains why energy use of households keeps rising. On the one hand, macro-level factors contribute to this increase. These may be referred to as TEDIC factors: Technological developments (e.g. energy-intensive appliances), Economic growth (e.g. increase of household incomes), Demographic factors (e.g. population growth), Institutional factors (e.g. government policies) and Cultural developments (e.g. emancipation, increasing mobility of women). In turn, these TEDIC factors shape individual (viz., micro-level) factors such as motivational factors (e.g. preferences, attitudes), abilities and opportunities (Abrahamse et al, 2005).
Why is it that all consumers do not behave in a more energy-conscious way? First, energy conservation is not seen as a problem that concerns them. Many consumers hold others (e.g. the government) to be responsible for the supply of energy. Second, consumers do not behave in an energy-conscious way due to their social environment. Third, consumers do not always know the energy costs of many household behaviors. They do not consider behavioral change to be effective to conserve energy. Fourth, the feedback information of the energy bills comes too late to make people aware of energy wasting types of behavior. Finally, energy-conscious behaviour asks for some involvement with thermostat settings, closing curtains, turning off radiators. This means that households have to put effort and concern in the energy area, in addition to their other concerns and efforts (Vaanraaij and Verhallen, 1983).

Do consumers behave rationally in making decisions regarding energy use and energy efficiency? Do observed choices reflect an optimal balance between the costs and benefits of energy-efficient technologies? Do people use economic criteria when purchasing appliances or automobiles, or when considering building shell retrofits that would reduce household fuel consumption? Do households minimize the present-value costs of obtaining energy services? Debates over these key questions have continued unabated for two decades, becoming more intense since 1990s due to growing concerns over the environmental impacts of energy use (Sanstad and Howarth, 1994). For all the attention devoted to the topic, no widely-accepted answers to the basic questions about consumer rationality and its role in energy-related decisions have emerged in the literature. Moreover, there are few signs that any are soon forthcoming. This is not to say that strongly-held views on the subject cannot be identified. Among energy specialists, one can identify two polar positions to the question of whether consumers behave rationally when making decisions regarding energy use and energy technologies: Economists say "generally yes" while technologists and behavioural researchers say "definitely not." The middle ground is held by researchers from a variety of disciplines who argue that "more research is needed."

The behavioral literature has identified the following empirical regularities, each of which is thought to promote the overutilization of energy:

* Use of high implicit discount rates in evaluating energy-efficiency investments
* Use of incorrect units in calculating energy consumption and related costs, resulting in overconsumption relative to what would result from technically correct computations
* Salience effects, whereby consumers attach excessive weight to factors that are psychologically vivid or easily observed. For example, turning down the lights in an effort to reduce energy bills when such action will generate negligible cost savings
* Incorrect use of technology. For example, failure to understand the concept of thermostatic control so that users set air conditioners too "high" relative to the levels required to assure sustained comfort.

Households use fuel for a variety of activities, including cooking, water heating, lighting, and space heating. Different energy carriers can be used for each of these activities. For instance, firewood, dung, charcoal, coal, kerosene, electricity, and LPG can be used for cooking; and kerosene and electricity for lighting. These carriers (for a particular activity) form what is commonly referred to as an ‘energy ladder’ for that activity (Reddy, 2000). Each rung corresponds to the dominant (but not sole) fuel used by a particular income group, and different income groups use different fuels and occupy different rungs. Wood, dung, and other biomass fuels represent the lowest rung on the energy ladder for cooking. Charcoal and coal (when available) and kerosene represent higher steps up the ladder to the highest rungs, namely electricity and LPG.

The ordering of fuels on the energy ladder also tends to correspond to the efficiency of the associated systems (the fraction of energy released from the carrier that is actually used by the end-use device) and their ‘cleanliness’. For example, the cook-stove efficiencies of firewood (as traditionally used), kerosene, and gas are roughly 15, 50, and 65 percent, respectively. As one proceeds up the energy ladder, the emission into the air of carbon dioxide, sulphur dioxide and particulates also tend to decline.

Because different fuels require different appliances—stoves, lamps, and so on—with varying costs and durability, fuel costs have both fixed and variable components. The importance of this distinction between fixed and variable costs is magnified by three factors: the presence of quasi-fixed costs, such as fixed monthly charges for a natural gas or electricity hook-up; the
need to make large ‘lumpy’ purchases of some fuels, such as tanks for storing propane gas; and the need to make sometimes sizeable security deposits, either to guarantee the payment of monthly bills or the return of equipment such as LPG cylinders or canisters. Despite the fact that they are refundable, security deposits impose a present cost on households, the magnitude of which depends upon the return on those funds in their next best use, or their ‘opportunity cost’.

How have changes in lifestyle influenced the pattern of energy use in industrialised countries? What are the determinants of energy consumption? What are the driving forces of energy consumption patterns? These questions have bothered energy analysts for a long time and in fact are still relevant. The general relationship between per capita GDP (Gross Domestic Product) and per capita energy use has been established in many studies. The relationship is non-linear with energy use typically growing slower than GDP. For instance, in 1985–95 per capita GDP in OECD countries grew at 1.6% per year, whereas per capita energy use grew at 0.8% (Reddy, 2000).

It is instructive to look at energy use from the point of view of individual consumers or households. Households use energy directly (for example, electricity, natural gas, and gasoline) as well as indirectly, in the goods and services that they purchase. The sum of direct and indirect use represents the total energy requirements of a household. If it is assumed that, in the ultimate analysis, all products and services of society are produced for the service of households, then an overall picture of the energy requirements of society can be obtained.

The relationship between household income and energy requirements (using input-output analysis) has been known for a long time. In the early 1970s it was found that, if the income of households increases by 1%, their use of energy increases by 0.7–0.8%, that is the income elasticity of energy requirements for any year lies between 0.7 and 0.8 (Reddy, 2000). More detailed research in the Netherlands using a combination of process analysis and input-output analysis came to similar conclusions; for 1990 the income elasticity of energy requirements was 0.63. The most salient finding (as also revealed in this research work), is that income is the main determinant of energy consumption. Other household characteristics, such as size,
age of oldest member, life-cycle phase, degree of urbanization, education level, and so on, turn out to be relatively less important. Income elasticity was found to be smaller than unity because the growth of direct energy consumption was less than the growth of income. In contrast the indirect part of energy consumption grew in proportion to income. Thus, a shift to less energy-intensive products does not take place as household income grows.

Many of the driving forces cannot easily be altered to lead to lower energy use. But energy-efficiency improvement (including design that stimulates energy-efficient use of equipment) had a considerable impact in the early 1980s. Hence increasing the rate of efficiency improvement seems to be the most straightforward approach to limiting the growth of energy consumption. If it is necessary to go beyond the limits of efficiency improvements, it is not sufficient to identify income as the determinant. After all, one cannot look for income reduction strategies. But income is only a proxy for more fundamental determinants of energy use. Income is translated into consumption, which is the material expression (more appliances, bigger homes, heavier cars, more goods) of lifestyles. If one takes these material expressions as determinants, one can think of strategies directed towards altering the consumption patterns associated with the most energy-intensive categories of energy use without impairing quality of life. But, a great deal of thought and action will be required to influence lifestyles in this way. They may require a fundamental change in current pricing and taxing policies—not to mention taking advantage of the Internet revolution to change trends.

1.5 URBANISATION AND ITS IMPACT ON SUSTAINABLE DEVELOPMENT

Human-imposed threats to global sustainability have two fundamental dimensions: population growth and the ever-increasing per capita demand for goods and services, particularly material needs and energy. Both impose direct and indirect pressures on the human carrying capacity of the Earth. Today, 75% of the population in industrialized countries live in urbanised areas (Dhakal, 2004). Although a small number of the population live in cities in developing countries, cities are the driving forces for development and are centres for power, cultural and societal transformation.
The number of people living in urban areas is increasing rapidly worldwide. In recent decades, such rates have accelerated. In 1950, 30% of the population lived in urban areas, which has increased to 47% in the year 2000 and is expected to increase to 60% by the year 2030. From 2000-2030, virtually all population growth is expected in urban areas and mostly in less developed regions of the world (Dhakal, 2004). In Asia, rapid urbanisation is a distinctive feature. From 1990-1998, the average urban population growth per year was estimated at 3% for East Asia and 3.2% for South Asia, in contrast to average 2.1% for the world. Accordingly, the potential of urban growth is tremendous in Asia; it is estimated that in developing countries the population in cities will increase from today’s 37% to over 54% by 2030. This means, 2.6 billion people will live in Asian cities, exceeding twice the current population of the People’s Republic of China and representing 53% of the world’s urban population by 2030. Predictions for 2015 show a total of 358 cities worldwide with a population of over a million people, of which 153 are expected to be in Asia. From an estimated 27 mega-cities (exceeding a population of ten million), 15 such cities will be in Asia. The sustainability implications of these cities will be enormous.

Cities are contributors to the promotion of global sustainability, as well as the impediments to proceed towards sustainability. Since cities are centres of high living standards, cities are responsible for consuming large amounts of material goods, which leads to the over-utilisation of limited natural resources, including energy resources, and emit large volume of greenhouse gases. At the same time, people living in these cities set the direction of future development in all aspects, and therefore, cities can greatly help in the process towards sustainable development. Cities are also engines of economic growth that provide a space for innovation, knowledge and technology, as well as employment. In particular, high population density and massive consumption opens several options to use “compactness” as a means to effectively utilise natural resources and efficient (and effective) urban infrastructural development. For example, compact settlement and high population density in cities may reduce per capita infrastructure and distribution costs, and open up opportunities for economies of scale. Thus, cities can greatly facilitate the implementation of measures to reduce stress to sustainability. Therefore, city and sustainability bring two major environmental issues to the forefront for policy makers: the first is the intensive consumption
of energy and materials which affect natural systems and ultimately affect areas and people outside the boundaries of cities to future generations; the second is the exposure of a large and concentrated urban population to worsening urban air pollution, water pollution, solid waste and vulnerabilities related to global climatic changes.

1.6 ENERGY END USE EFFICIENCY

Today more than 400,000 peta joules a year of primary energy deliver almost 300,000 peta joules of final energy to customers, resulting in an estimated 150,000 peta joules of useful energy after conversion in end-use devices. Thus 250,000 peta joules are lost, mostly as low and medium-temperature heat (Jochem, 2000). Globally, then, the energy efficiency of converting primary to useful energy is estimated at 37%. Moreover, considering the capacity to work (that is, the exergy) of primary energy relative to the exergy needed by useful energy according to the second law of thermodynamics, the efficiency of today’s energy systems in industrialised countries is less than 15%. But energy efficiency can be improved—and energy losses avoided—during the often overlooked step between useful energy and energy services.

Energy efficiency—and indirectly, improved material efficiency—alleviates the conflicting objectives of energy policy. Competitive and low (but full-cost) energy prices support economic development. But they increase the environmental burden of energy use. They also increase net imports of conventional energies and hence tend to decrease the diversity of supply. Using less energy for the same service is one way to avoid this conflict. The other way is to increase the use of renewable energies.

There is a great deal of potential for energy efficiency improvements and these could result in real reductions in energy use. In reality, the savings are less than optimal, because of growth in the numbers of households—which cannot be altered by policy—and the emphasis on efficiency rather than conservation is facilitating the development of larger appliances, cars and houses (Boardman, 2004). Any energy saved is also offset by the introduction of an increasing number of energy-profligate pieces of equipment. New developments are welcome (for instance the digital revolution), but manufacturers do not focus sufficiently on making
these equipments energy efficient. Thus, the expectation is that electricity use in consumer electronics could completely wipe out the gains made with white goods.

Global CO₂ emissions are growing rapidly and will double by 2050, if appropriate climate change mitigation measures are not put in place (Wada et al, 2012). A wide range of technologies and practices will be required to reduce CO₂ emissions substantially. Above all, energy efficiency is expected to play a key role in the context of sustainable development because, it contributes to reducing energy use and CO₂ emissions without undermining the welfare of society.

According to the IEA (International Energy Agency), end-use energy efficiency accounts for more than one-third of the CO₂ emissions reductions necessary for cutting emissions by half by 2050. From a regional perspective, energy demand is expected to surge particularly in rapidly growing economies, such as China and India, over the coming several decades. These countries offer great opportunities to reduce CO₂ emissions through deployment of highly efficient products. From a sectoral perspective, substantial efficiency improvement opportunities lie in the residential sector, one of the world’s largest energy-consuming sectors with 25% of global end-use demand according to a report by McKinsey & Company.

Energy efficiency and conservation should appeal to the three main dimensions of human motivation: Reason, Pride, and Pleasure (Limerick and Geller, 2007). Reason is not necessarily the most powerful force of the three, but when considered in a rational framework, energy efficiency and conservation get high marks.

• Reducing energy use saves money for households. The savings can be substantial on every scale: for private home owners, for renters paying their own energy bills, for small business people, and owners and stockholders of large corporations.

• Reducing energy use, individually and collectively, leads to similar savings on a larger scale for individuals, communities, and governments. Turning natural resources – coal, oil, natural gas, biomass, geothermal heat, sunlight, and wind – into energy is an involved and expensive prospect. To fully calculate the cost of energy, to the expenses of finding and extracting the natural resources, we have to add the expenses of transporting and transmitting the energy, the
losses at each stage of energy conversion, the cost of building and maintaining the energy infrastructure, and the burdens of dealing with “externalities” (costs usually left out of the price paid for a commodity), including environmental damage, the human health consequences created by this whole process, and the protection of energy supplies from distant and in some cases hostile and unstable lands. Energy efficiency and conservation save money at every level by reducing all these costs.

- Conserving energy means less environmental disruption and disturbance. In the most down-to-earth way, energy efficiency and conservation will reduce opportunities to quarrel, litigate, and accuse each other of bad behaviour. Life could, thereby, become more pleasant and less characterized by noise and clamour.

- Reducing energy use can increase productivity in the workplace. Businesses that consume less energy are more competitive in the national and global market.

- Reducing energy use can create more jobs. Producing, marketing, and promoting energy efficiency measures prove to be relatively labour-intensive activities. When a family or business spends the money it saved by conserving energy, it bolsters the economy and supports more jobs.

- Reducing energy use limits the destructive power of disasters, both natural and technological.

- Reducing energy use will play a crucial role in enhancing national security in an age of terrorism and instability, decreasing the dependence on energy imports and thus making less vulnerable to the actions within unstable and unfriendly nations. Of all the practices that a citizen can honour with the term “real patriotism”, energy efficiency and conservation occupy a position right at the top.

1.7 HOUSEHOLD ENERGY USAGE IN INDIA

There are a multiplicity of reasons why the study of household consumption patterns and energy requirements is of immense importance especially for a large developing country like India. For one, households are a major consumer of energy and contribute, to a large extent, to the total energy use of the nation. At present, the share of direct energy use of households in India is about 40% of the total direct commercial and non-commercial indigenous energy use (Pachauri, 2004). If, in addition, one takes into account the indirect or embodied energy in all
goods and services purchased by households, then about 70% of the total energy use of the economy can be related to the household sector, the remaining 30% comprise of the energy requirements of government consumption, investments and net imports. (Shonali Pachauri and Daniel Spreng in their study on “Direct and indirect energy requirements of households in India” (Pachauri and Spreng, 2002) have established this fact using 115 sector classification input–output tables for India for the years 1983–84, 1989–90 and 1993–94). The total CO₂ emissions of Indian economy for the year 2003-04 was 1217 million tons, out of which the households share was 707 million tons, in other words a whopping 58% (Abrahamse et al, 2005).

Energy services make up a sizeable share of total household expenditures in developing countries. In India, energy consumption patterns vary widely across different areas and groups of households. Average per capita energy consumption is low compared to developed countries and even world average figures. However, the demand for energy using services in the household sector has been growing at an increasing rate since the early 1980s and is likely to expand rapidly in coming years as well (Pachauri and Spreng, 2002).

Between 1980 and 2000, the actual amount of energy consumed per household in India remained almost constant (Reddy and Balachandra, 2004). This static consumption per household has been achieved through improved efficiency. Working against this good trend is the increase of activities resulting in rising utilization of energy. Household appliances and automobiles are becoming more efficient, but there are more of them and they are being used more often, even though energy prices have increased at the rate of about 10 per cent per annum. The experience of the last 30 years show that the rise of gross energy demand has by far exceeded the growth rates of population. The 1990s saw energy use growing at 5% per year, while the Indian population increased by less than 2% per year. The growth in demand has even offset all the savings achieved by energy efficiency increases within society at large. This highlights the importance of consumption growth as the driving force of energy demand. Given this scenario and the growing share of India in global energy use and CO₂ emissions, it is important to analyse the factors that are contributing to this.
The main factors that determine the selection of energy carriers include: prices of fuels and the corresponding utilizing devices, disposable income of households; availability of fuels and cultural preferences. Even though price of a fuel plays an important role in the household fuel shifts, it is not possible to study the effect of price in India, where a major part of energy consumption is met by traditional fuels that are gathered informally and the costs consist mostly of time (for gathering fuel-wood) and hence are opportunity costs. Another reason is that prices of commercial energy carriers such as kerosene are administered and hence do not reflect the real cost.

During the past few decades, India has experienced many changes in its energy consumption patterns - both in quantitative and qualitative terms (Reddy, 2004). This is due to the natural increase based on population growth and due to the increase of economic activity and development. The pattern of household energy consumption represents the status of welfare as well as the stage of economic development. As the economy develops, more and cleaner energy is consumed. Household energy consumption is expected to increase in future along with growth in economy and rise in per capita incomes. The projected increases in household energy consumption are expected to result from changes in lifestyles. Hence, it is important to analyze household energy consumption patterns in order to formulate policies for promotion of sustainable energy use.

Realizing the importance of examining the role of various energy technology options for India’s energy sector under alternative policy scenarios, the Office of the Principal Scientific Adviser to the Government of India entrusted TERI (The Energy and Resources Institute) a study entitled ‘National Energy Map: Technology Vision 2030’. The key focus of this study was to examine the role that various technological options could play under alternative scenarios of economic growth and development, resource availabilities, and technological progress (TERI, 2006).

In the BAU (Business As Usual) scenario, the total commercial energy consumption is estimated to increase by 7.5 times over the 30-year modelling period from a level of 285 Mtoe (Million tonnes of oil equivalent) in 2001 to 2123 Mtoe in 2031. A comparison of energy
requirements across the alternative economic growth scenarios indicate that if the economy grows at a slower pace of 6.7%, as characterized by the LG (low-growth) scenario, commercial energy requirement would increase to only about 1579 Mtoe by 2031 (5.9% GDP growth), while the energy requirements could be as high as 3351 Mtoe (8.6% GDP growth) by 2031 with a growth rate of 10% as represented by the HG (high-growth) scenario.

Although, the Indian government has plans for enhancing the exploitation of its hydro power, nuclear energy, and renewable energy resources, the analysis indicates that the impact of these supply-side alternatives is minor when compared with the total requirements of commercial energy by 2031, as indicated in the REN (aggressive renewable energy) and NUC (high nuclear capacity) scenarios. Although the contribution of hydro, nuclear, and renewable energy forms together increases by about six times during 2001–31, these sources can at most contribute to a mere 4.5% of the total commercial energy requirements over the modelling time frame. It is, therefore, evident that the pressure on the three conventional energy forms, that is coal, oil, and gas will continue to remain high at least in the next few decades.

The EFF (high-efficiency) scenario, however, indicates that there exists a significant scope for reducing energy (≈ 581 Mtoe in 2031) if efficiency measures are deployed on both the demand as well as the supply side.

1.8 ENERGY EFFICIENCY INITIATIVES IN INDIA
India with a population of over one billion inhabitants, more than one quarter of which are unable to meet their basic requirement, faces a formidable challenge in meeting its energy needs in a sustainable manner and at a reasonable price. To eradicate poverty and meet the basic requirement of the citizens, it is estimated that the economy must grow at a rate of 8 to 9 percent in the next 25 years (Dey, 2007). To meet the energy requirements for such a fast growing economy, India will require an assured supply of 3 to 4 times more energy than the total energy consumed today. Per capita consumption of energy in India is one of the lowest in the world and Indian citizen consumed only 439 kg of oil equivalent (kgoe) per person of primary energy in 2003. The corresponding world average and the consumption figures for China were 1,688 kgoe and 1090 kgoe respectively. In 2003-04, India consumed a total of
470 Mtoe primary energy of which the amount of commercial energy was 327 Mtoe (69.57%). Rest 143 Mtoe (30.43%) was met through non-commercial sources like fuel wood, agro waste, dung cake, biogas etc. Compared to this, India consumed a total of 132 Mtoe and 246 Mtoe energy in 1970 and 1990 respectively. By 2031–32, the power generation capacity must increase to nearly 800,000 Megawatt (MW) from the current capacity of 160,000 MW. There is huge potential for saving energy through different mechanisms. It is estimated that nearly 25,000 MW of energy could be saved through energy efficiency measures. The Report of the Expert Committee on Integrated Energy Policy (2006), has stated that over the next 25 years, ‘energy efficiency and conservation are the most important virtual energy supply sources that India possesses’. Another study estimated that the economy has an energy saving potential up to 23% as a whole, and the key sectors like agriculture, industry, transport, domestic, and commercial have the energy saving potential of 30%, 25%, 20%, 20% and 20% respectively.

‘Energy Conservation/efficiency’ is no more a fancy term used by energy planners as it has been the case during the last four decades. Now, it has become an integral part of India’s future energy planning strategies. The main focus of Indian energy planners was more on ‘conservation’ at least until the early nineties (phase one). The focus got shifted to achieving ‘energy efficiency’ only recently (explicitly after the formation of BEE (Bureau of Energy Efficiency) ), when environmental issues also got linked to India’s energy planning.

Between 1970 and 1990, India’s energy intensity of primary modern energy use had increased by 38%. Thereafter, it started to decline (Dey, 2007). The above period has been divided into two phases: during the first phase, between 1970 and 1990, the economy was controlled to a large extent by the state and the energy intensity of the economy was growing. During the second phase between 1991 and 2005, the economic liberalization process was in force and the energy intensity of the economy has been declining.

The elasticity (% change in commercial energy use for 1% change in GDP) for per capita primary commercial energy supply with respect to per capita GDP has improved to 0.82 between 1990–91 and 2002-03 from the estimated figures of 1.08 between 1980–81 and 2002
– 03. In 2003, India consumed 0.19 kgoe (kilograms of oil equivalent) per dollar of GDP expressed in Purchasing Power Parity. The corresponding figures for OECD, China, US and World average are 0.19 kgoe, 0.21 kgoe, 0.22 kgoe and 0.21 kgoe respectively (Dey, 2007). Though the statistics indicate some improvement in the energy usage, in terms of huge potential the achievements are insignificant.

Therefore, it becomes clear that neither the implementing agencies, nor the consumers, did exhibit serious intention in saving energy despite the fact that huge potential for saving existed. To quote the Report of the Expert Committee on Integrated Energy Planning, ‘despite these potential studies, actual implementation has been sluggish’. The eighth Five Year Plan (1992 – 1997) made a provision of $ 0.22 billion for energy efficiency to provide targeted energy savings of 5,000 MW and 6 Million Tonnes in the electricity and petroleum sectors respectively. There is no clear quantification of the actual costs and savings achieved. The target for energy savings in the tenth Plan (2002 – 2007) is 95 billion kWh which is about 13% of the estimated demand of 7,19 billion kWh in the terminal year of the tenth Plan (Dey, 2007). However, there is no specific resources that have been allocated to meet the energy saving targets.

The Bureau of Energy Efficiency (BEE) has just made a beginning after a very slow start. Due to administrative red tapes, BEE did not have a fulltime head and, till September 2005, had only 4 professionals on staff (Dey, 2007). But BEE has, among others, initiated few important initiatives: the National Energy Conservation Award for small scale industries, for shopping mall buildings, hotel and hospital buildings, office buildings, and also large and medium scale industries. They have also come out with a detailed scheme of energy efficiency labels in May 2006. Moreover, BEE has also drafted a model energy performance contract for ESCOS (Energy Service Companies). The most important initiative taken by BEE during last few years was the organization, on a regular basis, of the National Certificate Examination for Energy Managers and Energy Auditors. A vast country like India needs substantial numbers of such energy experts without whom, no conservation measures will be successful.
Since nearly one third of total energy is used for domestic cooking, efficiency of the cooking process should have been given a high priority, particularly since this process is currently marked by poor level of efficiency and dependence on fire-wood is very high, especially in the rural sector. A focused program to increase the efficiency of traditional wood stoves is urgently required. But the report of the expert committee on integrated energy planning revealed that successes in disseminating information on improved wood stoves have been limited. They penetrated only 15% of Indian’s homes between early 1982 and 1992. A survey showed that one-third of the ICs (improved cooking stoves) installed became non-functional within the first year of installation. During the same period, China covered 70% of the rural household under a similar type of program (Dey, 2007). In the early 1990s, priority on wood stove research was reduced and the effort was put on solar energy. It was a worldwide phenomenon. Restricting the efforts to improve fuel wood stoves implied the acceptance of a ‘dual-fuel’ society, i.e. a society in which the poor cooked with messy solid fuels in relatively inefficient stoves and the rich enjoyed clean gaseous fuels like LPG in efficient stoves. There was also little consciousness of the strong gender bias against women in this shift of priorities.

A ‘dual fuel’ society is an outcome of economic dualisms still very strong in India. For example, in 2002-03, 80% of the energy needs of rural India (75% of the total population) was met from traditional renewable energy sources like fuel-woods etc., (65%) animal and human energy (15%). Even towards the end of 1990s, more than 55% of the total cultivated area was managed by using draught animals as against 20% by tractors. In 1991, the percentages of electrified rural and urban household were 30.5% and 75.8% respectively. The corresponding figures in 2001 were 43.5% and 87.6% respectively. A study based on an integrated survey, as quoted in the India Development Report (2004-05) covering 15,293 rural households from 148 villages estimated that 96% of households used biomass energy, 11% used kerosene and 5% used LPG for cooking. Most of them used multiple fuels. Respiratory symptoms were prevalent among 24 million adults of whom 17 million had serious symptoms; 5% of adults suffered from Bronchial asthma, 16% from Bronchitis, 8.2% from Pulmonary TB and 7% from Chest infection; Risk of contracting respiratory diseases increased with longer duration of use of bio-fuels.
The Eco-labelling scheme (Eco-Mark) which was launched in 1991 just before the earth summit (1992) was a total failure. No Eco-mark product is available in the market. One reason for this could be numerous regulatory requirements and cost involved in implementing them. The only silver lining was the success of the Green Rating Project (GRP) initiated by an NGO. The success of this project indicates that industry responses positively if a program is designed, giving due respect to all the stakeholders’ views by involving them in every stage of it from inception to implementation (Dey, 2007). Probably NGOs are more equipped and philosophically more attached to this kind of program delivery process than the bureaucrats.

1.8.1 Possible reasons of failure of the energy conservation initiatives

*Lack of seriousness and leadership:* All these initiatives towards conservation measures taken by the government remained as an appendix to the long term energy policy (if there was any!). All the measures taken were reactive to certain events, not proactive by nature. This was the case for the establishment of the Petroleum Conservation Action Group in 1976 (as a reaction to oil shock of 1973–74), the Inter-Ministerial Working Group for Energy Conservation (IMWGEC) in 1981 (again as a reaction to second oil shock of 1979), the Eco-labelling initiatives in 1991 (as part of the preparation for the Earth Summit 1992). Even the most recent initiative, the establishment of the BEE in March 2002, coincided with the Rio +10 summit at Johannesburg. Moreover, even after three years of its formation, BEE remained almost non-operational.

*Technical backwardness:* In the early fifties, India - then a newly independent state could not mobilize fund or develop appropriate technology for its nascent industry. Indian industry had to accept obsolete technology from whatever source it could get. Replacement of those old fashioned, inefficient power technologies in industries and transport sector is a prerequisite for improving the energy intensity of the economy. Until the early 1990s, the shortage of adequate foreign exchange was the major constraint for the entrepreneurs who wanted to import better technology to improve their efficiency. Appropriate indigenous technology could not be developed also for various reasons. Signs of improvement in the energy intensity figures were only observed with the opening up of the economy during the last one and half
decades. Increased competition both at home and abroad, has compelled the business leaders to look into alternative options to save energy cost.

*Limited exposure to global trade*: Indian economy during the first fifty years of its independence relied mostly on protected domestic market. In 1980, India’s share in the global trade was 0.57%. This share increased only at a snail’s pace as the figures indicate: 0.60 % (1990); 0.71% (2000) and 0.80% (2002) (Dey, 2007). In this new century, when most of the industries were gearing up to boost exports, they realized that the cost of energy was robbing off their competitive edge in the international market. The World Economic Forum study on competitiveness of countries for the year of 2001 ranked, India 57th on the Growth Competitiveness Index (GCI); down by 9 points from the GCI ranking of 48 in the previous year. The high cost of energy, was the main reason identified for the poor competitiveness of Indian industry. In India, the cost of power has escalated three fold in the last ten years. This probably explains why various new initiatives on improving energy efficiency have been taken recently.

*Wrong pricing policy and high subsidies*: Through cross subsidisation between different products, oil PSUs (Public Sector Units) tried to persuade targeted customers to switch from other competitive energy sources and to use more petroleum products. The main objective of cross subsidisation between products was to attain distributional equity and social welfare. In reality, it helped to popularise different petroleum products in the targeted markets. Between 1975-76 and 1989-90 subsidised HSD (High Speed Diesel) and kerosene consumption increased by 300% and 250% respectively (Dey, 2007). The Kerosene subsidy was mainly given to the poorer section of the population. In September 1997, the government announced its intension to dismantle Administrative Pricing Mechanism (APM) in phased manner. It was decided that, by April 2002, it would be fully dismantled and prices of petroleum products would be determined on the basis of import parity system. The APM- a complicated pricing formula had two important components: ‘retention’ and cross subsidization’. The ‘retention concept’ (a variant of the World Bank suggested ‘cost plus’ pricing model was introduced in Shipping Corporation of India in the early 1970s) was introduced to crude and petroleum products pricing system in 1976. Accordingly, the price of indigenous crude was based on
operating cost plus 15% post tax return on capital employed. Oil refineries and marketing companies calculated the price of their products on the basis of operating cost plus 12% post tax on net worth. Natural gas was kept out of this pricing mechanism.

The other important component of APM is ‘cross subsidization mechanism’ which has enabled the Indian oil industry to establish its dominance in the energy sector in the last few decades. Cross subsidized petroleum products competed with other energy sources like coal, and penetrated into their domain. Thus, low priced kerosene has replaced vegetable oil and coal for illuminating lamps and cooking respectively. Subsidized LPG has become an essential household fuel making coal gas uncompetitive, long distance trucks fed with cheap diesel easily competed with the railways in freight movement and subsidized naphtha made the indigenous coal technology unviable for fertilizer production. This pricing policy backed with elaborate distribution system has made the entire economy almost completely dependent on petroleum products. The ‘retention concept’ on the other hand did not allow the public sector oil companies to become sick. Thus investors’ (mainly multilateral funding agencies like World Bank, ADB etc.) funds were safe.

In April, 2002, the Government of India dismantled the APM. Domestic price of petroleum products has been linked to global price fluctuations (‘import parity’). But the government continues with the controlling mechanism through exercising various fiscal measures like taxes and subsidies. As of January 2006, subsidies on PDS (Public Distribution System) kerosene and domestic LPG rose to $3.33 billion and $2.44 billion (Dey, 2007). In 2003/04, central subsidy on petroleum products was $1.44 billion. This was a 26% increase from the previous year. Under pressure from diesel lobby, in February 2007, the price of diesel has been reduced by cutting excise duty on diesel. (1 US$ is approx 45 INR (Indian Rupees)).

Subsidies on both kerosene and LPG do not target a specific segment of the population. According to Census 2001, biomass accounts for about 90% of the total primary fuel consumption for cooking in rural areas. LPG is the primary fuel consumed by the urban households. While traditional fuels are also consumed in these areas, their usage is restricted to the lowest expenditure classes. Subsidies have not been able to change the pattern of
consumption in rural areas, and the dominance of traditional fuels still continues. Subsidized kerosene is used by rural households to meet their lighting needs. The consumption pattern of LPG is highly skewed towards the higher expenditure classes in the rural areas. Even in the urban areas, LPG consumption increases significantly with the increase in income but the quantities consumed are much larger, and therefore, the subsidy benefits in urban areas are also much larger. It has been observed that 76% of the LPG subsidy goes to urban areas with 25% of total population. Nearly 40% of the LPG subsidy is enjoyed by the top 6.75% of the population (Dey, 2007). TERI estimated that around 26% of the total kerosene consumed in the country could not be accounted for. It is believed that the kerosene that is siphoned off is used for adulterating diesel, used as a transportation fuel, and in pump sets /generator sets in rural areas. A key reason for adulteration is the price difference between diesel and kerosene. At present diesel is priced at $0.68/litre (as on 2007) and PDS kerosene is priced at just $0.20/litre. This differential is a big incentive for retail sellers to adulterate.

Wrong priority on road transportation: In 1950-51, railways accounted for 89% of total freight movement which fell to 66% in 1970-71 and further to 46% in 1988-89. Contrary to this, freight movement by road went up from below 30% of total freight in 1970 to 54% in 1988-89. Most importantly, 88% of the total diesel consumption in India in 1986-87 for freight haulage was utilized by trucks in carrying 59% of the total diesel hauled freight. The railways in the same year, accounted for only 12% of total diesel consumption to move 41% of total diesel freight (Dey, 2007). This clearly indicates the relative energy efficiency of rail movement. But, transportation through road had overtaken the railways mainly because of the availability of cheap diesel. The share of railways in total tonne kilometre of goods traffic came down from 70% in 1970-71 to 39% in 2003-04. Had the railway carried 70% of the goods traffic, it would have carried 300 btkm (billion ton kilometre) of additional traffic. Assuming that Railways using diesel would have carried all of this goods traffic, the diesel saved in year 2003-04 is around 5 MMT (Million Metric Ton) out of a total consumption of 40 MMT in the country that year. Thus, a significant saving of diesel is possible, if railways operations can be upgraded to win back the haulage lost to road traffic.
Easy availability of energy sources: In addition to the easy availability of petroleum products due to wrong pricing and subsidy policy, other factors like power theft (Dey, 2007), illegal mining, high percentage of disguised unemployed people in the rural economy and usage of more fertilizer in cultivation, allowed the availability of electrical power, coal, fire wood and dung cakes at a lower rate than the market price. This acted as a disincentive to the consumers both domestic and industrial to make any investment in energy saving technology.

Power theft: According to the Planning Commission figures, the transmission and distribution losses in the State Electricity Boards (SEBs) have grown over time, from 21% in 1992-93 to about 28% in 2004-05. The practice of the SEBs in later years was to hide the T&D (Transmission & Distribution) losses under agriculture and irrigation supplies, which are subsidized. The Electricity Act 2003 has introduced the term ATC loss (Aggregate Technical and Commercial loss) which also includes loss due to pilferage. Recent data indicates that the ATC losses of few SEBs were as high as over 70%. The average ATC losses to the SEBs were around 50%. This indicates the extent to which pilferage takes place in India. Voluntary groups like the Pune-based PRAYAS have also pointed to high-level collusion involving big industrialists and politicians, leaving utility managers helpless to prevent large-scale thefts for fear of vindictive action. Independent studies of the phenomenon of large-scale theft have shown that the perpetrators tend to be well-to-do citizens who maintain air conditioned homes rather than poor people who live in the slums and may tap power off overhead cables to light up their shanties. India has the reputation of having the highest transmission and distribution losses in the world, ranking above the Dominican Republic with its 38% losses, Burma 36% and Bangladesh at 33%. There are no hard figures, but the best estimate is that somewhere between a third and half of the country’s electricity supply is unpaid for. No other country suffers revenue losses on this scale. In China, Asia’s other emerging economic giant, no more than 3% of the nation’s power supply is lost to theft. The commercial loss of India’s SEBs’ has gone up from $5.01 billion in 2004-05 to $5.02 billion in 2005-06.

1.8.2 Future challenges
The analysis indicates that initiatives, including the most current ones, are mostly aimed at increasing the energy efficiency of the sectors which use modern form of energy. However
the presence of traditional form of energy (including animal and human) is still substantial. No effective measure has been taken to improve the efficiency of traditional form of energy system. Given the existence of a dual energy economy where there exists a very clear division between urban and rural energy usage, the energy planners face an uphill task to improve the efficiency of the traditional energy usage and simultaneously increase the supply of modern form of energy to billions of energy starved population.

Second, the most formidable challenge would be to curb the non essential energy demand in the urban sector. For example, as developed countries are taking measures to restrict the usage of automobiles the global automobile industry is focusing their attentions to India with active support from the Government. India is being considered as a potential global automobile manufacturing and export hub. Initiatives have been taken to produce smaller cars suitable for congested Indian lanes. The controversial small car project initiated by the Tatas (one of the largest business groups in India) in West Bengal is a case in point. All these would increase the future demand for energy. Again, to solve the increased demand for energy, construction of large scale nuclear plants (instead of cheaper energy options) have been suggested in the name of restricting carbon emission. It is heartening to note that already different civil societies and common citizens have started protesting against this kind of initiatives and the government is also trying to find the solution in new and renewable energy sources. India is one of the few countries which has separate ministry to look after the renewable energy sources. The Ministry of Non Conventional Energy Sources which has a very poor performance record, has been renamed (with effect from October 2006), as the Ministry of New and Renewable Energy. After a long wait, India’s energy planners might have found their proper direction.

1.9 CHAPTER SCHEMATA
This thesis is organised as follows: Chapter 2 highlights the details of the literature survey which was under taken to to explore the past and the present status of research work in the field of energy in general and household energy in particular. The entire discussion has been grouped into seven themes. Chapter 3 discusses the theoretical frame work, objectives, scope and the methodological issues of the research. Chapter 4 is devoted to a discussion on the
questionnaire design. Chapter 5 explains how the raw data collected from the survey was converted to a form which can be subjected to further statistical analysis. The preliminary data analysis which was carried out to explore the general pattern of the data also has been covered in this chapter. The methodology of factor analysis which has been used for data reduction and to identify the factors which are influencing the adoption of Energy efficient technologies and Conservation habits in Indian urban households has been dealt with under Chapter 6. Modeling adoption of Energy efficient devices and Conservation habits in Indian urban households is another major objective of this research work. Multiple regression analysis has been used for this purpose and Chapter 7 spells out the details of this step. The Quantile regression model which is a natural extension of Multiple regression analysis and used for observing the variations in the predictors at lower and higher quantiles, has been applied for the first time in the Indian context to study household energy consumption and conservation in this study. The details of this are available in Chapter 8. Finally the implications of the research findings of the current study for - policy implications, manufacturers of Energy efficient devices and NGOs have been discussed in Chapter 9.