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Abbreviations

ACT	Active Conservation Techniques
ADB	Asian Development Bank
AIWC	All India Women's Conference (AIWC)
APSRTC	Andhra Pradesh State Road Transport Corporation
ARI	Acute Respiratory Infections
BCM	billion cubic metres
BDTC	Biogas Development and Training Centres
BELP	BESCOM Energy Efficient Lighting Programme
BIOTECH	
BIS	Bureau of Indian Standards
BPL	below poverty line
BT	billion tones
CAGR	Compounded Annual Growth Rate
CASE	Commission for Additional Sources of Energy
CEA	Central Electricity Authority
CFLs	compact fluorescent lamps
CO	Carbon monoxide
DACs	District Advisory Committees
DNES	Department of Non-conventional Energy Sources
DSM	Demand Side Management
EETs	energy efficient technologies
EOR	enhanced oil recovery
ESCOS	energy service companies
FPSs	Fair Price Shops
GDP	Gross Domestic Product
GHG	greenhouse gas
GNESD	
GoI	Government of India
HBJ	Hazira Bijaipur Jagdishpur
ICD	International Co-operation Division
ICS	improved cook stove
IEA	International Energy Agency
IEP	Integrated Energy Policy
IGCC	Integrated Gasification Combined Cycle
IOR	improved oil recovery
IPE	Information, Publicity and Extension
IR	International Relations
IREDA	Indian Renewable Energy Development Agency Limited
IREP	Integrated Rural Energy Programme
ISPRL	Indian Strategic Petroleum Reserves Limited

IT	Information Technology
Kgoe	kilogram of oil equivalent
KVIC	Khadi and Village Industries Commission
LaBL	Lighting a Billion Lives
Lm	Lumens
LPG	liquefied petroleum gas
MDGs	Millennium Development Goals
MMSCMD	million metric standard cubic metre per day
MNES	Ministry of Non-Conventional Energy Sources
MNRE	Ministry of New and Renewable Energy
MPCE	monthly per capita consumption expenditure
MTOE	million tonnes of oil equivalent
NCAER	National Council of Applied Economic Research
NDDB	National Dairy Development Board
NELP	New Exploration Licensing Policy
NO_x	oxides of nitrogen
NPBD	National Project on Biogas Development
NPBD	National Project on Biogas Development
NPIC	National Programme on Improved Chulhas
NRSE	new and renewable sources of energy
NSSO	National Sample Survey Organization
OIDB	Oil Industry Development Board
OMCs	oil marketing companies
OVL	ONGC Videsh Ltd
PAH	Poly-aromatic hydrocarbons
PCRA	Petroleum Conservation Research Association
PDS	Public Distribution System
PIC	products of incomplete combustion
PV	solar photovoltaic
R&D	Research and Development
REEPS	Renewable Energy Electronic Processing System
RENET	Renewable Energy Network
RET	Renewable Energy Technologies
RIL	Reliance Industries Limited
SEWs	self-employed workers
SHP	small hydro power
SNAs	State Nodal Agencies
SO_2	Sulphur dioxide
TIFAD	Technology Information Forecasting, Assessment and Data Bank
TSPs	total suspended particles
VESP	Village Energy Security Programme

Executive Summary

ES 1 Introduction

The objective of the project has been to study the nature of energy security issue specific to the selected country (India) and to analyse the threats to energy security, measures taken to improve energy security and impact of such measures on energy security. This analysis has been carried out at both the national and household levels.

With the robust economic growth of more than 7% over the past few years, the energy requirements in the country is rising sharply which raises the energy security concerns. There is an increasing recognition of the importance of energy security in India. A number of policies have been framed for improving energy security at national and household levels. The Integrated Energy Policy 2006, GoI, defines energy security as 'we are energy secure when we can supply lifeline energy to all our citizens irrespective of their ability to pay for it as well as meet their effective demand for safe and convenient energy to satisfy their various energy needs at competitive prices, at all times and with a prescribed confidence level considering shocks and disruptions that can be reasonably expected.'

ES 2 Methodology

The study is based on the review of policy documents, legislations, literature review of the studies carried out by various organizations and interaction with the relevant stakeholders.

Based on the above, various indicators have been identified to analyse various aspects of energy security at the national and household level. The indicators have been developed to analyse the physical availability of the energy sources and the financial aspect of the same. At the national level, indicators such as demand supply gap of various fuels (coal, oil, natural gas and electricity), import dependence of oil/coal and reserves to production ratio of coal/oil/natural gas measures the extent of present and future availability of the energy resources in the country. In order to capture the financial impact of import of the energy sources, indicators such as energy import bill as a percentage of the total import bill of the country or of national export revenues and of gross domestic product of the country,

has been developed.

Similarly, at the household level, indicators such as percentage of households using cleaner fuels; per capita consumption of energy sources such as electricity, kerosene, LPG and biomass; and access of clean fuels in the households measures the physical availability of the clean energy sources at the household level. Indicators such as, household's expenditure on the fuel and lighting and affordability of energy sources measures the financial aspects of the energy security concerns at the household level. Indicators such as time spent on collection of traditional sources of the energy sources and the impact of indoor air pollution due to usage of traditional sources of energy measures the social and environmental impact of the energy security concerns at the household level.

ES 3 Socio economic and energy profile of India

Increasing population and rising economic growth of the country, has put an immense pressure on the scarce natural resources. At present, India is the fifth largest energy consumer in the world and has the highest incremental demand for energy. More so, such increase in energy demand is expected to continue in the future also. India's total primary energy demand is expected to grow at an average rate of about 3.2% between 2002–25 and 2030. Although the commercial energy sources in the form of coal, oil and natural gas are consumed in India, the country still depends on the traditional sources of energy for meeting about 30% of their energy needs.

Coal is the mainstay of the Indian energy sector. There were about 255 billion tonnes of coal reserves in India as of April 2007.[1] With this, the total production of coal has reached to about 432.50 million tonnes (MMT) in 2006/07 (17.90 MMT of coking coal and 414.60 MMT of non-coking coal).[2] Production of coal has been increasing at a CAGR of about 4% over the past decade. However, the share of coking coal in total coal production is decreasing. Coal is expected to be a dominant fuel in future as well. It is expected that the coal shall comprise the 50% of the fuel mix in 2031. With demand of coal rising to 2854 MMT by 2031, its import dependency is expected to rise to about 78% by 2031.[3]

Crude oil reserves in the country are more or less stagnant with

[1] Annual Report 2006/07, Ministry of Coal, Government of India
[2] TERI Energy Data Directory 2006/07
[3] National Energy Map for India, Technology Vision 2030, TERI 2006- National Energy map for India, Technology Vision 2030

about 756 MMT of reserves in 2006. However the demand for crude oil in the country is rising at a CAGR of 8.45%. Crude oil is expected to comprise about 31% of fuel mix in 2031. With rising demand and stagnant reserves of crude oil, its import dependency is expected to rise to about 93% by 2031.

Natural gas is regarded as a fuel of 21st century. In 2006, natural gas reserves in the country were about 1075 billion cubic metres (BCM). The production of natural gas was about 32.2 BCM in 2005/06. However, presently, about 30 MMSCMD of demand of natural gas is unmet. As regards the future availability of natural gas, about 93 BCM of natural gas needs to be imported to meet the domestic demand. This will result in import dependency of as high as 67%.[4]

Secondary source of energy such as electricity has a close linkage with the primary fuel supply. The electricity generation in the country increased at about 5.24% over the past decade and was about 659 512 Gwh in 2006/07. However, the country faced an energy shortage of about 10% in 2006/07, with peak time shortage of 13.5% in the same year.[5]

Using renewable sources of energy is regarded as a measure to attain the national economic growth while conserving the depleting natural resources. Renewable based power generation could be grid interactive or distributed renewable based power generation. As on 31 March 2007, the cumulative grid interactive power generation capacity using renewable energy sources was about 9372 MW (6315 MW-wind energy, 1905 MW-small hydro power and 1152 MW-bio power).[6] Taking this forward, the country aims to achieve at least 10% power generation installed capacity and about 4% of the electricity mix in the country shall be based on renewable energy sources by 2012.

Household sector is regarded as a largest energy consuming sector in India. It is responsible for about 45% of the total primary energy use, with non- commercial/biomass fuels bearing a large share of it. Biomass fuels provide around 72% of the household energy and 90% of all rural energy needs. However, there is a shift from traditional fuels to commercial fuels like LPG and electricity. At the household level, cooking and lighting are the major energy consuming activities.

As regards the cooking activity at the household level, there is

[4] National Energy Map for India, Technology Vision 2030, TERI 2006- National Energy Map for India, Technology Vision 2030
[5] TERI Energy Data Directory Yearbook, 2006/07
[6] TERI Energy Data Directory Yearbook, 2006/07

high dependence on traditional energy sources for meeting energy needs. This is especially high in case of rural household with about 85% of rural households using firewood and dung cake for cooking.[7] In urban households, though liquefied petroleum gas (LPG) is the primary fuel for cooking, still more than 20% of the urban households depend on traditional fuels for cooking.[8] However, as the income of the household increases, the usage of traditional sources decreases.

As regard the lighting activity, electricity and kerosene are the primary energy fuels used for the same. Although the usage of electricity for lighting needs has increased over the years, kerosene still continues to be major fuel among the rural households. Also, as the income of the household increases, usage of kerosene for lighting purposes decreases.

Thus it is seen that there is significant dependence on traditional energy fuels in the household sector. However, such dependence is decreases as the income level of the household increases.

ES 4 Energy security at the national level

This section discusses the threats to energy security at the national level, measures taken to enhance the energy security and the impact of such measures at the national level.

The energy scenario as described in the previous section highlights the threats to energy security at the national level. The following indicators indicate the physical threat to the energy security.

- Increasing demand supply gap: There has been a gap between the demand for coal and its domestic availability of about 9% of total demand in past two years. The country also faced electricity shortage of about 10% and peak shortage of about 13.5% in 2006/07.[9] For natural gas, the supply of natural gas within the country falls short of its demand by about 40% in 2006/07.

- Increasing import dependency: due to increasing demand supply gap, India's imports of energy sources are also increasing. India imported 65% of its total coking coal demand in the country in 2005/06 due to non-availability of the required quality of coal.[10] Also, crude oil import

[7] TERI Energy Data Directory Yearbook, 2006/07
[8] National Sample Survey Organization
[9] TERI Energy Data Directory Yearbook, 2006/07
[10] Integrated Energy Policy, Planning Commission, August 2006

dependency in India ha reached to about 71% in 2006/07 due to stagnant crude oil reserves in the country and the rising demand for the same.[11]

- Reserves to production ratio: With the increase in production rate of the energy fuels and the depleting reserves of the fossil fuels in the country, coal reserves are expected to last for 45 years and oil reserves for 23 years.

Increasing import dependence for meeting the energy needs of the country has financial implications attached to it. The following indicators highlight the financial threats to the energy security at the national level.

- Energy import bill as a percentage of the total import bill of the country: Energy imports accounts for a substantial portion of the total import bill of the country. Crude oil and coal together accounts for about 32% of the total imports of the country in 2006/07.[12]

- Energy import bill as a percentage of export revenue: It is necessary to assess the level of energy imports, which could be financed by the export earnings of the country. Crude oil and coal imports together are equivalent to about 49% of the export revenues.[13]

- Energy import bill as a percentage of foreign exchange earnings: With the increasing energy imports in the country, the fiscal strain on the economy is also rising as it results in the outflow of the scarce foreign exchange of the country. Crude oil imports accounted for about 38% of the foreign exchange earnings of the country in 2006/07.[14]

- Energy imports bill as a percentage of the gross domestic product (GDP): It is necessary to assess the level of the energy imports bill, which could be sustained by the domestic earnings of the country, if required. Crude oil and coal together accounted for about 10% of the total domestic earnings of the country.

The physical and financial threats to energy security, highlights that certain measures, both on demand side and supply side, need to be taken to improve the energy security of the country. Following measures have been taken in this respect.

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[11] Petroleum Planning Analysis Cell
[12] RBI Statistical handbook of India
[13] RBI Statistical handbook of India
[14] RBI Statistical handbook of India

- Enhancing energy security: There are policy level measures to promote energy efficiency. Electricity Act 2003, Energy Conservation Act 2001 and National Electricity Policy have laid provisions for promotion of energy conservation and energy efficiency in the electricity sector. Petroleum Conservation Research Association (PCRA) promotes strategies for promoting energy efficiency in sectors such as transport, domestic, industrial, agricultural and commercial. Implementation of energy efficiency measures are not expected to alter the energy mix of the country per se but it results in decrease in quantum of energy demanded in the country. Energy so saved has a favourable financial impact. For instance, audit of governmental building revealed that they have a potential to save 17.5 million Kwh, which amounts to about Rs 4.4 million to the government.[15] Measures taken by PCRA have resulted in saving of about 2700 thousand tonnes and about Rs 20.66 billion to the country.[16]

- Increasing use of renewable sources of energy: In wake of depleting fossil fuels resources, usage of renewable energy sources such as solar, wind, biomass, small hydro, etc., are emerging as an alternative source of energy. Government is promoting renewable energy resources through MNRE and public sector enterprises such as Indian Renewable Energy Development Agency Limited (IREDA) are promoting renewable energy technologies in the country. With such measures, share of renewable energy sources in the total electricity mix of the country has reached to about 8%.[17] Increased use of renewable energy sources also has a favourable impact on the environment.

- Other Measures: Apart from the above stated measures, measures such as diversification of energy mix, diversification of energy supplier, acquisition of equity in energy sector abroad, improving oil recovery or building strategic oil reserves contributes positively towards achievement of the energy security of the nation.

ES 5 Energy security at the household level

This section discusses the threats to energy security at the national level, measures taken to enhance the energy security and the impact of such measures at the national level.

[15] Presentation on Energy Conservation and Efficiency by Secretary, BEE
[16] PCRA website
[17] http://www.cea.nic.in/power_sec_reports/executive_summary/2008_03/27-33.pdf

The following indicate the physical threats to energy security at the household level.

- Per capita consumption of energy fuels: There is a wide disparity between the rural and urban households with respect to consumption of energy fuels. Rural households face serious energy security threat in terms of consumption of inefficient and polluting fuels. For instance, per capita consumption of fuel wood in rural household is about 21 kg as against 6 kg in urban households.[18]

- Access to cleaner energy fuels: It is observed that electricity is the major energy fuel used for lighting. However, rural households still use significant amount of kerosene, primarily to meet their lighting needs. Similarly for cooking activity, rural households depend on traditional energy sources such as firewood, whereas urban households have witnessed greater penetration of cleaner fuels such as LPG.

The financial threats to energy security at the household level can be captured through the following indicators.

- Per capita monthly expenditure on energy fuels: Expenditure on electricity and LPG constitute the major expenditure by urban households on energy consumption. On the other hand, rural household expenditure on energy fuels is mainly for traditional sources for energy such as biomass.

- Percentage expenditure on energy fuels: Urban households spend a larger share of their total expenditure on the energy fuels as compared to the rural households. This may be due to higher consumption of commercial fuels in urban households which has market value attached to them.

- Increasing expenditure on energy fuels: It is observed that the expenditure on the energy fuels as a percentage of the total household expenditure has been rising over the years. In case of rural and urban household, expenditure on fuel and lighting has increased from 5.6% of the total household expenditure in 1972 to about 10% in 2004.[19]

- Energy access and income: It is observed that the consumption of cleaner and subsidised energy fuels such as

[18] National Sample Survey Organization, Household consumption of various goods and services in India, 2004–05, 61st round (July 2004–June 2005)
[19] National Sample Survey Organization, Level and pattern of consumer expenditure, 2004–05, 61st round (July 2004–June 2005)

kerosene and LPG is skewed towards the households with higher income.

The physical and financial threats to energy security at household level indicate the need to take certain measures, both on demand side and supply side, to improve the energy security of the country. Following measures are taken in this respect.

- Enhancing energy efficiency: To bring about energy efficiency in cooking activities, use of improved cook stoves, with higher efficiency, was promoted through National Programme on Improved Chulhas (NPIC). The programme caters to installation of improved cook stoves in rural and semi urban households. As a result of the programme, about 350 million improved cook stoves were installed by 2003, which were estimated to save 10 million tones of fuel wood per annum.[20] Also, the government is promoting use of kerosene and LPG through various programmes. Government incurs large amount of cost in the form of subsidies to make cleaner fuels like kerosene and LPG affordable to the households. Subsidy amounting to Rs 178 per cylinder of LPG and about Rs 16 per litre of kerosene is provided by the government to oil marketing companies.[21] For the purpose of promoting energy efficiency in meeting the lighting needs of the households, use of compact fluorescent bulbs (CFLs) in place of incandescent bulbs is promoted. Power utilities undertake programmes to promote use of CFLs by making them affordable for the households. As a result of such programme undertaken by power utilities in Bangalore and Maharashtra, about 500 000 and 300 000 CFLs have been sold in respective places. Employment of improved and energy efficient energy resources lead to energy and monetary savings at the household level. At an all India level, there are about 320 million incandescent lamps. Assuming 25% of theses lamps are replaced with CFLs, households in India can save 7884 million units, which will approximately amount to Rs 23 650 million in monetary terms.[22] Thus, improving efficiency in energy use leads to efficient utilization of scarce resources and thus it is important from energy security perspective.

- Increased use of renewable energy sources: Another measure to improve energy security at the household level is the usage of renewable sources of energy for meeting

[20] http://www.reckonindia.com/indiatrade/busiopp/nonconventionalenergy.asp
[21] Petroleum Planning Analysis Cell
[22] Manisha Jain, Vikas Gaba, Leena Srivastava 'Managing Power Demand' TERI 2007

cooking and lighting needs of households. For cooking needs, use of biogas and solar cookers are promoted as they are regarded to be cleaner and efficient fuels. National Project on Biogas Development was launched to promote family type biogas plants. Over 3.89 million of biogas plants have been supported till 2006/07 under the project. It is reported that adding another 102 000 of plants in subsequent years would result in estimated saving of about 400 000 tonnes of fuel wood and production of about 1.4 million tonnes of organic manure.[23] Also, solar cookers are regarded as an efficient way of cooking since it does not involve use of any conventional fuels. MNRE has been promoting solar cookers by providing relevant financial support to the households. A dish type solar cooker and community based solar cooker leads to saving of about 10 and 35 LPG cylinders per year, respectively. These solar cookers last for about 20 years and its cost is recovered in just about 1.5 years for dish based solar cooker and about 4.5 years in case of community based solar cooker. Solar cooking has associated social and environmental benefits. MNRE is also promoting usage of solar lantern for meeting the lighting needs of the households by providing the financial support to the households. Each solar lantern promoted by MNRE is designed to operate for 4 hours every day for 300 days in a year and is able to save 1200 hours of a kerosene lamp.[24] Apart from these measures, certain measures are taken by the household themselves to procure energy for usage. Such measures may include hooking of electricity or use of candles or kerosene lamps in place of electricity. All these measures have a far reaching and long term impact on the Indian households.

ES 6 Recommendations and further scope of the work

The study recommends an integrated approach to Indian energy sector as the energy resources available in the country are closely linked to each other. For instance, there is close linkage between the coal and electricity sector, with electricity sector as major consumer of the coal. Any policy change in one sector impacts the other as well and therefore an integrated approach to the energy sector as a whole needs to be devised such that it aims at the overall improvement of the sector.

High dependence on traditional sources of energy fuels can be countered by increased penetration of renewable energy sources at the household level. However, despite the potential of

[23] MNRE website
[24] MNRE website

renewable energy sources at the household level, there is a lag in its implementation. Thus, it is necessary to address the barriers faced at the household level for the increase in penetration of renewable sources of energy. In the wake of depleting fossil fuels in the country, it is necessary to maximise the use of renewable sources.

It is necessary that the subsidies provided by the government for improving energy efficiency at the household level, should be targeted at the appropriate sector of the country. Since the provision of subsidies by the government leads to immense financial burden on the economy of the country, it is necessary that the subsidies should reach and benefit the targeted beneficiaries.

The study highlights the large potential of energy efficiency in improving the energy security of the country as a whole and of the household sector in specific. Taking this forward, a detailed study can be conducted with the objective to measure the actual impact of energy efficiency at the household level. To analyse this, a case study based approach may be followed. A typical household area in both the urban and rural sector may be selected to analyse if there is any change in the energy consumption pattern before the usage of energy efficient appliance/measures and after it.

Chapter 1 Introduction

1.1 Background to the study

Energy has always been an important element for the economic development and social progress of all nations. Today, a major part of the global energy needs is met by fossil fuels such as oil, gas and coal. Unfortunately, the global reserves of these non-renewable sources are very limited.[25] Therefore, many nations in the world are worried about security of their future energy supplies, especially those dependent heavily on the imports for these.

The World Energy Assessment report defines energy security as 'the continuous availability of energy in varied forms in sufficient quantities at reasonable prices'. This brings forth the critical dimensions of ensuring energy security. The energy supply needs to be maintained in short term as well as long term to meet the growing energy demand of a country. Interruptions in energy availability impose huge cost on a country's economy and human well being by disrupting the economic and commercial activities necessary for sustained economic growth of the country. An important aspect of energy security is the 'availability of energy in varied forms'. This shall ensure that there are multiple resources available, in case of short supply of one resource. This is particularly important with respect to oil security. Besides, it is also important that the energy resources are available at reasonable prices. However, the reasonability of the energy prices would differ widely depending on the state of economic development of the country, usage pattern of form of energy in question, etc.

The dimensions of energy security as described above, highlights that the concept of energy security is specific to each country depending on its state of economic development, availability of energy resources, energy consumption pattern and other related factors.

1.2 Objective of the study

Keeping in mind the above background on energy security, the objective of this study is to present the nature of energy security issue specific to the selected country (India) and to analyse the threats to energy security, measures taken to improve energy

[25] Current 1790 Science, Vol. 89, No. 11, 10 December 2005

security and impact of such measures on energy security. This analysis shall be carried out at both the national and household levels.

1.3 Country to be studied

The country selected for the study under this theme is ***India***. The reasons for the selection are detailed below.

1. The Indian economy has been growing at a rate of more than 7% for few years. An important element for the robust economic growth of the country is increasing energy requirements. At present, India ranks fifth in the world in terms of primary commercial energy consumption, accounting for about 3.9% of the world's commercial energy demand in 2006 and have the highest incremental energy demand in the world. Primary commercial energy demand grew at the rate of 5% between 1980/81 and 2005/06.[26] Between 2002 and 2025/30 India's total primary energy demand is expected to grow at an average rate of around 3.2%.[27] As against the energy demand, the supply of the same is constrained. The reserves of coal, the mainstay of India's energy sector, are expected to last for just 45 years whereas oil reserves will last for another 23 years. There is a gap between the demand and domestic availability of energy and therefore, the imports of commercial fuels are rising in the country, for instance India's import dependency for oil has risen to over 70% and for coking coal it was over 60% in 2006/07. With rising energy demand, India will not be able to meet these requirements domestically and, thus, import of fuels will rise in the near future. It is estimated that total crude oil imports will be around 93% of their total requirement by 2030 and coal imports is also expected to increase to as much as 45% by 2030.[28] Rising import of fuel raises serious energy security concerns for India in terms of assured availability of supply at reasonable price.

2. The household sector is one of the largest consumers of energy in India. It is responsible for about 45% of the total primary energy use, with non- commercial/biomass fuels accounting a large share of it. According to Census of India, 2001, in rural areas, biomass accounts for 90% of total primary fuel consumption for cooking. This has serious health impacts on the rural people. Also, at an all India level, 44% households are unelectrified with 22% and 57% urban

[26] TEDDY 2006/07
[27] Anant V Naik, Sajal Ghosh , V Raghuraman 'Energy security issues for India' CII July 2003
[28] TERI estimates and Integrated Energy Policy, Planning Commission 2006

and rural household being unelectrified. Due to lack of availability of electricity, households prefer to use kerosene for lighting purpose. Thus, India faces formidable challenges in meeting 'the continuous availability of clean energy in varied forms for varied uses in sufficient quantities at affordable prices to households'.

3. There is an increasing recognition of the importance of energy security in India. A number of policies have been framed for improving energy security at national and household levels, for instance, the Integrated Energy Policy (IEP), 2006 and Village Energy Security Programme (VESP). IEP addresses energy security holistically by incorporating the concept of lifeline provision of energy while defining energy security. The definition is an improvement from World Energy Assessmentreport definition of energy security, which limits the concept to '*the continuous availability of energy in varied forms in sufficient quantities at reasonable prices*'. The Policy lays down the measures that the country needs to adopt for ensuring energy security. VESP aims to meet the total energy needs of villages through locally available biomass resources along with community participation. With the establishment of The Ministry of New and Renewable Energy (MNRE), various measures have been taken to address energy security concerns at the household levels. For instance, programme such as National Programme on Improved Chulhas (NPIC), 1986/87, National Project on Biogas Development (NPBD), 1981/82 were launched. NPIC catered to the installation of improved chulhas in rural and semi urban households to conserve fuel wood and to reduce the drudgery of the women and girl children; and NPBD was launched for the promotion of family type biogas plants to provide clean and convenient fuel for cooking and lighting in rural areas.

4. There will be better access to both country specific and household specific data related to India. Further, TERI's past work experience in country would aid in conducting key interviews and stakeholder discussions for gaining insights relevant to the study. For developing a comprehensive report covering all relevant issues related to the theme, both the above-mentioned aspects are crucial.

1.4 Energy security concept in India

As mentioned above, India faces specific energy security concerns. The Integrated Energy Policy, Government of India

(GoI), 2006, defines Energy Security as 'we are energy secure when we can supply lifeline energy to all our citizens irrespective of their ability to pay for it as well as meet their effective demand for safe and convenient energy to satisfy their various needs at competitive prices, at all times and with a prescribed confidence level considering shocks and disruptions that can be reasonably expected.' This definition brings forth critical dimensions of energy security.

1. Energy up to a certain level is a basic necessity, referred as 'lifeline energy' should be provided to all citizens.
2. As different types of energy are used to satisfy different needs, the energy security concern is not only restricted to oil security but also includes other energy sources such as coal, electricity, natural gas and renewable sources.
3. It is important that energy resources are available at reasonable prices. The reasonability of price is seen in the context of the state of economic development of the country, usage pattern of energy and market forces in achieving energy security.

1.5 Importance of the study

As described earlier, India faces energy security concerns at the national and household level. Considering the fact that the household sector is the largest energy consumer sector of the country it is important to highlight the energy security concern at the household sector. Also, it is necessary to analyse the measures taken to improve the energy security and the impact of such measures at both the national and household level. This study will contribute to existing discussion in India and the world moving towards greater energy independence and stability. It will also bring better awareness to the people, policy makers, media, and son on, at the national and household level. The study is, therefore extremely important for India to establish a sustainable energy future by understanding the issues in detail, given the increasing dependence on the imported sources of energy.

1.6 Structure of report

Chapter 2 details out the methodology adopted for meeting the objectives of the study. It also defines various indicators for tracing energy security and insecurity level at both macro (national) and micro level (household level). Chapter 3 discusses the structure of Indian energy sector. Chapter 4

focuses on energy security concerns of India, measures taken to enhance the energy security and the impact of such measures at the national level. The Chapter 5 details the threats to energy security, measures to enhance energy security and their impacts at the household level.

Chapter 2 Methodology

To meet the objectives stated in the chapter 1, the study has been executed through a combination of literature surveys, interaction with experts and discussions with various stakeholders. These sources are elucidated below.

Policy review

Relevant policy documents, schemes and legislations dealing with energy security were examined to identify the facilitators and hurdles at the policy level relating to energy security in India.

Literature review

A review of studies undertaken over the years by multilateral agencies, bilateral organizations, academic institutions and research organisations in India and abroad on energy security has been carried out. From these studies, relevant indicators have been drawn for assessing energy security levels and their impact at national and household levels in India.

Stakeholders' discussion

A critical link to the study is the establishment of interactive dialogue with various stakeholders. The project team has carried out detailed discussions with various stakeholders in relevant sectors.

2.1 Indicators

An integral part of the study has been the indicators developed to track energy security/insecurity and the measures taken to achieve energy security such as energy efficiency, promotion of renewable sources or any other measure, at both national as well as household level. Following is the description of the indicators so developed for the study.

2.1.1 Indicators at the national level

Demand supply gap for coal, oil and natural gas and electricity

It measures the difference between the demand and domestic supply of coal, crude oil, natural gas and electricity. It measures the extent of energy requirement that could not be fulfilled domestically. Any increase in this gap will increase the energy insecurity of the nation, as it would denote increasing unmet energy needs.

Energy consumption per capita

This indicator measures the spread of energy consumption across the entire population of the country. It is the ratio of quantum of energy consumption to the total population of the country. The ratio signifies the extent of energy consumed in an economy. An increase in this ratio shall show increasing energy vulnerability of the entire economy as it indicates greater energy consumption per person.

Reserves to production ratio – coal, oil and natural gas

This ratio indicates the number of years the proven reserves of the commercial energy resources shall last at present production rate. It helps in estimating the sustainability of the present resources in the coming years, which can be used to meet the domestic energy demands.

Net energy imports dependency of oil/coal

This indicator measures the dependency on other countries for meeting our crude oil/coal requirements and thus measures the extent of energy security faced by the nation. It is the ratio of the amount of crude oil/coal imported from other countries to the amount of crude oil/coal consumption in our own country. Higher the ratio, higher is the threat to our energy security.

Crude oil/coal import bill as a percentage of total import bill

This indicator captures the financial burden due to increasing energy insecurity in the economy. This shall cover increases in quantum of crude/coal import and crude oil/coal prices.

Crude oil/coal import bill as a percentage of national export revenue

This indicator measures the extent of financing the crude oil/coal import by the foreign exchange earnings of the country.

Crude oil/coal import bill as a percentage of gross domestic product

This indicator measures the extent of financing the crude oil/coal import by the domestic earnings of the country.

Diversification of crude oil imports

This indicator measures the extent of diversification of sources of import of crude oil. Diversification of sources of supply minimizes supply risk. The more diversified the sources of supply higher is the extent of energy security since the country is not dependent on particular country for meeting its energy needs.

Diversification of fuel mix for power generation

The indicator would depict percentage share of various fuels in the total installed capacity in electricity sector. Excessive dependence on a single fuel for power generation can increase the economy's vulnerability in meeting its electricity

requirements.

Energy intensity

This indicator measures the extent of energy used per unit of GDP produced in the country. Increase in the ratio would indicate higher energy consumption in the country.

2.1.2 Indicators at the household level

Share of households using cleaner fuels and traditional fuels

Penetration of cleaner fuels is a direct indicator for enhancing household's energy security. The indicator would explain the percentage households out of the total households having access to these cleaner fuels. Higher usage of traditional fuels such as biomass for cooking in household indicates dependence on fuels that are inefficient and polluting.

Share of household's income on fuel and lighting

This indicator provides the percentage of income spent on fuel and lighting as compared to the total consumer expenditure. This indicator would take into consideration both the quantum of energy used as well as the price of the energy sources. The indicator shall be estimated across different Monthly Per Capita Consumption Expenditure (MPCE) classes available in the National Sample Survey Organization (NSSO) survey.

Access to clean energy fuels

One of the most important energy security indicators is the availability of energy itself. Further, along with provision of energy, availability of clean energy to households is also essential. This indicator would help in tracing the penetration of these resources for meeting both cooking and lighting needs.

Access to clean energy across income class

Another aspect related to energy access is to look at clean energy access across various expenditure classes. This aids in understanding if the distribution is equitable in two respects, that is, (a) income class (b) urban and rural areas.

Affordability of clean energy resources

Access and affordability of clean energy resources are two related concepts essential for understanding to form relevant policy recommendations for improving access. While looking at affordability of energy resources, the pricing mechanism for the clean energy fuels has been looked at. Further, under this indicator the effectiveness of the pricing system shall be looked in terms of enhancing access of the poor (both energy and income poor).

Impact of indoor air pollution on health of women and children

Usage of inefficient and polluting fuels at the household level impacts the health of women and children the most. Exposure to fumes of such fuels increases the risk of respiratory diseases.

Time spent in fire wood collection

There are gender related issues attached to usage of biomass for meeting energy requirements. Burden of this falls primarily on the women of the household.

Per capita electricity consumption

This indicator measures the extent of usage of cleaner fuels such as electricity for meeting energy needs at rural and urban level.

Per capita kerosene consumption

This indicator measures the extent of usage of traditional fuels such as kerosene for meeting energy needs at rural and urban level.

Per capita LPG consumption

This indicator measures the extent of usage of cleaner fuels such as LPG for meeting energy needs at rural and urban level.

Per capita biomass consumption

This indicator measures the extent of usage of traditional fuels such as biomass for meeting energy needs at rural and urban level.

Energy expenditure as a percentage of total household expenditure

This indicator measures the proportion of the total household expenditure spent on energy sources. It measures the vulnerability of a household to the rise in energy prices.

Chapter 3 Socio Economic and Energy Profiles of India

3.1 Socio economic profile of India

India is one of the fastest growing economies of the world with gross domestic product (GDP) growing at the growth rate of more than 8% since 2003/04.[29] The Government of India (GoI) plans to achieve a GDP growth rate of 10% in the period 2006/07–2011/12 and to maintain an average growth rate of about 8% in next 15 years. Despite a significant growth in the country's GDP, the per capita income remains on the lower side, on account of its increasing population. Per capita income in 2006 was about Rs 33 300 (USD 836.89)[30],[31]. Table 3.1 shows the movement in population, income and per capita income in India over the last decade.

Table 3.1 Socio Economic Profile of India

	Population	Gross domestic product	Per capita income
	(in million)	($ billion)	$
1997/98	964	352.33	365.48
1998/99	983	406.15	413.17
1999/00	1001	448.98	448.53
2000/01	1019	483.89	474.86
2001/02	1038	527.82	508.49
2002/03	1055	569.31	539.63
2003/04	1073	640.72	597.13
2004/05	1090	717.75	658.49
2005/06	1107	817.02	738.04
2006/07	1122	940.80	838.50

Source Statistical Handbook of India, RBI

In line with the demographic transition pattern followed by a developing country, India is currently in the intermediate transition phase, which is characterised by high birth rate and low death rate. In 2006, its birth rate and death rate were 22.69 and 6.58 respectively.[32] As a result, India's population is growing at a high rate and at present it is the second most populated country of the world after China. It is expected to surpass China's population with 1.5 billion people by 2045. Due to rising population, density of population is also increasing. The population density of India in 2006 was 340 persons per square kilometre, which are about 86 persons more per square

[29] Economic Survey
[30] Assuming exchange rate of 1 USD= Rs 39.79 as on 22 October 2007
[31] Statistical Handbook of India, RBI
[32] Census 2001

kilometre area in the country than the 1990 level[33]. The population of India is expected to increase from 1029 million to 1400 million during the period 2001-2026 - an increase of 36 % in 25 years at the rate of 1.2% annually[34]. Consequently, the density of population will increase to 426 persons per square kilometre by 2026[35].

Increasing population and population density puts immense pressure on the scarce natural resources of the country. It may hamper the economic growth of the country as well. Looking at the socio economic profile of the country, it is necessary to stabilize population of the country to ensure sustainable development of the country. Addressing the problem of over population is seen as a part of the overall socio economic development of the country, which aims to improve the quality of lives of the people and enhancement of their well being.

3.2 Overview of Indian energy sector

India is the fifth largest energy consumer in the world. Given the economic development path that is envisaged for the country, its energy consumption, especially consumption of commercial fuels is expected to grow exponentially in the coming years. In fact, even at present, India has the highest incremental energy demand in the world[36]. However, its per capita energy consumption is one of the lowest in the world. In 2003, India's per capita consumption was only 439 kg of oil equivalent per capita (kgoe/capita) as compared to the world average of 1688 kgoe/capita[37].

Between 2002-2025/30 India's total primary energy demand is expected to grow at an average rate of around 3.2%. In terms of energy requirement for the country, this would in effect triple the requirement from 325 million tonnes of oil equivalent (MTOE to 709 MTOE by 2030. [38] To meet the growing energy demand and to sustain the 8% economic growth rate through 2031-32, India's commercial energy supply need to grow at 5.2% to 6.1 % per annum, while it's total primary energy supply need to grow at 4.3% to 5.1% annually[39].

[33] Key Indicator 2007, Asian Development Bank
[34] Population Projections for India and States, 2001–2026, Census of India 2001
[35] Population Projections for India and States, 2001–2026, Census of India 2001
[36] TERI Energy Data and Directory Yearbook (TEDDY) 2003-04
[37] Integrated Energy Policy, Planning Commission,August 2006
[38] Anant V Naik, Sajal Ghosh , V Raghuraman 'Energy security issues for India' CII July 2003
[39] Integrated Energy Policy, Planning Commission, August 2006

Although the energy demand is expected to increase in the coming years, India would not be able to meet all these requirements domestically. Even at present India is importing around 71% of the total crude oil consumed and by 2030 is expected to import around 93% of its total requirements.[40] A similar trend is expected for coal, where the coal import is expected to increase to as much as 45% by 2030.[41]

India still continues to depend on traditional fuels for meeting its energy requirements. Although this dependence has decreased substantially from about 70% at the time of independence but it is substantially as high as 30%. Traditional sources of energy are primarily used in domestic sector. However, dependence on traditional fuels is expected to come down to 4% by 2031.[42]

The following section discusses in detail each of the energy sub sectors, their present and expected demand supply position. Although the energy security concerns are explained in detail in Chapter 4, the key energy security concerns related to the particular energy sub sector are discussed briefly in this section as well. This section focuses on the commercial sources of energy, viz., coal, oil, gas and electricity and the renewable sources of energy.

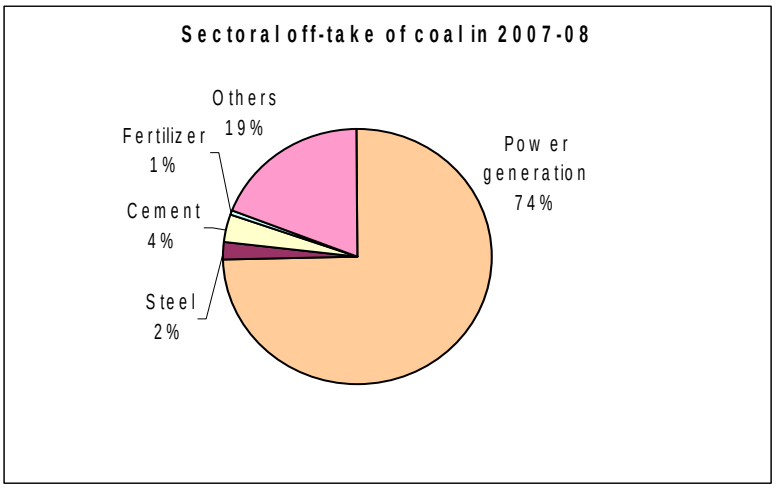
3.2.1 Coal

Coal plays a key role in India's energy scenario and it accounts for more than half of the total commercial energy supply. As on 1 April 2007, the coal reserves of India, up to the depth of 1200 metres have been estimated to be at 255.17 billion tones (BT).[43] Coal can be broadly classified into two types – coking coal and non coking coal, used primarily in steel industries and power sector respectively.

Major consumers of coal are the power sector and the industries such as steel, cement and fertilizers. Among these, power sector accounts for the major share of coal consumption (74%) and other industries accounting for less than 5% of share of coal consumption in the country. Figure 3.1 shows the sectoral, off-take of coal in 2007/08.

[40] National Energy Map for India, Technology Vision 2030, TERI 2006
[41] Integrated Energy Policy, Planning Commission, August 2006
[42] National Energy Map for India, Technology Vision 2030, TERI 2006
[43] Annual Report 2006–07, Ministry of Coal, Government of India

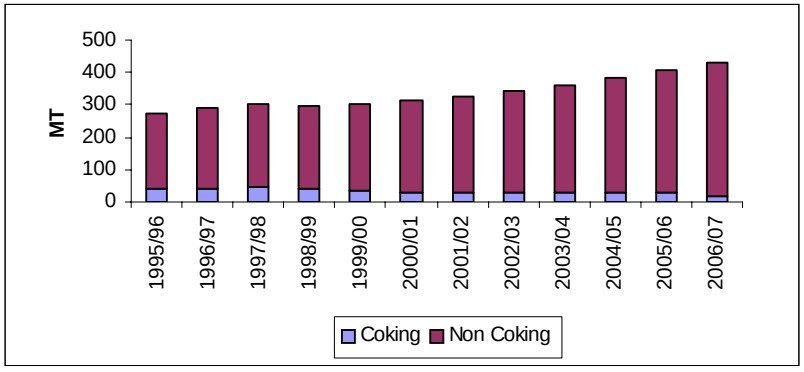
Figure 3.1 Sectoral composition of Coal off-take in 2007-08



Source Annual Report 2007/08, Ministry of Coal

The production of coal has been increasing at the Compounded Annual Growth Rate (CAGR) by about 4% from 1995/96, and with this growth the coal production in 2006/07 were 432.50 MMT comprising of 17.90 MMT of coking and 414.60 MMT of non-coking coal. Figure 3.2 shows the total production of coal in India segregated into coking and non-coking coal over the years.

Figure 3.2 Production of Coal in India



Source TEDDY 2005/06 and www.coal.nic.in , last accessed on 24 September 2007

As can be seen from the Figure 3.2, share of coking coal in total coal production has been declining over the years. In fact, share of coking coal in total production has declined from 15% in 1995/96 to about 5% in 2006/07. However, its demand has been increasing and the gap between the demand and supply has been met through increasing imports.

Future scenario

It is expected that even in 2031, coal will continue to be a predominant fuel accounting for about 50% of the fuel mix. About 2854 MMT of coal could be required in 2031 with about 70% being used in power sector alone. The imports of coal are likely to reach to about 1438 MMT by 2031, raising our coal import dependency to as high as 78%.[44] With coal demand expected to increase in Asian markets, prices of coal may also increase rapidly. In high price scenario, import dependency of 78% would result in huge foreign exchange outflow. Therefore, it is extremely important to increase the exploration and production activity in coal sector so as to boast domestic availability of coal.

Key Energy Security Concerns

The indicators assessing the energy security related to coal sector indicate that the large estimates of coal reserves gives a false sense of security as the inferior quality of coal makes it unusable in India and, thus, there has been increase in both the demand supply gap and dependence on import of coal.

3.2.2 Oil

India has about 0.4% of the total world crude oil reserves and consumes about 2.8% of the total crude production in the world. The crude oil reserves in the country are more or less stagnant over the years with 756 MMT of reserves in 2006.[45] Inspite of large investment in oil exploration activities there has not been any significant oil discoveries since Bombay High Fields, which was more than 28 years ago.

Even though the reserves have been stagnant and so has been the domestic production, demand for crude oil has been increasing. In the last decade, the demand for crude oil has increased at a CAGR of 8.45%. The increasing demand has been met through import of crude oil.

Future scenario

Crude Oil is expected to be a dominant fuel accounting for about 31% of the fuel mix in India in 2031. About 750 MTOE of crude oil could be available in India in 2031 with transport sector alone consuming more than 65% of oil. With likely growth in energy demand and production potential of all conventional energy forms fully exploited by 2016, it is expected that imports of oil will increase sharply by 2031. Import of crude oil is expected to reach 680 MMT by 2031, raising our import dependency to 93%.[46] High dependence on oil import indicates

[44] National Energy Map for India, Technology Vision 2030
[45] TEDDY 2005/06
[46] National Energy Map for India, Technology Vision 2030

the economy's vulnerability to oil supply disruptions and adverse impact of sudden oil price shocks.

Key Energy Security Concerns

Due to stagnation of crude oil reserve and production in India, the domestic availability of crude oil has not kept pace with its requirements. Thus, the import dependency of crude oil in India has risen to over 71%. Moreover, majority of import of crude oil are sourced from politically sensitive regions such as Middle East and Nigeria. This raises energy security concerns with respect to assured availability of crude oil in future.

3.2.3 Natural gas

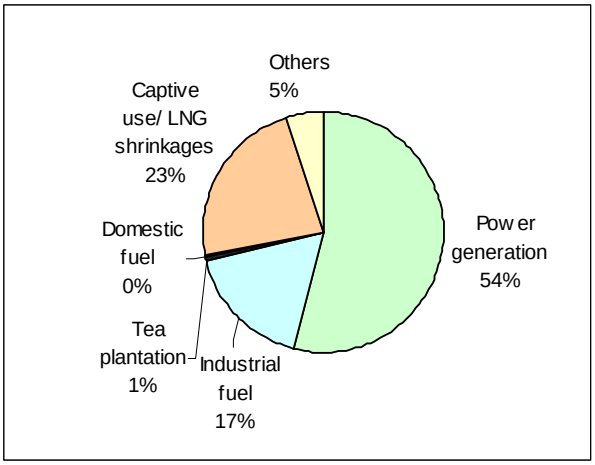
Natural gas, often termed as the fuel of 21st century, has gained prominence as it is clean and efficient energy resource and thus its demand is growing at a progressive rate over the years. The total natural gas reserve in India was 1075 billion cubic metres (BCM) in 2006. Registering a growth of 3.25% over the last ten years, the production of natural gas has increased from 22.64 BCM in 1995/96 to 32.2 BCM in 2005/06.[47]

As against the increased natural gas production, demand for natural gas has been growing at the rate of about 6.5% during the last ten years. Thus, even with the increase in production, amount of natural gas in India falls short of its requirements. The present demand for natural gas in the country is supply constrained. Out of about 120 million standard cubic metre per Day (MMSCMD) of natural gas demand, around 30 MMSCMD of demand is unmet.

Among the various consumers of the natural gas, power sector and the fertilizer industries account for almost 80% of the total gas demand. The balance goes to industrial units where it replaces fuel oil or to residential and commercial sector. Figure 3.3 shows the allocation of natural gas among the various consumers.

[47] TEDDY 2005/06

Figure 3.3 Composition of Natural Gas Off takes for Energy Purpose



Source Basic Statistics on Indian Petroleum and Natural Gas, MoPNG

In response to the rising demand for natural gas, efforts have been made to increase the domestic exploration and production activities through initiatives such as the New Exploration Licensing Policy (NELP) launched by the GoI in 1999. Reliance Industries Limited (RIL), an Indian company, has had a major natural gas find of about 40 MMSCMD in one of the natural gas blocks awarded to it under the NELP. Further, it is proposed to increase the production of natural gas in KG basin to 80 MMSCMD. Arrangements are being made for import of natural gas through pipelines and liquefied natural gas. Several cross border pipelines have been proposed for the purpose. The most prominent pipeline is the one connecting South Pars field in Iran with the Hazira Bijaipur Jagdishpur (HBJ) pipeline in India via Pakistan. For import of LNG, terminals have been set up. At present, there are 2 operational LNG terminals namely, Dahej LNG Terminal of capacity 5 MMTPA and Hazira terminal of capacity 2.5 MMTPA.

With the southern region of Iran on the west, India is surrounded by gas rich countries. With high economic growth of the country and scarcity of indigenous supply of hydrocarbons, it would be advantageous for India to have contractual arrangements with these sources to for import of natural gas through pipelines.

Future scenario

Natural gas can replace existing fuels in various sectors both for the feedstock as well as for energy purposes. However, this substitution will depend upon relative price of gas with respect to other fuels. Thus, to encourage the usage of this cleaner and efficient fuel in various sectors, it should be available at competitive prices. It is estimated that about 136 MTOE of

natural gas could be available by 2031 in India. However, to make this amount available about 93 BCM natural gas need to be imported and thus, our natural gas import dependency are expected to reach as high as 67%.[48]

Key Energy Security Concerns

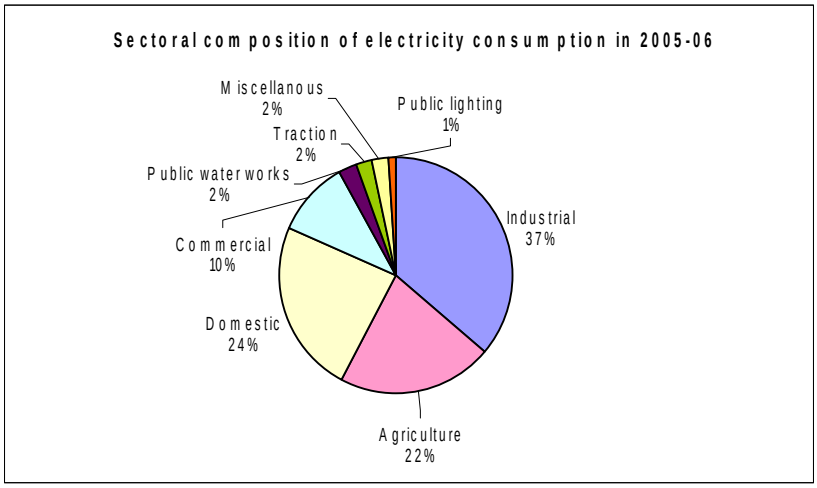
Higher rate of growth of demand for natural gas in India as compared to that of its production necessitates import of natural gas from our gas rich neighbour. However, there are concerns over transportation of natural gas through pipelines. Lying down of cross-country natural gas pipelines is more determined by the politics rather than by its economics. This further raises the availability of adequate natural gas in India.

3.2.4 Electricity

Over the decade, the installed electricity supply has increased at a CAGR of about 27% with 11916 MW of installed electricity capacity as on 1 April 1996 to 132 329 MW of installed capacity as on 1 April 2007. However the overall electricity generation in the country increased by about 5.24% over the decade and was 659 512 Gwh in 2006/07.

Electricity being an important source of energy, finds its usage in almost all areas of economy. Major electricity consuming sector are industry (37%), domestic sector (22%) and agriculture (22%). These are followed by commercial sector and other sectors like public lighting, public water works, traction, etc., which cumulatively account for 17% of the electricity consumption. Figure 3.4 shows the sectoral composition of electricity consumption in 2005/06.

Figure 3.4 Composition of electricity consumption in 2005-06



Source TEDDY 2007

[48] TERI 2006 National Energy map for India, technology Vision 2030

Although electricity is a secondary source of energy but it has close linkages with the primary fuel supply as electricity generation in the country is based on availability of coal, natural gas, hydropower, and so on. Therefore, security or insecurity of the fuel supply impacts the security and insecurity of electricity supply.

Future scenario

The total installed capacity for electricity is expected to be about 795 GW by 2031. Coal based capacity will continue to be dominant (59%) followed by hydro (20%). Coal based power generation has environmental concerns associated with it, which emphasizes the need for cleaner sources of energy. Further, supply of coal will also be constrained which will further affect the electricity generation. Therefore, efforts are needed to exploit the hydropower potential and replace the coal based power generation technology with efficient options such as Integrated Gasification Combined Cycle (IGCC). Etc.[49]

Total electricity consumption is expected to increase by 8.9 times in 2031 as compared to 2001 level with industry and residential sectors accounting for nearly 80% of the total electricity consumption in 2031 as compared to 63% in 2001.The electricity consumption in the domestic sector is expected to increase by 12.6 times during the same time period. Increase in consumption of electricity in domestic sector indicates the movement of the sector from traditional fuels to modern fuels.

Key Energy Security Concerns

There is a need to increase the electricity generation capacity of India to match the rising electricity demand. However, our generation plant mix is excessively dependent on coal, whose availability is also limited. This will further deteriorate the electricity demand supply position and raises serious concern over uninterrupted electricity supply.

3.2.5 Renewable energy

Renewable energy is considered as a viable option to attain the national economic growth while conserving the depleting natural resources.

The renewable based power generation could be Grid-interactive Renewable Power Projects and Distributed/Decentralized Renewable Power Systems (including

[49] TERI 2006 National Energy map for India, Technology Vision 2030

captive generation). Grid-interactive renewable power projects imply centralized power generation facilities with grid inter-connection at transmission line side for power export. Such facilities are envisaged to directly add to the installed grid power capacity. Distributed/decentralized power implies dispersed generation of electricity characterized by generation capacity ranging from kW to MW levels, generation at distribution voltages (11kV or below), grid inter-connection at distribution line side for power import and/or export – inter-connected to a local grid, or – totally off-grid, including captive.

India has significant potential for the effective use of renewable energy. As regards wind energy, the gross wind energy potential has been assessed at 45 000 MW. However, the technical potential is estimated at about 13 390 MW, assuming 20% grid penetration, which is expected to go up with the augmentation of grid capacity in potential states. India also has a vast potential for co-generation and the estimated potential for co-generation is about 15 000 MW in various core industries (mainly sugar industry), breweries, caustic soda plants, textile mills, distilleries, fertilizer industry, paper and pulp industry, etc. In case of small hydropower, an estimated potential of 15 000 MW is available in India. The potential for energy recovery from urban waste is estimated at 2550 Mw_e and industrial waste at 1287 MW..[50]

As on 31 March 2006, the total power generating capacity from renewable energy sources including grid interactive renewable power and distributed renewable power was about 9497.05 MW. As on 31 March 2007, the cumulative grid interactive power generating capacity using renewable energy sources was about 9372 MW (6315 MW – wind energy, 1905 MW – small hydro power and 1152 MW – bio power). Renewable energy power generation systems constitute about 7% of the total installed power generating capacity in the country. About 5923 MW of capacity has been added since the beginning of the Tenth Five-year Plan against a target of 3075 MW. This indicates the increased usage of renewable energy resources in the country.

Future scenario

According to the working group report on new and renewable energy for Eleventh Five-year Plan (2007–2012) at least 10% installed power generation capacity in the country as well as about 4% of the electricity mix, should come from renewables by the end of the Eleventh Plan. Out of the overall target of 70 000 MW power generation installed capacity addition during the Eleventh Plan period, 14 500 MW of (about 20%) capacity

[50] TERI Energy Data Directory Yearbook, 2006/07

addition is proposed from renewable energy sources.[51]

Energy Security Concerns

Due to shortage of energy resources faced by the country, it is essential to develop energy from renewable options. However, efforts made in this direction have not been very successful. Contribution of renewable energy sources in the total energy mix of the country remains low. The main cause is the high initial cost associated with usage of renewable sources. Moreover their usage is location specific. Therefore, to increase usage of renewable energy strong policy measures are required to provide incentives for technical improvements and cost reduction.

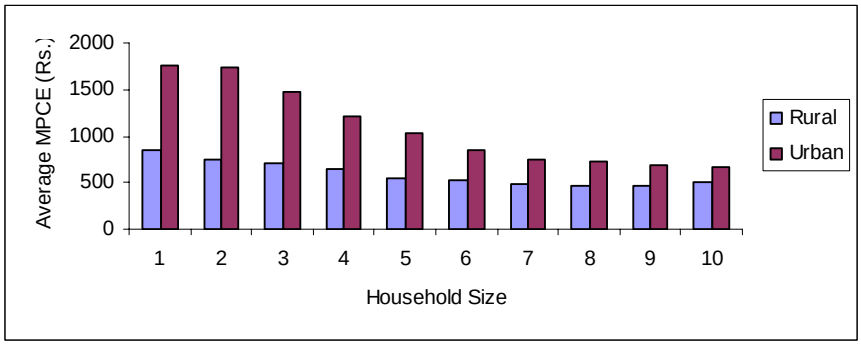
3.3 Overview of household sector

According to the census 2001, about 72% of the Indian population resides in rural area and rest in urban area.[52] National Sample Survey Organization (NSSO) collects data on household consumer expenditure every year. NSSO defines a household as a group of persons normally living together and taking food from a common kitchen. Average household size in rural India is 4.9 including 1.8 children (persons under 15) per household. In urban India, the average household size is 4.4 with 1.3 children per household.

NSSO regards MPCE (Monthly Per Capita Consumer Expenditure) as the main indicator of standard of living. MPCE is defined as an aggregate monthly consumer expenditure of the household divided by the household size. The all-India average MPCE was Rs 559 for rural India and Rs 1052 for urban India in 2004/05. Thus, average urban MPCE exceeded average rural MPCE by 88%. However, urban price levels being higher than rural price levels, the differential would be narrow in real terms. Figure 3.5 shows the relation between the household size and MPCE. Average MPCE decreases substantially as the household size increases from 1 to 10 in case of urban households as compared to rural households.

[51] Report of the Working Group on New and Renewable Energy for Eleventh Fiv-year Paln (2007–12), MNRE, Government of India
[52] Census 2001

Figure 3.5 Relationship between household size and MPCE



Source National Sample Survey Organization

3.3.1 Household energy scenario

The household sector is one of the largest consumers of energy in India. It is responsible for about 45% of the total primary energy use, with non- commercial/biomass fuels bearing a large share of it. Biomass fuels provide around 72% of the household energy and 90% of all rural energy needs. However, there is a shift from traditional fuels to commercial fuels like LPG and electricity, as discussed below.

At the household level, cooking and lighting are the major energy consuming activities and, hence, in our study we will be focussing at theses two household activities. These two activities are discussed both for rural and urban households.

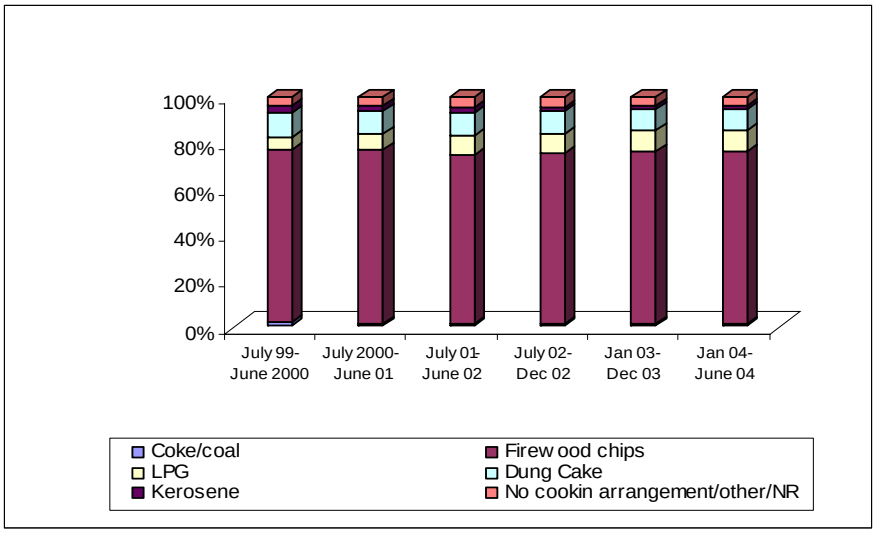
3.3.1.1 Cooking

For cooking purpose households use energy fuels such as coke, coal, firewood chips, LPG, dung cake and kerosene. The following section discusses the energy fuels used for cooking in rural and urban households.

Rural households

Although energy usage pattern in rural households is changing, traditional fuels continue to be the main source of household cooking. Figure 3.6 highlights the distribution of households by primary source of energy used cooking activities over the last decade.

Figure 3.6 Percentage distribution of households by primary source of energy used for cooking: Rural

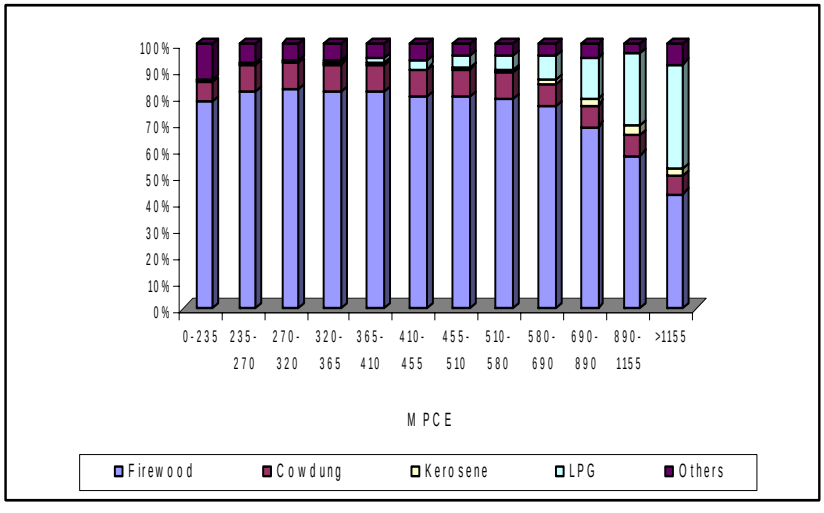


Source TERI Energy Data Directory Yearbook 2006/07

As seen in Figure 3.6, about 85% of households depend on traditional fuels such as firewood and dung cake for cooking purposes. As per Census 2001, biomass accounts (including firewood crop residue and cow dung) for 90% of total primary fuel consumption for cooking in rural areas.

Looking at the usage of energy sources over the income classes among the rural households, it is observed that poor households use more of firewood and dung cake. However, the dependence on traditional fuels is substantial even among the richer households. (Figure 3.7)

Figure 3.7 Usage of energy sources for cooking at different MPCE (Rural)

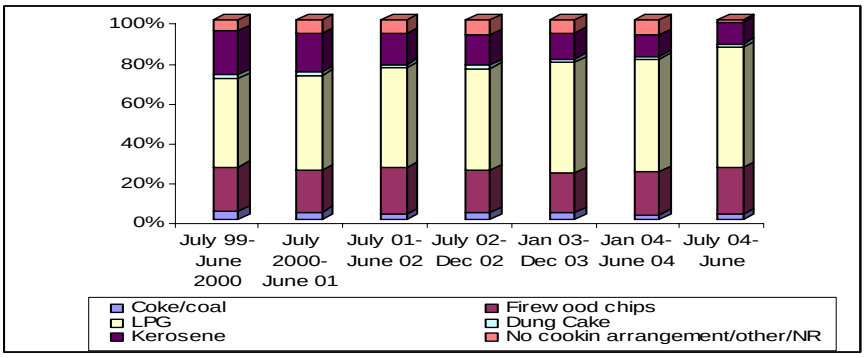


Source National Sample Survey Organisation

Urban households

In urban households, Liquefied Petroleum Gas (LPG) is the primary fuel used for cooking. Apart from the usage of modern fuels (LPG-48% and kerosene-20% of total fuel requirement for cooking), more than 20% of households still depend on traditional fuels. Figure 3.8 highlights the increasing proportion of households using cleaner fuels such as LPG for cooking purposes.

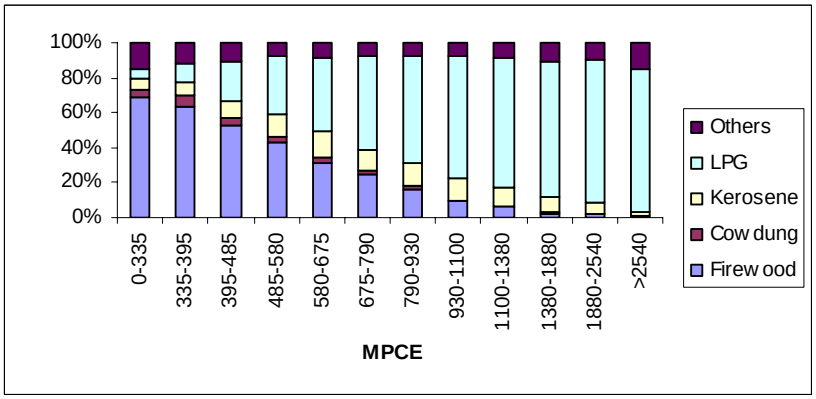
Figure 3.8 Percentage distribution of households by primary source of energy used for cooking: Urban



Source National Sample Survey Organisation

In the urban sector, the usage of traditional fuels decreases as the income of the household increases. About 70% of household in the lowest income bracket uses firewood for cooking purposes whereas households in highest income bracket do not uses traditional energy sources for cooking (Figure 3.9).

Figure 3.9 Usage of energy sources for cooking at different MPCE (Urban)



Source National Sample Survey Organisation

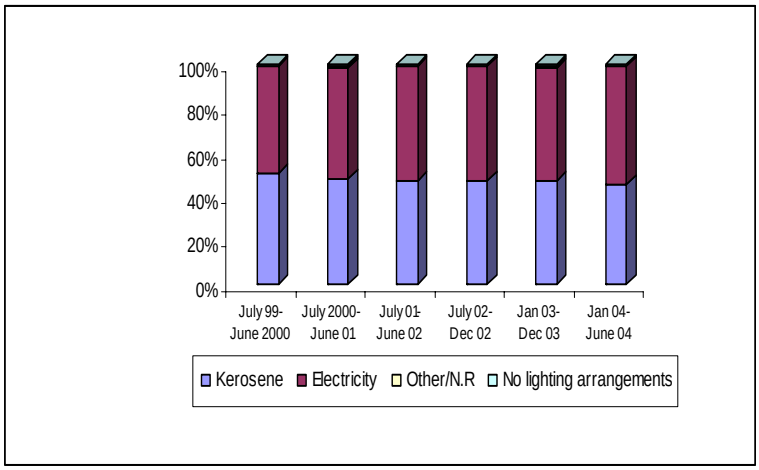
3.3.1.2 Lighting

The primary sources of energy used for lighting by the households in India are electricity, kerosene and others (gas, candle etc). Following discusses the energy fuels used for cooking in rural and urban households.

Rural households

Electricity and kerosene constitute the major energy fuels used for lighting purposes. Although usage of electricity for lighting purposes is increasing over the years, kerosene still continues to be major fuel among the rural households. (Figure 3.10)

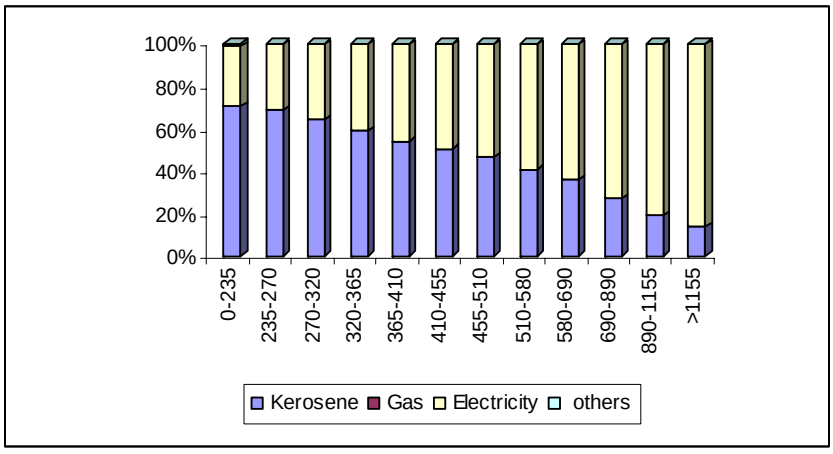
Figure 3.10 Per cent distribution of households by primary source of energy used for lighting: Rural



Source TERI Energy Data Directory Yearbook 2006/07

Among the rural households, about 70% of the households in the lower income bracket use kerosene for lighting purposes. However dependence on kerosene for lighting purposes decreases as the income of the rural households increases (Figure 3.11).

Figure 3.11 Usage of energy sources for lighting at different MPCE (Rural)



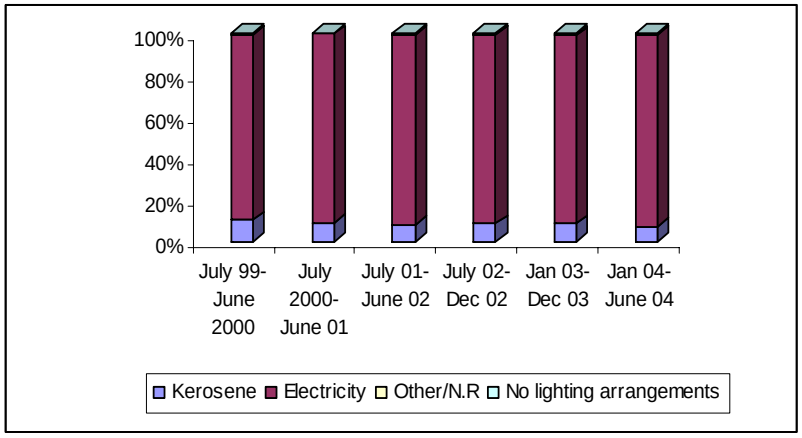
Source National Sample Survey Organisation

Urban households

Among the urban households, electricity has continued to be a

dominant fuel for the lighting purposes. Moreover, proportion of households using electricity for lighting purposes has also increased over the years. (Figure 3.12)

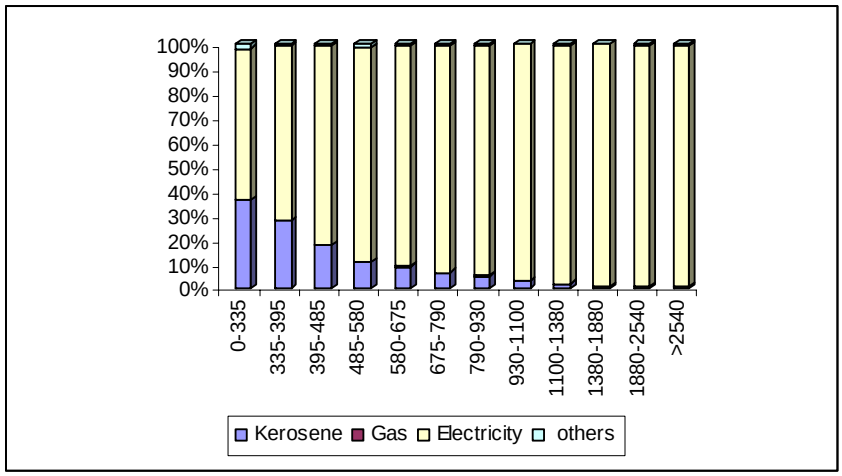
Figure 3.12: Percentage distribution of households by primary source of energy used for lighting: Urban



Source TERI Energy Data Directory Yearbook 2006/07

Looking at the usage of fuels for the lighting purposes over the income classes of the urban households, it is observed that as the income increases among the urban households, these households use more of electricity. (Figure 3.13)

Figure 3.13 Usage of energy sources for lighting at different MPCE (Urban)



Source National Sample Survey Organisation

The chapter 5 discusses the household sector in greater detail along with elucidating the key energy security threats faced by the household sector.

3.4 Conclusion

Due to rapid economic development of the country, the energy requirements of India are rising steadily. However, there are constraints in energy supply, which leads to widening of energy demand supply gap. The unavailability of energy at affordable prices raises concerns about energy security in India. Concentrated efforts are required to meet the impending energy challenges. Household sector being one of the most vulnerable sections of India needs special attention for improving energy security for the country as a whole. Considering the threats to energy security, certain measures are taken to ensure energy security at household as well as at national level.

Chapter 4 Threats to Energy Security, Measures to Enhance Energy Security and their Impacts at the National Level

This chapter provides an overview of the threats to energy security, measures taken to enhance energy security and their impacts at the national level in India.

4.1 Threats to energy security

The country faces the critical challenge of meeting increasing demand of energy with rapidly increasing population. This brings the issue of energy security to the forefront. The present and projected energy requirement and various supply options highlight country's increasing concerns with respect to energy security. This sections details out the indicators with respect to the threats to energy security as faced by India. The threats to energy security have been classified into physical and financial threats.

4.1.1 Physical threat

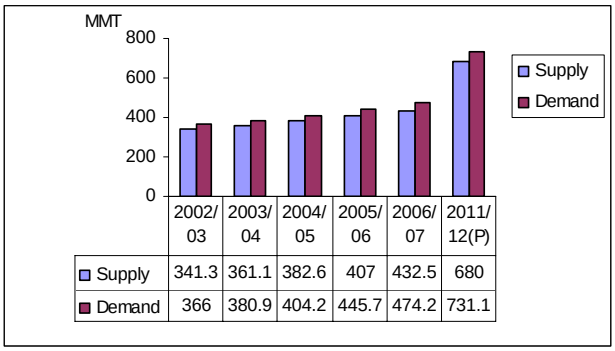
The physical threat to the energy security is accentuated with the increasing gap between the demand for the energy sources and its domestic availability; increasing import dependence for the meeting the energy needs of the country, decreasing reserves to production ratio for various energy resources and high dependence on particular energy resource. The physical threats to energy security are discussed below.

4.1.1.1 Demand supply gap

Coal

The demand for coal in the country is rising continuously as against its domestic production. This widens the gap between the requirement of coal and its domestic availability. Figure 4.1 indicates the demand supply gap for coal in India over the past few years. Supply of coal has been short by at least 9% of its total demand in last two years.

Figure 4.1 Demand Supply Gap for Coal



	2002/03	2003/04	2004/05	2005/06	2006/07	2011/12(P)
Supply	341.3	361.1	382.6	407	432.5	680
Demand	366	380.9	404.2	445.7	474.2	731.1

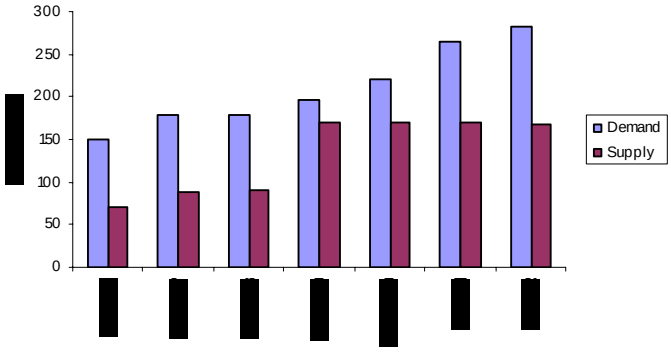
Source (i) Teddy 2005/06; (ii) Annual Report 2006/07 Ministry of Coal, GoI

A direct implication of the increasing demand supply gap is the increasing import dependence to meet the domestic needs.

Natural gas

Demand for natural gas is steadily increasing over the years, primarily because it is cleaner and cheaper fuel. Although the supply of natural gas is also increasing due to increased exploration activities in the country, the availability of natural gas in the country is far less than its demand. Figure 4.2 indicates the increasing demand supply gap for the natural gas in the country.

Figure 4.2: Demand and Supply for Natural Gas



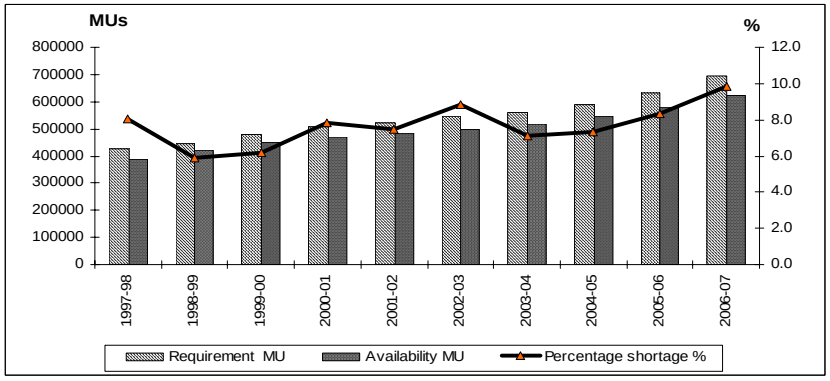
Source Presentation on 'Can India Be Self Sustainable In Gas: New Frontiers', V.K.Sibal, Directorate General of Hydrocarbons

Electricity

Although the installed capacity and generation of electricity in India has increased over the years but it still falls short of the electricity requirement and thus India faces huge electricity

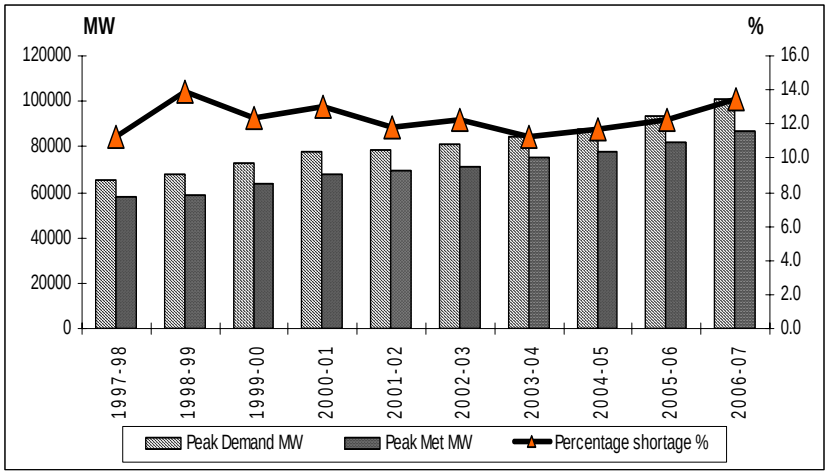
demand supply shortages. Electricity demand supply gap was around 10% in 2006/07 with peak time shortage of 13.5 % in the same year. Figures 4.3 and 4.4 show the electricity supply and peak supply position India.

Figure 4.3 Energy requirements, Availability and Shortage



Source: ww.cea.nic.in , last accessed on 24th September 2007

Figure 4.4 Peak Demand and Peak Met with Peak shortages



Source ww.cea.nic.in , last accessed on 24th September 2007

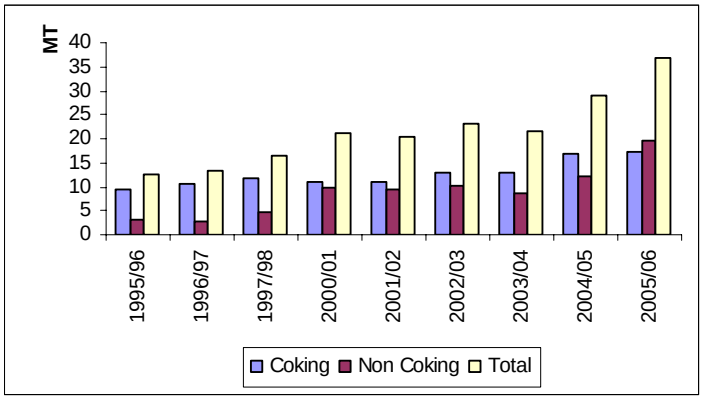
As per the National Electricity Plan of the Central Electricity Authority (CEA), the electricity demand is likely to increase by 35.6% in 2011-12, and by 35.2% in 20016-17. Further, the GoI's initiative to achieve 100% village electrification and the plan to provide power to all by 2012 will lead to growth in demand for power at an even faster rate. However, the actual capacity addition has been less than the planned capacity addition. For instance the Eighth Five Year Plan India has been able to add only around 50% of the planned power capacity. With increasing demand on one hand and constrained supply on the other, the scenario for electricity will deteriorate even further and raises serious concerns over uninterrupted electricity supply.

4.1.1.2 Import dependency

Coal

Although coal is regarded as a mainstay of Indian energy sector, its imports are rising sharply, especially that of coking coal. In fact, India imports about 65% of its total coking coal demand.[53] Figure 4.5 shows the rising dependency on import for meeting coal requirements of the country.

Figure 4.5 Import of Coal in India (1995/96–2005/06)



Source Teddy 2005/06, Annual Report 2006/07 Ministry of Coal

The coking coal available in India is of inferior quality as it has a high ash content and low calorific value (an average of 4000 kcal/kg as compared to 6000 kcal/kg in imported coal.)[54] The high ash contents result in higher suspended particulate emission. Also, domestic coking coal requires intensive washing to make it suitable for coke making. Even then it is marginally accepted because of its inert material content. Thus, for these reasons India imports much of its coking coal. Coking coal import increased at a CAGR of about 6.9% from 1995/96 to 2005/06.

Apart from excessive dependence on imported coking coal, import of non-coking coal is also increasing due to degrading quality of domestic non-coking coal. In last decade, import of non-coking coal has increased from 3.1 MT (1996/97) to 20 MT (2006/07) implying at a CAGR of about 23%. Power sector, the biggest consumer of coal (accounts for 75% of the total production), is one of the most vulnerable sectors as result of the increasing coal import dependence.

Oil

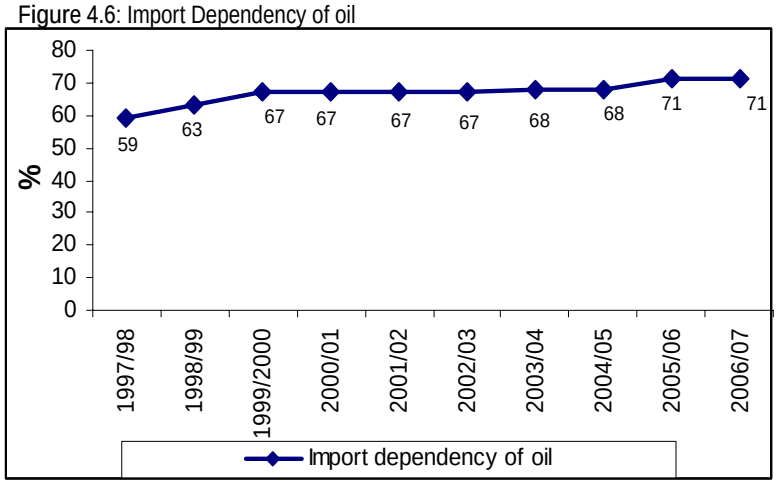
The domestic production of crude oil has also stagnated at around 32 MMT over the last decade. [55] The domestic production has been out paced by the requirements of the

[53] Integrated Energy Policy, Planning Commission, August 2006
[54] Integrated Energy Policy, Planning Commission, August 2006

[55] TERI Energy Data and Directory Yearbook 2005/06, TERI 2006

Indian refineries and, hence, our import of crude oil has risen from 40 MMT in 1996/97 to about 110 MMT in 2006/07. India's crude oil import dependence, which is the amount of crude oil imported to meet only the domestic demand, has risen to about 71% (Figure 4.6). This raises serious concerns with respect to energy security of the country. According to International Energy Agency (IEA), if the present trends continue till 2030, the India's oil import dependency will increase to over 94%.[56]

Figure 4.6: Import Dependency of oil



Source Petroleum Planning Analysis Cell

Another concern related to security of supply of crude oil is the excessive dependence on Middle East for import of oil. India's oil import from Middle East in 2001/02 was 68%, which further increased to about 74% in 2005/06. Moreover, among the Middle East countries, Saudi Arabia alone accounts for a quarter of crude oil imports in India. Saudi Arabia accounted for 17% of total crude imported by India in 2001/02, which increased to 25% in 2005/06. [57] Apart from Middle East, Nigeria accounts for about 14% of total crude oil imports by India.

The above scenario indicates that majority of crude oil imports are sourced from countries, which have delicate political conditions. Thus, excessive dependence on these countries for crude oil requirement raises energy security concerns over ensuring undisrupted crude oil supply in future.

4.1.1.3 Reserves to production ratio

Coal

According to BP Statistics, India's current coal reserves are

[56] Neha Misra, Ruchika Chawla, Leena Srivastava, R K Pachauri *"Petroleum Pricing in India, Balancing Efficiency and Equity" TERI 2005*

[57] TEDDY 2005/06

expected to last for about 207 years. However, according to the Integrated Energy Policy 2006, the proved reserves of coal at current rate of consumption will last for only 80 years. Moreover, if domestic production of coal grows at 5% per year, the total extractable coal reserves will run out in around 45 years only. This creates serious energy security concern relating to availability of coal in near future considering the fact that coal is the mainstay of the Indian energy sector. This coupled with increasing import dependence puts in front an enormous energy security issue, which needs to be tackled at the earliest.

Oil

At the current level of crude oil production, indigenous crude oil reserves are expected to last for 23 years. However, if these reserves were to meet the entire crude oil demand of the country they would last for less than 7 years .[58] The low reserves to production ratio calls for an urgent need to intensify domestic exploration and development activities to explore new fields and increase the reserves base of the country.

Natural gas

The demand for natural gas has been increasing continuously over the years. In order to keep up with demand, the production of natural gas has also been stepped up. Even with increased production, it is expected that the natural gas supply shall fall short of the projected demand. It is expected that with the current production rate for natural gas, the domestic reserves for the same will last for 50 years from 2005/06.[59]

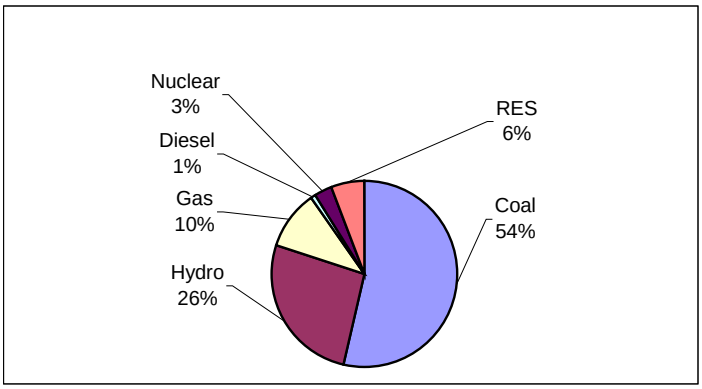
4.1.1.4 Diversification of fuel mix

Figure 4.6 shows the fuel mix of the installed capacity for power generation in India. Out of the total installed capacity more than 50% of the capacity is coal based followed by hydro, which accounts for another quarter of the total capacity.

[58] Integrated Energy Policy, Planning Commission, August 2006

[59] Presentation on 'Can India Be Self Sustainable In Gas: New Frontiers', V K Sibal, Directorate General of Hydrocarbons

Figure 4.7 Electricity Plant Mix for 2006/07



Source http://powermin.nic.in/JSP_SERVLETS/internal.jsp

High dependence on one particular fuel, that is, coal raises concerns regarding energy security especially in respect to the dwindling reserves of coal in the country. Also, there are significant environmental concerns associated with extensive coal based generation apart from the lack of suitable quality and quantity of coal availability in the country.

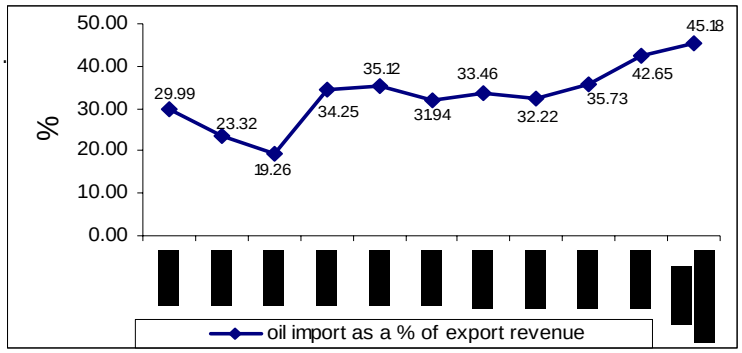
4.1.2 Financial threats

The physical threats to energy security highlight the high dependence on the import of energy fuels for meeting our domestic requirements. Increasing import dependence implies the high financial burden on the nation's economy. This is because the import of energy fuels needs to be financed either from the earnings generated within the country, that is, the gross domestic product of the country or from foreign earnings. Moreover, the country needs to arrange for relevant foreign exchange to pay for its imports. This puts a financial strain on the economy. Following are the indicators, which highlight the financial implication of achieving energy security.

4.1.2.1 Oil imports as a percentage of export revenues

As highlighted above, rising crude oil imports has serious financial implications attached to it. This is clear from the fact that in 2006/07, crude oil import bill was as high as 45% of the total export revenue of the country. Figure 4.8 tracks the relationship between the increasing crude oil import bill and the total export revenue of the country. This implies that a major proportion of export revenue is required to finance oil imports, which increases the financial burden of the country. Moreover import of energy furls leads to outflow of foreign exchange from the country.

Figure 4.8 Oil imports as a percentage of national export revenue (1996/97 2006/07)

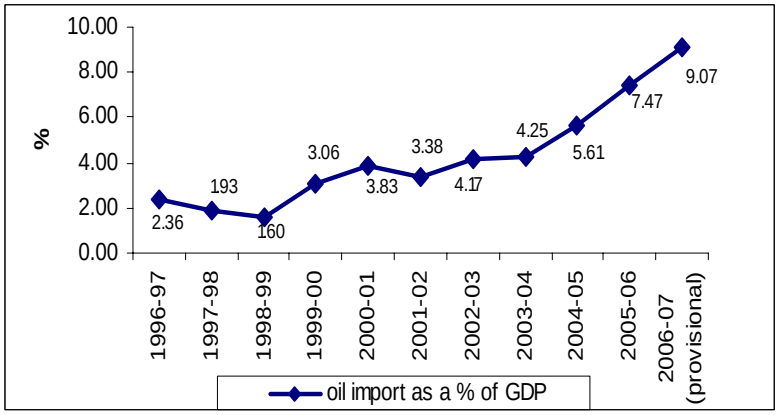


Source Statistics on trade and balance of payments, Statistical handbook of India, RBI

4.1.2.2 Oil imports as a percentage of GDP

Along with analysing the impact of crude oil import bill on the foreign earnings of the country, it is also important to see the relation between the crude oil imports and the domestic earnings of the country. This is important in order to assess as to how much of the crude oil imports can be sustained from the income generated within the country. This becomes especially important in case the foreign earnings of the economy are widely fluctuating over the years. Figure 4.9 tracks the relationship between the two variables, that is, the crude oil import bill and the domestic income of the country. It indicates that crude oil imports as a percentage of domestic earnings have been increasing, that is, from 2% in past decade to about 9%in 2006/07.

Figure 4.9 Oil imports as a percentage of GDP (1996/97– 2006/07)

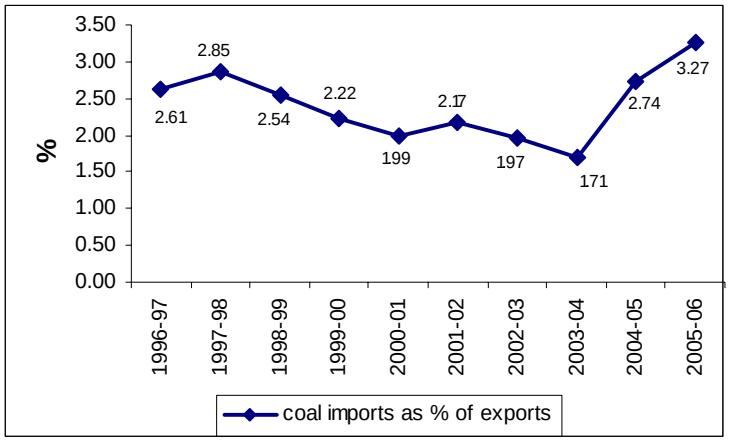


Source RBI, data on Indian Economy, Handbook of Statistics

4.1.2.3 Coal Imports as a percentage of export revenues

It is important to assess the amount of coal imports which could be supported by the revenues earned through exports by the country. Rising imports for coal is increasing the financial burden of the country . Coal import bill as a proportion of the export revenue has increased by over 1.5% over the last deacde and has reached to about 3.27% in 2006/07. (Figure 4.10).

Figure 4.10 Coal imports as a percentage of national export revenue

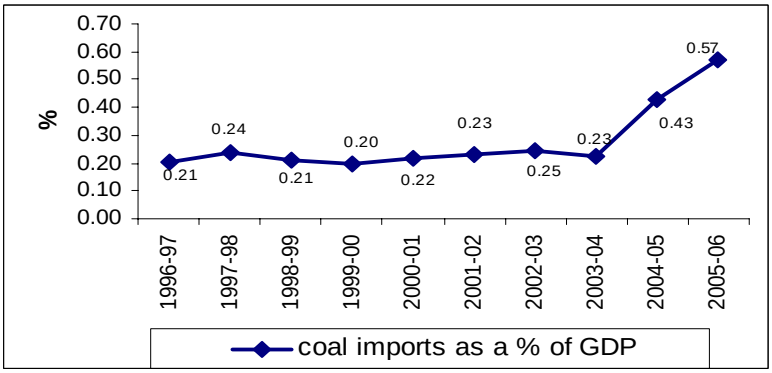


Source Coal directory of India 2005/06

4.1.2.4 Coal imports as a percentage of GDP

It is necessary to establish the relationship between the coal import bills and the domestic earnings of the country to assess the extent of coal import bill, which could be financed, from the domestic earnings of the country, if needed. Figure 4.11 indicates the relationship between theses two variables and highlights that the coal import bill as a percentage of domestic earning is rising slowly over the years and it was about 0.57% in 2005/06.

Figure 4.11 Coal imports as a percentage of GDP (1996/97– 2005/06)

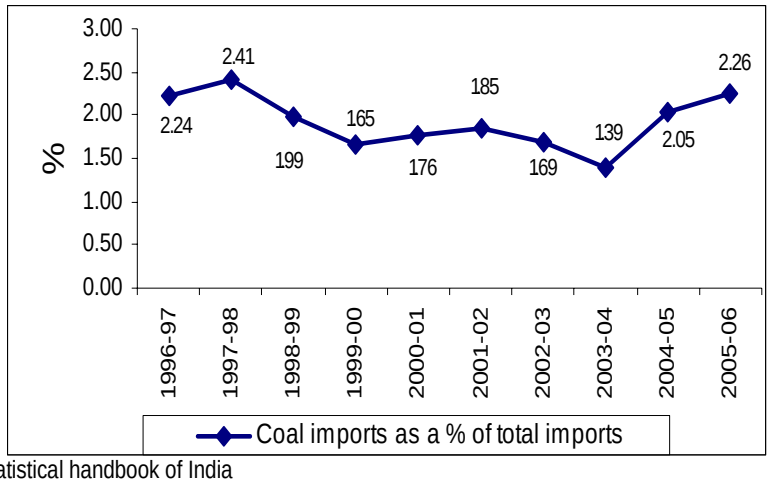


Source Coal directory of India 2005–06

4.1.2.5 Coal imports as a percentage of total imports of the country

Although the quantum of coal imports in India has increased over the years, but the coal import bill as a proportion of the total import bill of the country has increased very marginally. Figure 4.12 tracks the import of coal as a percentage of total import bill of the country over the years.

Figure 4.12 Coal imports as a percentage of total import bill (1996/97– 2005/06)

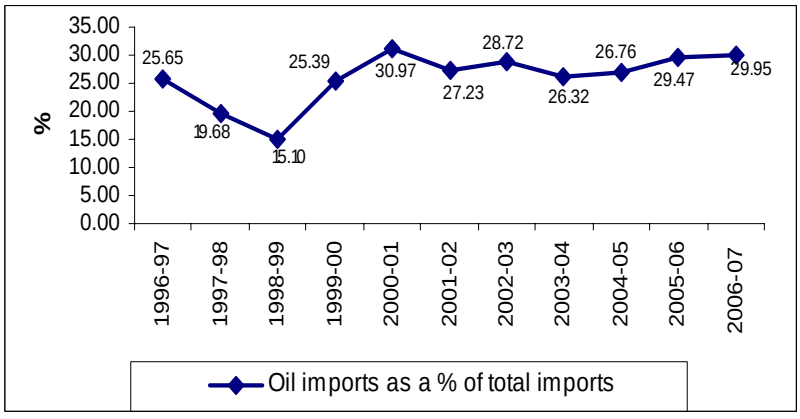


Source RBI Statistical handbook of India

4.1.2.6 Crude oil import as a percentage of the total imports of the country

Unlike the imports of coal, crude oil import bill forms a substantial portion of the total import bill of the country. During 2006/07, oil imports were about 30% of the total imports. Figure 4.13 tracks the oil imports as a percentage of total import bills over the years.

Figure 4.13 Oil imports as a percentage of total import bill (1996/97– 2006/07)



Source RBI Statistical handbook of India

4.1.3 Vulnerability to high-energy price and energy supply insecurity

The indicators relating to threats to energy security, highlights the vulnerability of the Indian economy to the rise in energy

prices and the energy supply insecurity. There has been steep rise in the demand supply gap for energy fuels and the subsequent rise in the import dependency for the energy fuels, which is as high as 71% for crude oil. It indicates the high level of dependence the country is on the other countries for meeting its crude oil requirement. Such a scenario raises concerns over the regular supply of the energy fuel. Apart from this, it makes the country venerable to the price of the energy fuel that the exporting country may demand. This makes the country dependent on the international price of the energy fuels, which are volatile in nature. Moreover, the large imports of the energy fuels creates financial burden on the Indian economy, which subsequently impacts the energy prices within the country.

4.1.4 Environmental and social impact of current and forecast energy scenario

The following describes some of environmental and social impact of the energy scenario in the country.

- Coal is expected to continue as the main source of commercial energy of the Indian energy sector. However, usage of coal has adverse environmental implications. In India, most of the coal production is from opencast mining, which contributes around 87% of the total raw coal production.[60] It leads to the release of suspended particulate matter and generation of coal dust. The dust can pollute nearby surface waters and stunt crop growth by shading and clogging the pores of the plants. Another major concern related to combustion of coal is the emission of green house gases. The combustion of coal produces gaseous emissions of sulphur dioxide (SO2) and oxides nitrogen (NO_x) that are responsible for 'acid rain' and 'ground level ozone'. Ground level ozone leads to the formation of smog that forms a brown haze over cities.[61]

- Coal mining in India has associated adverse social impacts. The most important social impact being large scale displacement of people. It has been estimated that the overall displacement from all development projects between 1951–1991 is about 21 million people and this number was approximately 30 million by 2006. Even with resettlement and rehabilitation, the social and economic impact on the displaced families is huge. More specifically, there occurs breakdown of family and community structures, loss of livelihoods, vulnerability of women, elderly, particularly children and worsening of economic situation due to

[60] TERI Project report 2007ER04, 'Relative Environment Economics of Natural Gas and Other Fossil Fuels for Power Generation and Policy Options for India'

[61] http://www.teriin.org/events/docs/gurdeep.pdf, accessed on 23 July 2008

disruption.

- As indicated in the previous chapter, renewable sources of energy are increasingly contributing towards the energy mix of the country. This reduces the adverse impact on environment as caused by the usage of fossil fuels as energy sources.

- Petroleum refineries also contribute to pollution. They are a major source of toxic air pollutants, which have serious health implications. Refineries are also potential contributors to ground water and surface water contamination. Refineries use deep-injection wells to dispose of wastewater (which is highly hazardous) generated in plants and some of these wastes end up in groundwater.

- The energy scenario in the country indicates high dependence on traditional fuel to meet the energy requirements. This is a cause of concern because not only are these traditional sources of energy inefficient in nature but also negative health impact is attributed to them. Furthermore, women and girl children are involved in the procurement and management of traditional fuels in rural areas. The time spent by them on this is estimated to be in the range of 3 to 6 hours per day per family, which can otherwise be utilized more gainfully.[62]

4.2 Measures to enhance energy security and their impact at the national level

Ensuring energy security at national level requires both supply and demand side measures. Supply side measures include adoption of efficient and environment friendly technologies, improvement in generation parameters, diversifying fuel mix, increased usage of renewable energy sources, etc. On the demand side measures include increased penetration of energy efficient appliances, promoting energy conservation, energy efficiency and others. Having described the serious threats to India's Energy Security, the following section discusses the various measures taken to achieve energy security at the national level.

4.2.1 Enhancing energy efficiency

Energy efficiency encompasses all changes that result in decreasing the amount of energy used to produce one unit of economic *activity (for example, the energy used per unit of*

[62] http://www.unesco.or.id/apgest/pdf/india/india-bp-re.pdf accessed on 16th October 2007 (Best Practice on Renewable Energy: India)

GDP or value added) or to meet the energy requirements for a given level of comfort. By reducing the amount of energy demand through energy efficiency, net energy supply capacity increases. If the increase in net supply capacity through energy efficiency can be done cheaply than with installing new generating capacity, it would lead to lower energy prices. This will also delay investments in both network and generation capacity and in turn delay the negative environmental impacts associated with supply side investment. Thus, energy efficiency is considered as an option to improve energy security.[63]

Following are the various policies and programmes undertaken to use energy efficiently and their impact. The section further discusses the estimated cost and potential saving from using energy efficiently and the barriers to energy efficiency.

4.2.1.1 Potential of energy efficiency in the country

Huge potential for energy savings through various energy efficiency measures exists in India. Efficiency can be brought in energy extraction, conversion, transportation and consumption. According to a study prepared for Asian Development Bank (ADB), there exists an energy saving potential of about 54 500 kWh and peak saving of 9240 MW in India.[64] Although there could be some uncertainty in aggregate estimates but cost effective saving potential through Demand Side Management (DSM) is at least 15% of the total power generation. Additional savings could also be achieved through reduction in auxiliary consumption. Also, according to energy audits as carried out by Petroleum Conservation Research Association (PCRA) there is energy saving potential of about 60 590 KLOE (Rs 1.15 billion) in industrial sector alone.[65]

According to Integrated Energy Policy, the Eighth Five-year Plan (1992–97) made a provision of Rs 10 billion for energy efficiency to provide targeted energy savings of 5000 MW and 6 MT in the electricity and petroleum sectors respectively. There is no clear quantification of the actual costs and savings achieved during the above mentioned time period. The target for energy savings during the Tenth Plan (2002–07) was 95 billion kWh, which is about 13% of the estimated demand of 7,19 billion kWh in the terminal year of the Tenth Plan. However, there are no specific resources that have been allocated to meet the energy saving targets.

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[63] J P Rutherford, E W Scharpf, C G Carrington 'Linking consumer energy efficiency with security of supply' *Energy Policy* **35** (2007) 3025–3035
[64] Integrated Energy Policy, Planning Commission, August 2006
[65] Annual Report 2006–07, MoPNG, details available at http://petroleum.nic.in/Annual_Report/AR06-07.pdf, last accessed on 19 July 2008

4.2.1.2 Energy efficiency policies/programmes at national level

Following are the major initiatives at the national level since 1990s to improve efficiency in electricity, hydrocarbon sector and other areas.

Electricity sector

Electricity Act 2003 (EA 2003) contains provisions for promotion of efficient and environmentally benign policies. National Electricity Policy, in compliance with EA 2003 also laid great emphasis on energy conservation.

Hydrocarbon sector

Petroleum Conservation Research Association, on behalf of Government of India, Ministry of Petroleum and Natural Gas, has been working since 1978 for the development and deployment of strategies for energy conservation and environmental protection in the major sectors of the economy, that is, transport, domestic, industrial, agricultural and commercial.

In the industrial sector, PCRA focuses on improvement in fuel use efficiency through upgrading of technologies and reducing wastages by conducting energy audits in large, medium and small enterprises. Soft loans and subsidies are given to industrialists to implement energy conservation measures.

For the transport sector, PCRA conducts variety of programmes for STUs, private fleet operators, and so on, to promote efficient use of petrol, diesel, lubricants and greases through better maintenance practices, driving habits, model depot studies, emission awareness programme, workshops, and so on.

PCRA provided assistance in agricultural sector by replacing non ISI and sub standard foot valves, pump sets and other equipment with better appliances. This helps in conserving energy. Also PCRA conducted demonstration and educational programmes to create awareness.

For the domestic sector, PCRA created awareness among housewives and youth on better cooking and driving habits.

Other areas

Indian government initiated a voluntary eco-labelling programme known as the 'Eco Mark' in 1991. Any product that is made, used or disposed of in a way that significantly reduces the harm it would otherwise cause the environment is considered as an environment-friendly product. The scheme aims to provide an incentive for manufacturers to reduce adverse environmental impact of products and to encourage

consumers to purchase such products.[66]

Considering the vast potential of energy savings and benefits of energy efficiency, the Government of India enacted the Energy Conservation Act, 2001 (52 of 2001). The Act provides for the legal framework, institutional arrangement and a regulatory mechanism at the Central and State level to embark upon energy efficiency drive in the country. The measures undertaken as parts of the Act include programmes for energy efficiency in government buildings, conducting energy audit of government buildings and preparing action plan for wider dissemination and implementation of energy efficient programmes.

Bureau of Energy Efficiency (BEE) was established under Energy Conservation Act 2001, with the objective to 'institutionalise' energy efficiency services, enable delivery mechanisms in the country and provide leadership to energy efficiency in all sectors. The primary objective would be to reduce energy intensity in the economy. BEE recently introduced a number of important initiatives such as the National Energy Conservation Award for various industries and buildings, developing energy performance contract for energy service companies (ESCOS) and energy efficiency labelling scheme. BEE also conducts on a regular basis, a National Certificate Examination for Energy Managers and Energy Auditors.

4.2.1.3 Impact of energy efficiency policies/programmes

Following describes the impact of above stated measures to achieve efficiency in usage of energy in the country.

Impact on energy mix

Using energy efficiently will not alter or affect the energy mix of the country per se, however, it results in decrease in quantum of energy required in the country. It helps in lowering energy intensity growth of the country, which is regarded as an important challenge for ensuring energy security. The energy intensity of India's growth has been falling and is about half of what it used to be in the early seventies.[67] Though, it indicates some improvements in energy usage but as regards the huge potential of energy saving in India, this achievement appears insignificant.

Impact on the cost of energy

The measures to achieve energy efficiency at the national level are expected to result in savings in quantum of energy. However, there are certain costs associated with implementing such

[66] http://www.cpcb.nic.in/Eco-mark%20Scheme/default_Eco-mark.html

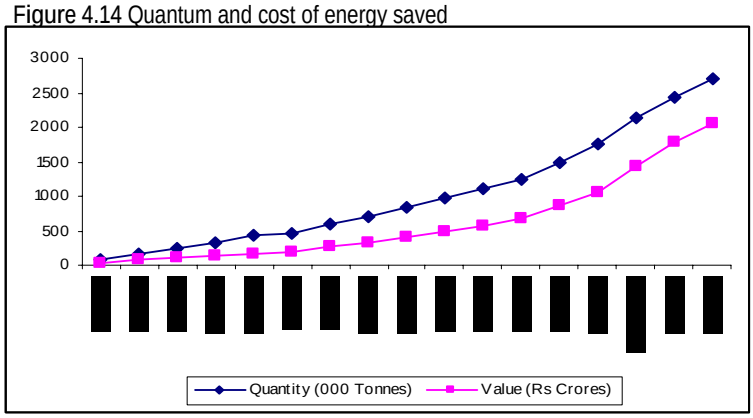
[67] Integrated Energy Policy, Planning Commission

measures. The following describes the energy savings and cost involved in some of the above measures.

BEE conducted energy audits of eight government buildings (including President House, PMO, Shram Shakti Bhawan). Such energy audit revealed that such buildings had an energy saving potential of about 17.5 million kWh. This in turn amounts to saving of Rs 4.4 million to the government. However, the cost involved in implementation of measures to achieve such savings is Rs 186 million.[68]

Various measures taken by PCRA have resulted in huge amount of energy savings. Figure 4.14 indicates the quantum of energy saving achieved and the cost of energy saved.

Figure 4.14 Quantum and cost of energy saved



Source PCRA website

Environmental impact

The eco labelling scheme was initiated with the objective to reduce the adverse impact of some products on the environment. However, the scheme did not meet with much success. The product categories covered under the scheme have been arbitrarily chosen and the quantum of impact of the category on the environment has not really been considered. Also, some product categories such as agro-chemicals, which impose a significant burden on the environment, have been taken outside the purview of Eco mark.[69]

Though government notified standards for 16 categories of products, but no significant steps were taken by Indian industries in this regard. Few companies have taken Eco-mark

[68] Presentation on Energy Conservation and Efficiency by Secretary, BEE
[69] 'Competitive Labelling Vs regulatory Eco label – A look at the Eco Mark Scheme', Indian Institute of Materials Management, details available at http://www.iimm.org/knowledge_bank/8_competitive-labeling-v-sregulatory-eclabel.htm, last accessed on 23 July 2008

license for their products from Bureau of Indian Standards (BIS) but there are no Eco Mark products available in the market. Consumer awareness about Eco-mark is low as there was hardly any initiative to generate awareness among them.

The other measures mentioned above, impact the environment indirectly. Such measures intend to reduce the demand for energy in the country, which in turn reduces the generation of energy and associated environmental impact with it.

4.2.1.4 Barriers to energy efficiency

According to the study conducted by TERI on the energy saving potential of basic demand side management measures in Delhi, there are some barriers to the implementation of these measures. Inspite of huge potential of energy saving through various energy efficiency measures, the achievements in this regard have been quite low. Following are some of the barriers in implementing energy efficiency measures.[70]

- Owing to low demand in the market for energy efficient appliances, manufacturers are reluctant to manufacture such devices, therefore consumers despite being aware of these energy saving devices are unable to purchase them. The government too, has limited incentives to provide relaxation in excise duty to manufacturers and thus encourage the production of the same.

- The implementation of any energy efficiency measure requires support from the users of such energy. However, there is a lack of awareness about such measures among energy consumers in India. It has been observed in some cases, that though consumers are aware of energy efficient options available, but lack of information

- Hampers their ability to make informed decision regarding energy efficient measures. In other cases, it has been seen that consumers are not even aware of the new energy efficient technologies available in the market.

- The way of making energy efficiency improvements such as replacement of incandescent bulbs with compact fluorescent lamps are considered as expensive by poor people in terms of upfront payments and thus these measures are not very popular among them.

- In case of electricity, irrational tariffs are also one of the

[70] Manisha Jain, Vikas Gaba, Leena Srivastava 'Managing Power Demand', TERI 2007

reasons of wasteful usage of electricity. Therefore, it is necessary to design tariffs in a way that they reflect its scarcity, thus encouraging its efficient use and conservation. Attempts have been made by a few electricity regulatory commissions to implement ToD tariffs, but these have been mainly in the industrial category. Absence of appropriate mechanisms that can help in bringing down the high upfront cost can prove to be a major deterrent in the adoption of energy efficient appliances by the consumers.

4.2.2 Promoting renewable energy

As the country is short of energy resources, the need to develop all energy sources is paramount. In the wake of depleting fossil fuels resources, renewable energy sources such as solar, wind, biomass, small hydro, and so on, are emerging as alternative energy options. Thus, usage of renewable sources of energy is regarded as an important step towards our aim of achieving the energy security.

4.2.2.1 Renewable energy potential

India has a vast potential for effectively using renewable energy sources. The gross wind power potential has been assessed at 45 000 MW. However, the technical potential is estimated at about 13 190 MW, assuming 20% grid penetration, which is expected to go up with the augmentation of grid capacity in potential states. In case of small hydro power (SHP), an estimated potential of about 15 000 MW is available in India. The potential for energy recovery from urban waste is estimated at 2550 MWe and from industrial waste at about 1287 MWe. The current potential of conversion of surplus agro and forestry residue is estimated to be about 16000 MWe and the estimated potential for bagasse based co-generation in sugar mills is estimated at about 5000 MWe. The potential for solar thermal collectors is assessed at 140 million square metres.

The total power generating capacity from renewable energy sources including both grid interactive renewable power and distributed renewable power was 9497 MW. This comprised of 9372 MW of cumulative grid interactive power generating capacity. Of this, the wind power, small hydropower and biomass constituted 6315 MW, 1905 MW, and 1152 MW respectively.

4.2.2.2 Measures taken to promote renewable sources of energy

The following section discusses the various measures taken to increase the usage of renewable sources of energy at national level and the impact of such measures.

- Government of India established the ‘CASE’ (Commission for Additional Sources of Energy) under the Department of

Science and Technology with the mandate to promote Research and Development (R&D) activities, develop, demonstrate renewable energy technologies (RET) and oversee the introduction of RETs into different sectors. In 1982, CASE was incorporated into the Department of Non-conventional Energy Sources (DNES), which was upgraded to an independent ministry – Ministry of Non-conventional Energy Sources (MNES) in 1992. Since early 2006, this ministry is known as the Ministry of New and Renewable Energy (MNRE).

- To overcome the difficulties in financing RE projects and the R&D of newer technologies, the Ministry in March 1987 established a public sector enterprise known as the Indian Renewable Energy Development Agency Limited (IREDA Ltd) with the objective of promoting and developing renewable energy technologies and energy efficiency and conservation projects through extended financial assistance.

- The central government through MNRE and other public organizations is pursuing a multi-pronged strategy for the promotion of RE sources through collaborative public–private sector involvement. This includes promoting private investment through fiscal incentives, tax holidays, and depreciation allowance and providing guidelines to the state utilities for favourable purchase of power from RE-based power producers. IREDA is facilitating the deployment of renewable energy systems by providing term loans. IREDA has sanctioned loans amounting to Rs 2.9 billion and disbursed about Rs 2.19 billion as on 31 January 2007.

- MNRE implemented centrally sponsored scheme modified Integrated Rural Energy Programme (IREP) on 50:50 cost sharing basis with the state governments from 2003/04 to 2006/07. The programme aimed at the development of planning and institutional capabilities of the states to prepare and implement the micro-level energy plans for selected clusters of villages. Renewable energy and energy conservation devices were installed in the identified village clusters. Five IREP Training Centres were also set up in Bakoli (Delhi), Lucknow (Uttar Pradesh), Anand (Gujarat), Bangalore (Karnataka) and Shillong (Meghalaya) with support from the programme. The programme was implemented in 21 States/UTs covering 323 districts in the country.

- With respect to renewable energy sources, the Integrated Energy Policy specified the need for special policies to encourage the improvement in outcome of renewable sources. Power regulators must seek alternative incentive

structures that encourage utilities to integrate wind, small hydro, cogeneration, etc., into their systems. All incentives must be linked to energy generated as opposed to capacity created. Respective power regulators should mandate feed-in laws for renewable energy, where appropriate, as provided under the Electricity Act and as mandated in many countries.

- The EA 03 also had its impact on the renewable power sector and recognized the role of renewable energy technologies in the National Electricity Policy and in stand-alone systems. It has been made mandatory for the SERCs to promote co–generation and generation of electricity through renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any persons, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee.

- The National Tariff Policy says that the appropriate Commission shall fix a minimum percentage for purchase of energy from non-conventional sources taking into account availability of such resources in the region and its impact on retail tariffs. Such percentage for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by April 1, 2006. At present, 15 SERCs have fixed the percentage of energy to be purchased from renewable sources. The regulatory commissions of the following states namely Andhra Pradesh, West Bengal, Haryana, Himachal Pradesh, Gujarat, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, Punjab, Karnataka and Chhatisgarh have fixed the percentage of energy to be procured from renewable sources[71]. Several state-level quota's and purchase obligations have been issued to promote renewable energy in India. The existing state level initiatives are provided in the table below.

[71] 'Promotion of co-generation and generation of electricity from renewable sources of energy', CERC discussion paper.

Table 4.1 State-wise initiatives for promoting renewable energy technologies in India

S.No.	State	Quota/Renewable purchase obligation	Time period
1	Andhra Pradesh	Minimum 5% of total energy consumption (of this 1/2% is to be reserved for wind)	2005/06, 2006/07 and 2007/08
2	Gujarat	Minimum 1% of total energy consumption	2006/07
		Minimum 1% of total energy consumption	2007/08
		Minimum 2% of total energy consumption	2008/09
3	Himachal Pradesh	Minimum 20% of total energy consumption	2007/10
4	Haryana	Up to 2% of total energy consumption	2006/07
		Up to 2% of total energy consumption	2007/08
		Up to 3% of total energy consumption	2008/09
		Up to 10% of total energy consumption	2009/10
5	Karnataka	Minimum 5% and maximum of 10% of total energy consumption	
6	Kerala	Minimum 5% of total energy consumption (of this 2% from SHP, 2% from wind and 1% from all other NCE sources)	2006–09
7	Madhya Pradesh	Minimum 0.5% of total energy consumption including third party sales from wind energy	2004–07
8	Maharashtra	Minimum 3% of total energy consumption	2006/07
		Minimum 4% of total energy consumption	2007/08
		Minimum 5% of total energy consumption	2008/09
		Minimum 6% of total energy consumption	2009/10
9	Orissa	3% (for wind and SHP)	
10	Rajasthan	Minimum 4.88% of total energy consumption	2007/08
		Minimum 6.25% of total energy consumption	2008/09
		Minimum 7.45% of total energy consumption	2009/10
		Minimum 8.50% of total energy consumption	2010/11
		Minimum 9.50% of total energy consumption	2011/12
11	Tamil Nadu	Minimum 10% of total energy consumption	2006–09
12	Uttar Pradesh	5% of total energy consumption	—
13	West Bengal	Minimum: 1.9%	2006-07/
		Minimum 3.8%	2007/08

Source Report of the Working Group on New and Renewable Energy for the Eleventh Five-year Plan (2007–2012), Ministry of New and Renewable Energy, Government of India, December 2006

- For the Eleventh Five-year plan, a supporting programme to Information, Publicity and Extension (IPE) aims at creating conditions for and facilitating deployment of new and renewable energy systems/devices. Sustaining, accelerating and extending outreach of deployment programmes is considered essential for increasing share of renewable in the energy-mix. Areas most likely to gain are rural, urban, commercial and industrial. IPE programme will cover support for renewable energy field level training institutions, Renewable Energy Clubs, Rajiv Gandhi Akshyay Urja Diwas celebrations, Publicity through Electronic and Print media, Publications (Aksya Urja, etc.) and District Advisory Committees (DACs). It will also cover support for BOVs/Hybrids/SPV devices/other RE devices on extension

basis. A budget provision of Rs 5.25 billion ($131.3 million) is proposed for the Eleventh Plan period.

- Another supporting programme called International Relations (IR) programmes aims at obtaining leverage for the country in RE related activities at multilateral, and bilateral levels. In pursuance of this aim, IR support covers, among others, the multilateral/bilateral events; training for foreign scientists/technologists in the country; deployment of NRE systems/devices in other countries; technical consultancy to other countries; seminars/symposia/workshops, etc., in the country; deputations abroad; and related activities. Budget provision of Rs 0.5 billion is proposed for these activities during the Eleventh Plan.

4.2.2.3 Barriers in promotion of renewable energy

- Commercialisation barriers faced by new renewable technologies competing with mature technologies. For instance, coal and oil based thermal power is preferred to hydel power due to its short gestation period and marginal physical displacement of people.

- RETs are characterized by high initial costs, though they have lower fuel and operating costs. High initial cost means that they provide less installed capacity per initial rupee invested than conventional energy sources. Therefore, renewable energy investments typically require higher amount of financing for the same capacity.[72]

- Long and tedious procedural formalities for funding and financing of installation of RETs discourage probable investors. These are capital-intensive equipment and procedures should be simplified with a single window application submission and disbursal with very low rates of interests to encourage investment.

- Lack of knowledge and requisite skills may increase uncertainties about RETs and block decisions. For example, skilled personnel who can install, operate and maintain renewable technologies may not be readily available.

- Legal obstacles like restrictions on construction of RETs and siting, etc., (for example, wind turbines, rooftop solar water heaters, etc., may face restrictions with respect to height, noise and safety requirements).

[72] 'Renewable energy policies and barriers', Fred Beck and Eric Martinot

- Renewable energy producers may not be allowed transmission access or they may be charged with high transmission access charges. Transmission access is essential for direct third party sales between renewable energy producer and a final consumer.

- Failure of the market to value the public benefits of renewable sources of energy

4.2.2.4 Impact of measures

Impact on Energy mix

Renewables contribute significantly to the national electricity mix of the country. The share of renewable energy in power generating capacity has increased from 6% in 2006/07 to 8% to 2007/08. The Integrated Energy Policy states that even if the share of renewable energy rises by 40% from the current level, it would constitute only 5-6% of the country's commercial demand. Nevertheless, renewable energy sources are very important from the point of view of increasing India's resource base.

Environmental impact

Apart from electricity generation, the application of these technologies has benefited millions of rural folk by meeting their cooking and other energy requirements in an environmentally benign way.[73] Renewable energy sources do not contribute to air pollution as other fossil fuels and do not have any significant threats such as those associated with nuclear plants. Small hydro projects help to conserve water supply. Biomass energy sources help in preventing land degradation and promote cultivation of crops in wasteland.

In spite of all these benefits, renewable energy sources still cause degradation of a different kind. Unsustainable use of biomass leads to depletion of forests. Wind energy causes noise pollution and can also lead to bird mortalities, and thus, despoil the aesthetics of the landscapes. Large arrays of photovoltaic panels cause considerable demand on land and destroy aesthetics. Use of chemicals in the solar panels and use of lead batteries also have adverse environmental impacts. Similarly bio energy though considered carbon neutral has adverse impacts on water and soil resources.[74]

4.2.3 Other measures

[73] http://mnes.nic.in/annualreport/2007_2008_English/Chapter1/chapter1_1.htm, accessed on 28th July 2008.

[74] Integrated Energy Policy report

4.2.3.1 Diversify energy mix

Diversifying the energy mix by using different types of fuels can increase energy security. The security provided by such diversification is enhanced when the ability of the users to switch among fuels increases. High dependence on one particular energy source makes the country vulnerable to the availability of that resource. In India, coal is regarded as a mainstay of Indian economy. About 53% of power generation in India is based on coal as a main energy fuel. This raises concerns related to energy security, especially in the situation of depleting coal reserves in the country. In respect to this, government is planning to diversify the fuel mix of power generation capacity in the country. The government is making concerted efforts to develop renewable sources of energy for sustainable growth of the country. The Integrated Energy Policy emphasizes the need for developing solar power in view of energy independence in the long run. It further states that with a concerted push and a 40-fold increase in their contribution to primary energy, renewable may account for 5%–6% of India's energy mix by 2031/32. Even though the figure is small, it is expected to have large socio-economic benefits and would be desirable from the point of view of energy security.[75]

4.2.3.2 Diversification of energy supplier

With increasing crude oil imports, dependency on the Middle East region is also increasing. In 2001/02, India imported about 68% of its crude oil requirements from Middle East region, which increased to about 73.5% in 2005/06. In Middle East, the country that accounts for maximum share of export to India is Saudi Arabia, which accounts for nearly a quarter of our total imports. This indicates the high dependence on a particular supplier of energy sources, which increases the vulnerability of the country with respect to the availability of energy resource. However, government is taking measures to diversify the supplier of energy fuels by sourcing oil and gas from different countries. Supply risk can also be reduced by policy coordination among the importing and exporting countries by importing gas from pipelines or getting hydropower from neighbouring countries. Several cross border gas pipelines have been proposed to import gas from India's neighbouring gas rich countries.

4.2.3.3 Oil equity

In line with diversification of supply sources for energy, obtaining oil equity abroad is considered as one of the options. While giving special attention to international cooperation in achieving energy security, MoPNG has created a new Division

[75] Integrated Energy Policy Report, August 2006.

called International Co-operation Division (ICD). The principal role of the ICD is to promote long-term engagement of Indian Companies in the hydrocarbon sector abroad. OVL (ONGC Videsh Ltd), an arm of ONGC, which is into the business of international exploration and production, has the lead role in acquiring equity oil assets from overseas. It has acquired assets in Asia Pacific (Myanmar, Sakhalin, Vietnam), Middle East (Iran, Iraq, Syria, Qatar), Africa (Libya Sudan, Egypt) and Latin America (Brazil Colombo, Cuba). ICD has provided support in many of these initiatives.

4.2.3.4 Enhanced oil recovery/improved oil recovery

Recovery from the existing major fields by implementing enhanced oil recovery (EOR)/improved oil recovery (IOR) schemes, in particular, is targeted to improve India's crude oil production. ONGC has completed 12 IOR/EOR projects and another 6 are under implementation .The estimated gain from these projects is placed at 110 MMT by 2030.

4.2.3.5 Strategic oil reserves

For enhancing energy security and to safeguard the country against short term supply disruption, government has approved setting up of 5 million tonnes of strategic storage of crude oil by 2012 at three locations in the country, namely Mangalore (1.5 MMT), Visakhapatnam (1.0 MMT), and Padur near Udipi (2.5 MMT). The Government also plans to raise the reserves to 15 MMT in next phase. These reserves would be in addition to the existing crude oil and petroleum products, operating stocks maintained by the oil companies. The reserve will be used essentially as a hedge against short-term supply disruptions. The estimated capital cost of the project is around Rs 24 billion. In addition, the cost of crude oil would be around Rs 90 billion at $55/bbl crude price. ISPRL (Indian Strategic Petroleum Reserves Limited), a subsidiary of OIDB (Oil Industry Development Board), will carry out the implementation and management of strategic storage of crude oil. MoUs have been signed with China, Japan and Korea for sharing their experiences in the construction of strategic storage of Crude Oil by exchanging information, technologies and knowledge.[76]

4.2.3.6 Behavioural changes

Small changes in the type of energy consuming appliance and the manner of using them can bring large saving on an aggregate basis. In this respect, certain measures are taken by the government to induce changes in the behaviour of the energy consumers. For instance, PCRA has been taking initiatives to promote energy conservation measures in industrial, transport, agricultural and domestic sectors.

[76] Annual Report , Ministry of Petroleum and Natural Gas, 2006/07

In the transport sector, PCRA identifies savings of about 20% of fuel by conserving energy. It has promoted development of model depots where fuel/lube conservation measures are effectively implemented with PCRA assistance and sustained by the depot manager at the attainable performance level. The measures thus introduced in model depots can be emulated by fleet operators. PCRA also promotes usage of high performance lube oils, which saves energy fuels. Training is also provided to vehicle drivers to create awareness about saving the energy fuels. As a result of this, drivers may implement few tips to save diesel and to increase mileage of their vehicles by taking simple measures such as driving at consistent speed, avoiding brakes, planning the route to be taken and driving in correct gear. Such measures encourage the driver to take the necessary steps to conserve energy.

In order to bring about efficiency or saving of energy in industrial sector, PCRA conducts energy audits, fuel oil diagnostic studies; organizes seminars, consumer meets, clinics, and workshops and also undertakes R& D projects such as the development of low air pressure industrial burners, etc., for efficiency improvement. Such activities have highlighted that about 20% of petroleum products consumed in the industrial sector can be saved by using energy efficiently.

In case of agricultural sector, energy can be conserved by using the water pump more efficiently. With application of better technology such as more efficient valves pumps, proper design and construction of well and by better use of the water can lead to 30%–50% of energy saving in the sector.

By such awareness creating measures, certain behavioural changes are induced in various sectors of the economy which may lead to substantial energy saving.

4.2.3.7 Impact of other measures

Although the impact of the measures stated above will be difficult to express on quantifiable terms, but on an aggregate basis, the measures stated above contribute positively towards achievement of the energy security. The measures such as acquiring oil equity abroad, enhancing oil recovery measures and building up of strategic oil reserves in the country helps in assuring the availability of energy sources in the country. Diversification of energy sources and fuel mix helps in reducing the vulnerability of the economy by reducing high dependence on particular energy source or a fuel. Behavioural changes in the various sectors of the economy bring about substantial saving in the respective sectors.

Conclusion

It is observed that the country has a long way to go to achieve its energy security. Physical threats to energy security relates to availability of energy sources. Due to depleting reserves of energy resources in the country, import dependency for meeting the energy needs is rising sharply. This in turn has financial implications attached to it. Imports of the energy resources put a fiscal strain on the Indian economy as these imports have to finance by the export earnings of the country. It also, leads to outflow of the scarce foreign exchange in the country. Energy efficiency and increased usage of renewable energy sources are regarded as measures to improve energy security in the country. Policy measures in this regard has been taken, For instance, National Electricity Policy, Electricity Act 2003, and Energy Conservation Act 2001 laid provisions for promotion of energy conservation and energy efficiency in the electricity sector. PCRA has strategies to promote energy efficiency in sectors such as transport, domestic, industrial, agricultural and commercial. MNRE and public sector enterprise, IREDA are promoting renewable energy sources in the country. Such measures have resulted in positive impact on energy security of the country.

Chapter 5 Threats to Energy Security, Measures to Enhance Energy Security and their Impacts at the Household Level

As mentioned in Chapter 3, the household sector is one of the largest energy consumers in India, accounting for nearly 45% of the total primary energy use. This chapter provides an overview of the threats to energy security, measures to enhance energy security and their impacts at the household level in India.

5.1 Threats to energy security at household level

Energy is an indispensable prerequisite to development. As has been widely recognized, provision of clean energy is essential to achieve the Millennium Development Goals (MDGs). Availability of clean energy has a multidimensional impact on macroeconomic growth, gender inequality and local and global environment. However, in India a large proportion of the population is still dependent on traditional fuels to meet its energy needs. In India, around 20% of the total energy needs are met through traditional sources of energy.[77] This has adverse social and environmental impacts. A related aspect to energy provisioning is the lack of uniformity in provisioning of services in rural and urban areas and between the rich and poor. All this relates to concerns of energy security at household level. This section details out the indicators, which represents the threat to energy security as faced by the household sector in India. The threats to energy security have been classified into physical and financial threats.

5.1.1 Physical threats

The physical threat to energy security faced by households can be explained in terms of consumption of various energy fuels, access to cleaner energy fuels and social impact of usage of inefficient energy fuels. The physical threats to energy security at household level are discussed below.

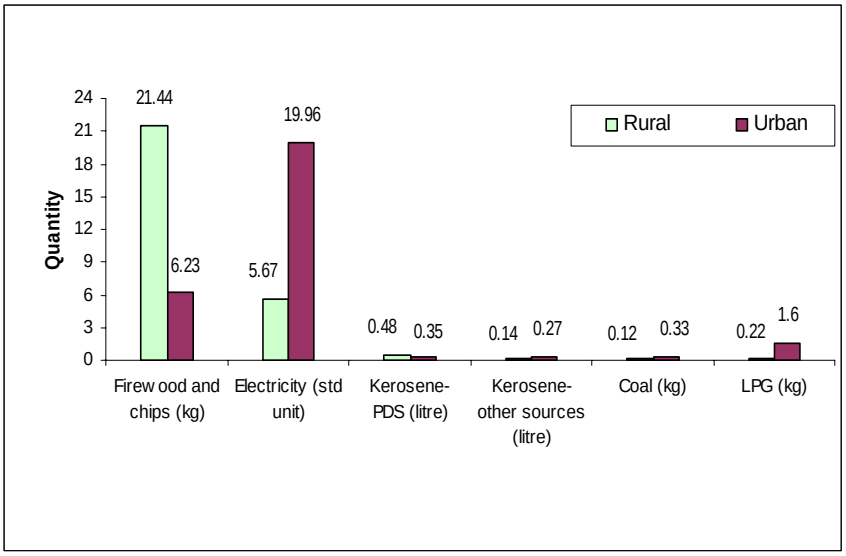
5.1.1.1 Per capita consumption of energy fuels

Households in urban areas consume more of cleaner energy fuels such as electricity and LPG, whereas rural households have a high dependence on traditional sources of energy. Figure 5.1 indicates the monthly per capita consumption of various energy fuels at rural and urban households. This highlights the

[77] Human Development Report 2006; UNDP

wide disparity between rural and urban households with respect to consumption of cleaner fuels. Rural households face serious energy security threat in terms of consumption of inefficient and polluting fuels.

Figure 5.1 Per Capita Consumption of Energy Fuels



Source National Sample Survey Organization, household consumption of various goods and services in India, 2004/05, 61st round (July 2004–June 2005)

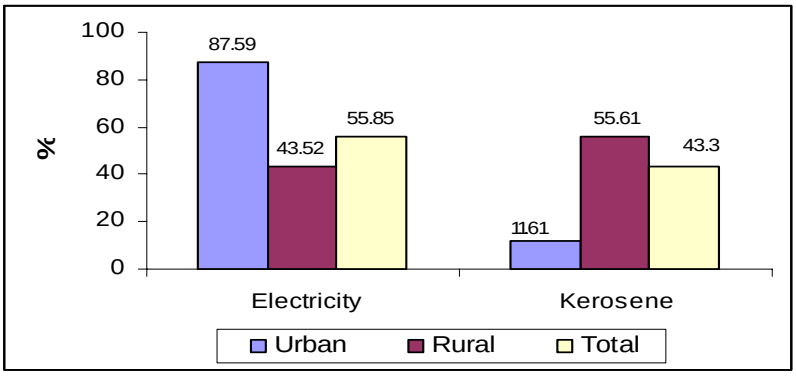
5.1.1.2 Access to cleaner energy fuels

An important energy security concern of the Indian households is the provision of clean energy. Access to clean fuels encompasses provision of three energy sources, that is, electricity, kerosene and LPG. These energy resources are essential to meet the cooking and lighting needs of the households.

Access to clean lighting fuels

In India, around 56% of households have access to electricity. However, the penetration of the clean energy source is not uniform across the country. There is a substantial rural-urban divide for consumption of electricity (Figure 5.2). Although 72% of the total households in India live in the rural areas, only 44% of these rural households use electricity as their primary source for lighting. On the other hand, in urban areas, around 88% of the households use electricity as their primary source of lighting.

Figure 5.2 Primary source of lighting for household



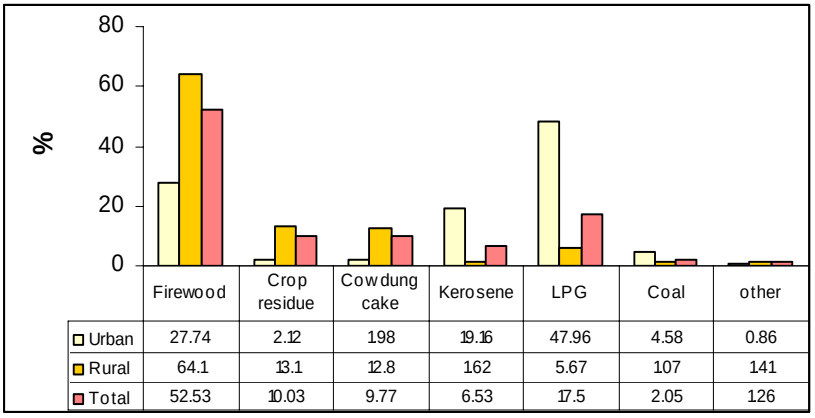
Source Census of India 2001

In rural areas, the situation is grave because the major source of lighting in these areas is kerosene, which is not an efficient source of lighting. Majority of the kerosene lamps used are hurricane type lamps, which produce very poor light of about 60–70 lumens (lm) (a 100 W bulb produces ~1300 lm and for reading about 100-200 lm/m^2 or lux is sufficient). Further more, burning of kerosene results in indoor emissions, which are harmful for the members of the household. Being inefficient source of lighting, kerosene is not even suitable to meet the lighting needs of household such as reading, cooking and other chores in the night.

Access to clean cooking fuels

Biomass and other traditional sources of energy are the dominant fuel consumed to meet cooking needs in households. On an all India basis, firewood is the most prominent fuel used by more than half of the population (Figure 5.3). Traditional sources of fuel account for about 72% of the total cooking energy requirement.

Figure 5.3 Distribution of households by primary source for cooking energy



	Firewood	Crop residue	Cowdung cake	Kerosene	LPG	Coal	other
Urban	27.74	2.12	1.98	19.16	47.96	4.58	0.86
Rural	64.1	13.1	12.8	1.62	5.67	1.07	1.41
Total	52.53	10.03	9.77	6.53	17.5	2.05	1.26

Source Census of India 2001

Similar to the case in lighting, again there is a rural-urban divide in energy service provisioning in cooking. In urban areas cleaner basket fuels are used for cooking. Majority of urban households, around 48%, consume LPG as the primary source of cooking energy (Figure 5.3).

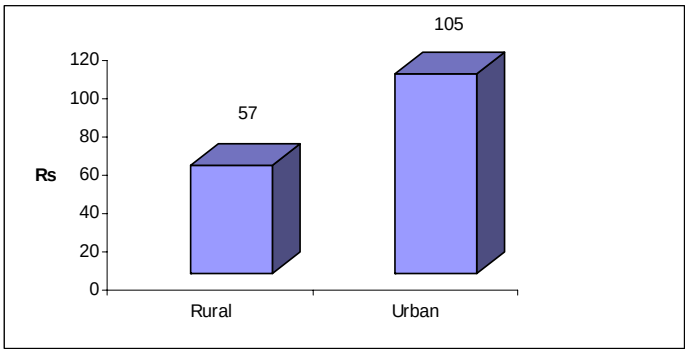
5.1.2 Financial threats

The financial threats related to energy security at the household level can be explained in terms of expenditure on energy fuels for cooking and lighting purposes, affordability of cleaner fuels by different households and the relationship between energy access and income level of households. The financial threats to energy security at household level is discussed below.

5.1.2.1 Absolute per capita monthly expenditure on energy fuels

The monthly per capita fuels and lighting expenditure in 2004/05, incurred by urban population was almost double the expenses incurred by their counterparts in the rural areas, as indicated in Figure 5.4. This is mainly due to fact that the urban households consume more of commercial fuels which are priced higher than the energy fuels used in rural households as shown in Figure 5.5.

Figure 5.4: Absolute per capita monthly expenditure on energy fuels

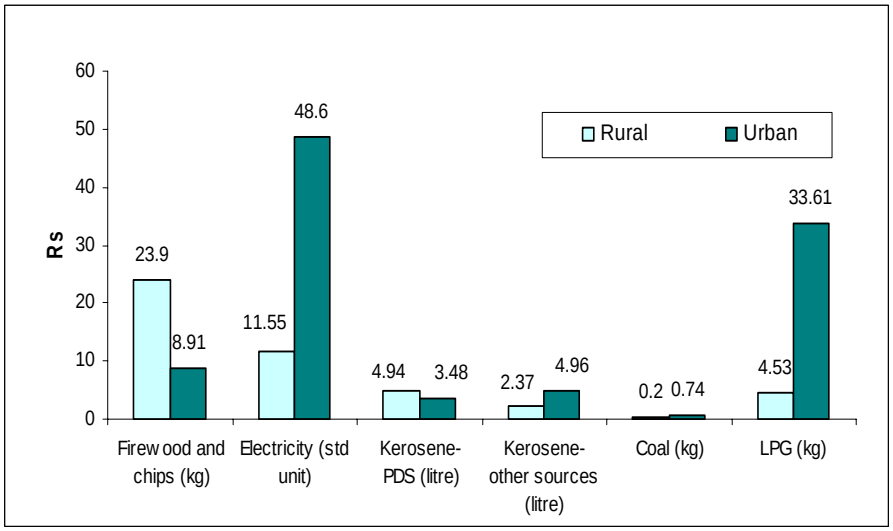


Source National Sample Survey Organization, household consumption of various goods and services in India, 2004/05, 61st round (July 2004–June 2005)

5.1.2.2 Per capita monthly expenditure on energy fuels

Expenditure on electricity and LPG constitute the major expenditure by urban households on energy consumption. On the other hand, rural household expenditure on energy fuels is mainly for traditional sources for energy such as biomass as indicated in figure 5.5.

Figure 5.5 Per capita monthly expenditure on energy fuels



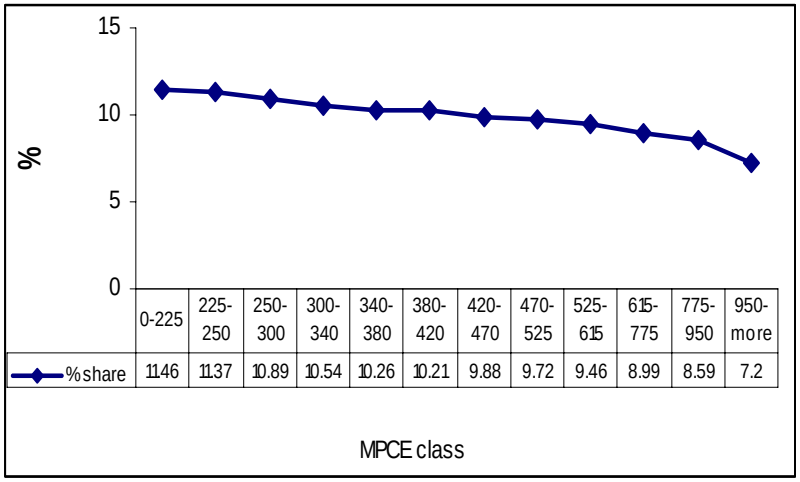
Source National Sample Survey Organization, household consumption of various goods and services in India, 2004/05, 61st round (July 2004–June 2005)

Absolute expenditure on fuel and lighting by households gives an incomplete picture of the extent of financial burden faced by households on the energy fuels. Absolute expenditure needs to be looked at in tandem with the total expenditure of the households. Thus, it is relevant to look at the percentage spending on energy fuels out of the total expenditure of the households.

5.1.2.3 Percentage expenditure on energy fuels

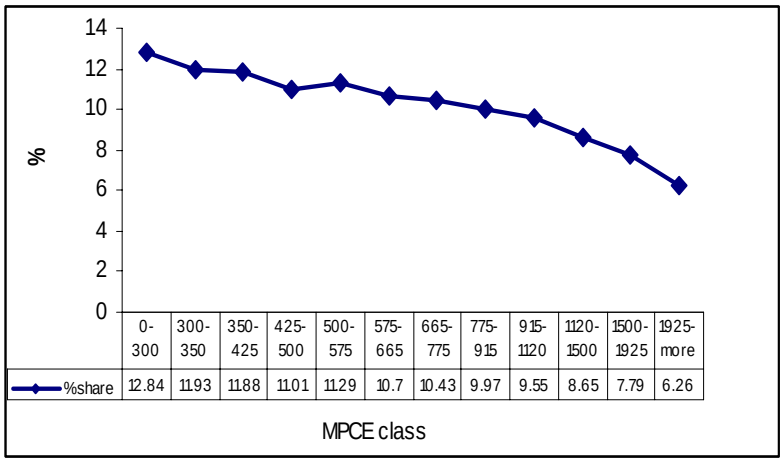
Figures 5.6 and 5.7 indicate the percentage spending on energy fuels for cooking and lighting purposes by households in different MPCE classes respectively for rural and urban households. Comparison of two figures highlights that the urban households have a higher share of expenditure on fuel for lighting and cooking as compared to their counterparts in the rural areas. A probable reason is the higher consumption of commercial sources of energy in urban households, which have market value, attached to them and thus is relatively priced higher than the traditional fuels used in rural areas.

Figure 5.6 Percentage spending on lighting and cooking (rural)



Source NSSO, 2005, Ministry of Statistics and Programme Implementation, GoI

Figure 5.7 Percentage spending on lighting and cooking (Urban)



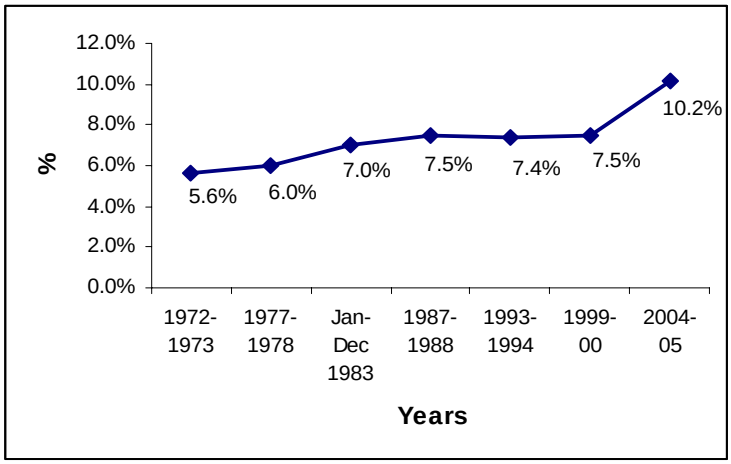
Source NSSO, 2005, Ministry of Statistics and Programme Implementation, GoI

The figures 5.6 and 5.7 also highlight that the households in lower MPCE classes have a larger share of expenditure on energy fuels for cooking and lighting purposes than the households in higher MPCE classes. This is true both for rural and urban households. This indicates the higher vulnerability of poor households to the energy fuel prices.

5.1.2.4 Increasing expenditure on energy fuels

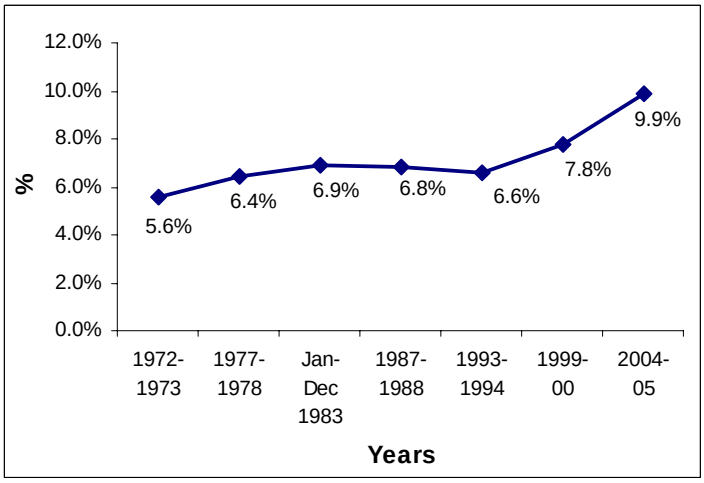
It is observed that the percentage share of expenditure on energy fuels have been rising steeply over the years, both for rural and urban households. Figure 5.8 and 5.9 indicate that the share of expenditure on energy fuels has almost doubled over a span of 32 years. Rural households continue to spend a larger share of their total expenditure on energy fuels as compared to their counterparts in urban households.

Figure 5.8 Fuel and light expenditure as a percentage of total housheold expenditure (Rural)



Source National Sample Survey Organization, level and pattern of consumer expenditure, 2004/05, 61st round (July 2004–June 2005)

Figure 5.9: Fuel and light expenditure as a percentage of total household expenditure (Urban)



Source National Sample Survey Organization, level and pattern of consumer expenditure, 2004/05, 61st round (July 2004–June 2005)

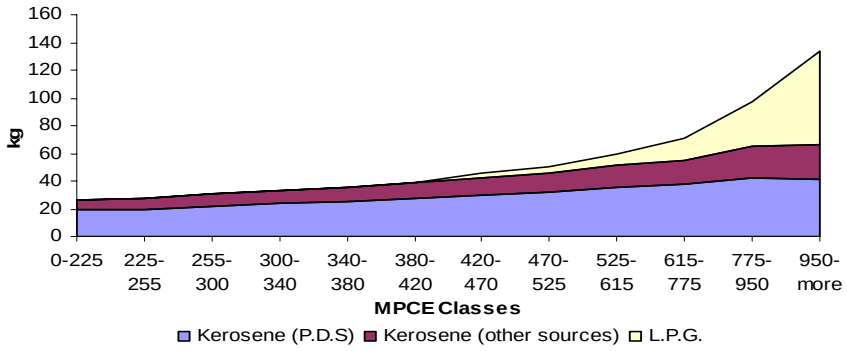
Since poor households spend a larger share of their expenditure on energy fuels and such expenditure is rising steadily over the years, the above indicators of financial threat to energy security highlight the increasing vulnerability of poor households to high energy prices.

5.1.2.5. Energy access and income

Another important aspect related to access as well as energy security is the status of energy access across income classes. In an ideal situation it is expected that consumption of subsidised fuels by the poor should be more or less be similar to that by the rich. However, in India consumption of both clean and

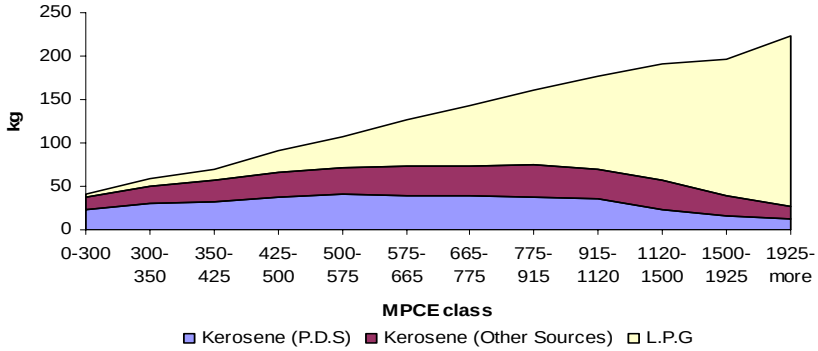
subsidized fuels, that is, kerosene and LPG is skewed towards higher MPCE classes (Figures 5.10 and 5.11)

Figure 5.10: Consumption of kerosene and LPG across MPCE classes (Rural)



Source NSSO, 2000, Ministry of Statistics and Programme Implementation, GoI

Figure 5.11 Consumption of kerosene and LPG across MPCE classes (Urban)



Source NSSO, 2005, Ministry of Statistics and Programme Implementation, GoI

5.1.2.6. Affordability of energy fuels

Another aspect related to household energy security is affordability of clean energy sources. Affordability of energy sources is closely linked to the accessibility of clean energy sources. It has also been considered as one of the facets of energy security in terms of provision of affordable energy sources. Prices are an effective tool to ensure efficient utilization of energy sources. In India clean energy sources such as LPG and electricity are subsidized to encourage access.

In the electricity sector, there are widespread subsidies and cross subsidies. The industrial and commercial sectors cross subsidize the domestic sector in India and thus in most states domestic consumers pay far less than their cost of supply. As a result of subsidised prices of electricity, the household sector has no incentives to use electricity economically and this at times leads to wastage of electricity.

Liquefied Petroleum Gas (LPG) subsidies are universal in nature and are available to all; however, kerosene subsidies are available only to BPL consumers through PDS. The government since 1975 has provided these subsidies. The subsequent paragraphs discuss in detail the impact of kerosene and LPG subsidies in enhancing access to household.

LPG subsidies had limited success in increasing penetration of the clean fuel in poor population. Even after more than three decades of subsidies, LPG usage in Indian households is restricted. Further, there is a substantial difference between the penetration of the fuel in rural and urban areas. In rural areas the penetration is merely 6%, where as in urban areas it is around 48%. According to a study conducted by TERI in 2005, around 76% of the LPG subsidy goes to urban areas with 25% of total population, and that 52% of this urban subsidy is enjoyed by top 27% of households, implying that nearly 40% of the LPG subsidy is enjoyed by the top 6.75% of the population.[78] One of the primary reasons for restricted penetration of LPG is the high upfront cost attached in getting an LPG connection. This is especially for the urban poor.[79]

Similar to subsidies levied on LPG, subsidies on kerosene are also universal in nature. Kerosene was originally subsidized with a view to provide cleaner cooking fuel to the poor, however not even 2% of the households use kerosene as their primary source of cooking. Although, subsidies on kerosene were intended for its usage as cooking fuel, however, a major proportion of subsidised kerosene is used for lighting, which is not an efficient source of lighting and thus it leads to mis-application of subsidies. Another associated concern with the kerosene subsides is that, due to the wide disparity between diesel and kerosene prices, around 26% of kerosene is siphoned off either to the black market or for adulterating diesel. According to National Council of Applied Economic Research (NCAER), the siphoning is around 40% of the total kerosene supplied.[80] Consequently, some of households procure kerosene from the black market at a price more than double the subsidised price.

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[78] Misra N, Chawla R, Srivastava L, Pachauri RK 'Petroleum pricing in India: balancing efficiency and equity' TERI 2005, New Delhi

[79] According to estimates there is an upfront cost of Rs 1525 per connection associated with LPG. Source: 'Supply of clean energy services to urban and peri-urban poor' TERI Study No. 2006ER28

[80] Adulteration of low-sulphur diesel with higher-level sulphur kerosene can cause the fuel to exceed the sulphur maximum. This impacts unfavourably on the quality of ambient air as it affects the engine efficiency of vehicles and increases tailpipe emissions of hydrocarbons, carbon monoxide, oxides of nitrogen and particulate matter. (Source: Misra N, Chawla R, Srivastava L, Pachauri RK 'Petroleum pricing in India: balancing efficiency and equity' TERI 2005, New Delhi)

5.1.3 Environmental and social impact of energy scenario at household level

Following are the examples of the environmental and the social impact of the energy scenario at the household level.

- Majority of households in rural India depend on traditional biomass fuels (wood, animal dung and crop residues, etc.) for meeting their energy needs. This has severe environmental implications. Burning of biomass and deforestation significantly contribute to GHG (green house gas) emissions. It is estimated that 68.3 million tonnes of carbon is released annually due to burning of biomass of which fuel wood alone constitutes 82.3%. Apart from carbon emissions, burning of biomass also creates products of incomplete combustion (PIC). PICs have a significant global warming potential.[81]

- Use of agricultural residues as energy sources instead of fertilizers can lead to the reduction of soil nutrient level and decrease in productivity of land. This can have economic implications for the local communities as they may be forced to buy food, as their needs are not met from the food produced on their own plots because of decreasing productivity of land.[82]

- In India, women and children spend several hours a day collecting energy fuel and it is found that women in fuel wood collection spend around 50 hours every month. There are economic implications linked to this as precious time is used in collecting low quality fuels, which is then used at low efficiency reducing their ability to accumulate financial resources required for improving their livelihoods. Further, it negatively affects children's learning by keeping them away from school.[83] Therefore, this increases the gap between the haves and have-nots.

- In rural areas, about 90% of the household use traditional sources as the primary source for cooking. Firewood accounts for the highest share in the traditional sources. Indoor air pollution caused by burning traditional fuels such as wood, dung and crop residues cause considerable damage to the health of particularly women and children as they work in close proximity in poorly ventilated

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[81] http://www.hedon.info/goto.php/EnvironmentalImplicationsOfTheEnergyLadderInRuralIndia, last accessed on 25t July 2008

[82] http://www.hedon.info/goto.php/EnvironmentalImplicationsOfTheEnergyLadderInRuralIndia, last accessed on 25 July 2008

[83] http://www.unicamp.br/fea/ortega/energy/Reddy.pdf, last accessed on 25 July 2008

kitchens.[84] Studies undertaken indicate that exposure to biomass smoke or indoor air pollution is associated with chronic bronchitis, tuberculosis, cataracts and Acute Respiratory Infections (ARI). Infact, ARI is the largest single disease category in India and the Indian portion of ARI accounts for 2.5% of the global burden of ill health – about 400 000 to 500 000 deaths on a national scale annually. Burning solid fuels also emits carbon monoxide, particulates, benzene and formaldehyde, which can result in pneumonia, asthma, blindness, lung cancer, tuberculosis and low birth weight.

5.2 Measures to improve energy security at household level

The section discusses the measures taken by the government and the households to ensure energy security, that is, access to cleaner fuels at an affordable price to households.

5.2.1 Enhancing energy efficiency

This section discusses the various measures taken to bring energy efficiency in cooking and lighting activities at household level and the impact of such measures.

5.2.1.1 Energy efficiency in cooking

The present cooking arrangements are considered as inefficient especially in rural areas. To bring about energy efficiency in cooking, measures such as encouraging usage of Improved Cooking Stoves (ICS) as against traditional cook stoves and LPG are taken. Also, kerosene is regarded as a better fuel as compared to the traditional fuels. Following are the measures taken to bring efficiency in cooking.

Improved cooking stoves

Traditional cooking stoves use firewood, crop residues and cow dung as fuel. Due to its inherent disadvantages such as low thermal efficiency of just 8%–15%, indoor air pollution caused by it and risk of accidents associated with it, it is regarded as an inefficient means of cooking. A modified version of the traditional cooking stove is the ICS. ICS has improved fuel efficiency of about 25%–30% through efficient burning of fuel and through better heat transfer.

ICS is considered to be more efficient with respect to fuel wood consumption, convenience for cooking and much safer from health point of view.

A nationwide project called National Programme on Improved Chulhas[85] (NPIC) was launched in 1986/87 with the following

[84] http://www.icmr.nic.in/bumay01.pdf, last accessed on 31 July 2008
[85] Chulhas is a term used for cook stoves

objectives.

- Conserving fuel wood, thereby checking deforestation.
- Eliminating smoke from kitchens
- Reducing the drudgery of women and girl children
- Generating employment in rural areas

The programme caters to installation of improved chulhas in rural and semi urban households. It is implemented through multiple agencies.

Out of various models of ICS available, NPIC popularised durable chulhas with a chimney, having a potential life span of at least 5 years. The ICS, though costlier than the traditional cook stoves, is preferred as it lasts longer than the average life of just 2 years of traditional cook stoves. Moreover, harmful smoke emissions are taken out of the house through chimney. Although different models of ICS are priced differently but the costliest model is the two pot hole chulhas with a chimney which can cost about Rs 222 per piece and can last a longer duration whereas traditional cook stoves cost Rs 150 per piece and last two years only.[86]

A target of covering 10 000 villages with about 1.755 million improved chulhas was allocated to state nodal departments and agencies, the KVIC and NGOs, namely, All India Women's Conference (AIWC) and BIOTECH, Thiruvananthapuram. The Panchayats were also actively involved in the implementation of the programme. Some state governments have integrated the NPIC with other popular schemes. For instance in Andhra Pradesh schemes such as Vana Samarakshna Samithi, Scheduled Caste Society and Housing Corporation are integrated with NPIC. In Gujarat, Haryana, Maharashtra and Punjab, improved chulhas are promoted under Indira Awas Yojana and other housing schemes. The Government of Manipur is promoting improved chulhas under UNDP-funded BIOCON Project.[87]

Public distribution systems

In India, to ensure availability and affordability of essential commodities, including kerosene, to the consumers, Public Distribution System (PDS) is operated through a network of outlets or Fair Price Shops (FPSs). The PDS is decentralised and is the joint responsibility of the central and state government. The system aims to provide essential items at subsidized rates to the ration cardholders.

Kerosene oil is also supplied through PDS and sold at the FPS at

[86] http://www.hedon.info/goto.php/ImprovedCookstovesInIndia
[87] http://mnes.nic.in/html_folder/ch3_pg10.htm

subsidized rates. The allocation of subsidized kerosene by the central government varies from state to state based on historical patterns rather than on relative poverty levels. According to declared norms for distribution of kerosene through PDS in Delhi, 12 litres of kerosene is made available to households with 1–5 members, while 22 litres for family with 9 or more members. Also, kerosene through PDS is allocated only to those households, which do not have any LPG connections.

However, the system is beset with lot of problems relating to its transparency in functioning. Due to lack of knowledge about the assigned quota of kerosene of poor people, quota that is not availed by the people is diverted into black markets by retailers for earning extra profits. Moreover, subsides on kerosene and LPG provided by the government are not reaching the intended beneficiaries and are not able to create a desired impact.

Deepam scheme

Government of Andhra Pradesh[88] launched the '*Deepam Scheme*' in July 1999 for distribution of 1 million LPG gas connections to women from Below Poverty Line (BPL) families in rural areas with the following main objectives.

- To provide relief to women from drudgery of cooking with firewood, and
- To improve the health status of the rural women folk.

Refundable security deposit of Rs 1000 per gas connection will be paid by the Government of Andhra Pradesh for each connection towards cylinder and regulator. The beneficiary will have to pay cost towards the gas stove (ISI Mark), ISI tube, identification (Blue) book and administrative charges. The government ensures that the dealers do not sell stoves at exorbitant rates by fixing up the maximum rate for standard stoves as follows.

- Double burner brass top stove Rs 495/- per stove
- Double burner cast iron top stove Rs 468/- per stove
- Single burner brass top stove Rs 280/- per stove
- Single burner cast iron top stove Rs 260/- per stove
- Rubber tube Min Rs 12/- Max Rs 21.50

5.2.1.2 Impact of measures taken to improve energy efficiency in cooking

Impact on cost incurred and energy saving

The following paragraphs discuss the impact of measures taken to improve the energy efficiency in cooking. It includes the impact of measures in terms of cost involved and energy savings.

88??Andhra??Pradesh??is??a??Southern??State??of??India

1. As result of NPIC, up to March 2003, 35 million of ICS have been installed, covering about 29% of the estimated potential of 120 million. These are expected to save more than 10 million of tonnes of fuel wood per annum.[89]

2. Kerosene is made available to a household at subsidised price of Rs 9.05/litre through PDS. However, in case the quantity of kerosene allocated to a household falls short of its requirement, household have to purchase it from black market where it usually sells in the range of Rs20–30 per litre.

3. Penetration of LPG is found to be less in lower and middle-income classes of both rural and urban areas due to high upfront costs associated with usage of LPG. For a new connection of LPG following components are included in the cost for single cylinder connection.
   i. Rs 800/- as deposit for 1 cylinder
   ii. Rs 100/- as deposit for regulator
   iii. Rs 200/- for rubber tube
   iv. Rs 400/- for hot plate – single burner
   v. Rs 25/- for booklet

   Hence, the total cost of a new connection is approximately Rs 1525. The cost of new connection for LPG cylinder has to be paid upfront and households with low monthly income may not be able to afford such high onetime costs. Further, there is no provision by the service providers for paying such costs in instalments.

   However, even after taking into account these upfront costs, in a comparison between LPG and biomass, LPG turns out to be a cheaper option. This is because LPG is a more efficient source of energy vis-à-vis biomass. A sample calculation of amount spent on usage of various fuels is illustrated in Box 5.1.

[89] http://www.reckonindia.com/indiatrade/busiopp/nonconventionalenergy.asp

Box 5.1 Comparison of amount spent on LPG and biomass in a month

Cost of an LPG cylinder under a legal connection	Rs 294
Average number of days one LPG cylinder lasted	22–25 days
Amount spent on LPG usage, per month	Rs 350–400
Cost of biomass purchased from the local dealer	Rs 2/kg
Amount of biomass needed per day if used as primary fuel	6–8 kg
Amount spent on biomass, per month	Rs 360–480
Cost of kerosene purchased from FPS	Rs 9/litre
Cost of kerosene purchased from black market	Rs 25/litre
Quantity of kerosene allocated per ration card	22 litre (>9 members)
Quantity of kerosene needed per month if used as primary fuel	25–30litre
Amount spent on kerosene, per month	Rs 300–420

TERI compilation

Though LPG is a cheaper fuel, usage of biomass is more in households as a consumer can purchase it every day depending on his/her daily wage and does not have to pay for it as a lump sum amount. Besides, there was no upfront cost in using biomass or getting supplies. Hence, it turns out to be a more attractive fuel for very low-income households.

4. The government as well as the Oil Marketing Companies (OMCs) bear the cost of subsidies provided on kerosene and LPG. Moreover, the burden of subsidies is increasing over the years. Total subsidies per cylinder of LPG increased from Rs 130.02 in 2002/03 to Rs 178.66 in 2006/07. Out of the total subsidy of Rs 178.66 per cylinder of LPG in 2006/07, share of OMCs was about Rs 156 and subsidy from government amounted to Rs 22.58 per cylinder. Similarly, subsidies on kerosene have also increased tremendously over the years from about Rs 4.14 per litre in 2002/03 to Rs 15.99 in 2006/07. Also, OMCs bear the major part of the burden of subsidy on Kerosene. Out of Rs 15.99 per litre, share of OMC was Rs 15.17 per litre and subsidy from government amounted to Rs 82 per litre.

Social and environmental impact

The following section discusses the social and environmental impact of measures taken to improve energy efficiency in cooking activities at the household level.

- Usage of cleaner fuels helps in reduction of indoor air pollution caused by burning of traditional fuels. This in turn

can reduce the negative health impacts caused these emissions. For instance, in a study examining the relationship between cooking smoke and biomass usage and prevalence of tuberculosis, says that prevalence of tuberculosis could be reduced by at least 51% if everyone switches to cleaner fuels.

- Replacing biomass for cooking for LPG for cooking leads to saving in terms of productive time spent by women and girl child in fuel wood and biomass collection. The time so saved may be used in other productive activities. This can further lead to improvements of overall economy of the country. Moreover, involvement of women in market related activities could also result in improvement of social status of women in the household as well.

- Usage of LPG as against fuel wood/biomass for cooking purposes results in conserving our natural resources. Usage of LPG will lead to lesser cutting of tress for fuel wood and thereby saving our valuable forest cover.

- Cow dung if not used for cooking could be left at fields, which can add to nutrient content of the soil and improve its fertility.

- Using efficient energy fuels leads to saving in cooking fuels used, which in turn leads to less fatigue and more free time which can further be used productively in other economic activities.

- Employment opportunities can be created with introduction of ICs. Potters, masons and unemployed persons in rural areas can earn a livelihood by fabricating and installing ICS. A large number of trained self-employed workers (SEWs), mainly women, are constructing durable fixed type improved chulhas with chimneys and providing free maintenance service during the first year.[90]

5.2.1.3 Energy efficiency in lighting

The present lighting arrangements is considered as inefficient especially in rural areas. To bring about energy efficiency in lighting, following measures such as usage of energy efficient lighting arrangements like CFLs are considered.

Adoption of energy efficient lighting system such as replacement of incandescent bulbs with compact fluorescent bulbs (CFLs) can lead to reduction in energy load.

[90] http://mnes.nic.in/html_folder/ch3_pg9.htm

CFL is a type of fluorescent lamp that is designed to replace the incandescent lamps. It consumes less energy but provides more light compared to incandescent light.
CFLs offer the following benefits over the incandescent lamps.

- More efficient in terms of energy savings
- More compact and easy to handle
- Do not require frequent replacement, that is, they have longer life
- Lower energy consumption benefits the environment also as there are less emission into the air

Distribution utilities in power sector in some states have taken initiatives to encourage usage of energy efficient lighting system at household levels. Some of the initiatives are described below.

BESCOM Energy Efficient Lighting Programme (BELP): This project was launched in 2004, with technical assistance from United States Agency for International Development. Under BELP, consumers were given the option to purchase CFLs from the market against the utility coupons and repay the cost through utility bills. By this, consumers benefited as the CFL cost were lower due to bulk purchase by the utility and also, the consumers can repay the cost through savings achieved by the use of CFLs. The programme covers 1.6 million domestic consumers, who can replace their conventional lamps with energy-efficient CFLs. According to BESCOM, every light replaced with CFL, can save consumers around Rs 17 per month.

Home Bright – Residential High Efficiency Lighting Programme: On the similar lines as BESCOM, a programme called 'Home Bright Programme' was implemented in Maharashtra in 2003. Home Bright Programme is a Residential High Efficiency Programme to increase the use of CFLs in households. Under the programme, the customer can buy CFLs from the supplier at no up-front cost and will sign an agreement with the utility to pay for CFL over a period of time (about 9 to 12 months). The utility will collect the customer payments for the lamps through the utility bills, and will structure the monthly payments for the lamps to be lower than the customer savings form using the lamps. The utility will then reimburse the manufacturers and suppliers from the funds collected from the customers.

As a result of above measures, about 500 000 and 300 000 CFLs have been sold in Bangalore and Maharashtra respectively and has resulted in energy savings in the state.

5.2.1.4 Impact of energy efficiency measures for lighting

The following section discusses the impact of energy efficiency measures taken for lighting activities. It includes the impact in terms of cost involved for such measures, energy savings, social and environmental aspects.

A survey was conducted by TERI in 2007 to ascertain the usage and ownership pattern of electrical appliance in households in Delhi. According to the survey, when a consumer shifts from using incandescent lamps to CFLs, there is reduced energy consumption due to lower wattage of CFLs. This in turn shall leads to annual monetary savings of about Rs 138 per year/CFL to consumers despite of the high cost of CFLs.[91]

The measures taken at the state level for energy efficiency, result in energy and monetary saving. However, looking at an all India level, there are about 320 million incandescent lamps. Assuming the 25% replacement of theses lamps with CFLs, households in India can save 7884 million units of saving, which will approximately amount to Rs 23 650 million in monetary terms.[92] Thus improving efficiency in energy use leads to efficient utilization of scare resources and, thus, it is important from energy security perspective.

Energy efficiency at the household level can indirectly have a positive impact on the environment. This can be highlighted from the fact that one unit of energy saved at the consumer end is equivalent to savings of two units at the generation end, which implies a saving of approximately 1.3 kg of coal and reduction of approximately 1.10 kg of carbon dioxide (green house gas) emission.[93]

5.2.1.5 Barriers to energy efficiency

While many programmes and policies have been devised to promote energy efficient technologies, there are certain barriers, which prevent households to adopt these technologies. These barriers are discussed below.

- Higher cost of energy efficient appliances acts as a deterrent to the purchase of these appliances by the consumers. Households expect that their equipment first-costs should be low rather than focussing on minimising the costs on the entire lifetime. This kind of first cost bias is more prevalent in case where the purchasing party is not the same as the beneficiary of low energy bills (for example tenants). For

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91??Manisha??Jain,??Vikas??Gaba,??Leena??Srivastava"??Managing??Power??Demand"??TERI???2007

[92] Manisha Jain, Vikas Gaba, Leena Srivastava 'Managing Power Demand' TERI 2007

[93] 'Energy conservation through demand side management: A handbook for domestic consumers', TERI report 2007ER15

instance tenants do not have an incentive to invest in energy efficient devices as they do not own the house and likewise the house owners do not have incentive to invest in these devices, as they do not benefit from low energy bills.[94] Many consumers are unaware of the fact that high upfront cost of the appliances can be recovered in time much less the life of the appliance, thereby resulting in net savings.[95]

- Lack of finance to invest in energy efficient technologies (EETs) especially in the case of poor households, hinders their ability to buy such appliances.[96] Even though the return on investment on such appliances is high, households in many parts of the country are not able to adopt such technologies because of income constraints.

- Lack of information about comparative energy use especially in regard to those appliances, which are bought, by retail consumers. Consumers are ill informed about the new cost-effective technologies available in the market, which therefore prevents the implementation of EETs.

- Consumers perceive risk in investing in EETs, as they are not convinced of the technical soundness of the technology. Again, this prevents them from adopting energy conservation measures and this is a barrier towards the implementation of energy efficiency programmes.

5.2.1.6Linkage of energy efficiency measures with national energy security

Energy efficiency is associated with measures that lead to reduction in amount of energy required for carrying out a particular activity. For instance, usage of improved cooking stoves will lead to lesser fuel consumption for cooking activities as ICS have better fuel efficiency than the traditional cooking stoves. Also, usage of lighting arrangements such as usage of CFLs as against the incandescent bulbs is regarded as energy efficient. Thus, energy efficiency measures aim to reduce the demand for energy fuels which in turn increase the net energy supply. If the increase in net supply capacity through energy efficiency can be done cheaply than with installing new generating capacity, it would lead to lower energy prices. This will also delay investments in both network and generation capacity and in turn delay the negative environmental impacts associated with supply side investment. Since, energy efficiency measures directly impacts the availability of the energy and also

[94] B Sudhakara Reddy, 'overcoming the energy efficiency gap in India's household sector'
[95] Manisha Jain, Vikas Gaba, Leena Srivastava 'Managing Power Demand' TERI 2007
[96] http://www.indiaenergyforum.org/ipf/pres110907/BEE.ppt, last accessed on 30 July 2008

helps in keeping the energy prices in control, it positively impacts the energy security of the country.

5.2.2 Promoting renewable energy sources

Renewable energy has been identified as one of the thrust areas in order to ensure energy security. Using renewable energy sources leads to diversification of energy sources at the household level, particularly for the rural households as they are highly dependent on traditional energy sources for meeting their energy needs. The government is taking various steps to increase the usage of renewable energy sources, particularly in households by encouraging the use of community biogas plants, family size biogas plants, solar cookers, solar lanterns, etc. This section discusses the various measures taken to increase usage of renewable sources of energy in cooking and lighting activities at household level and the impact of such measures.

5.2.2.1 Usage of renewable sources of energy for cooking

Following measures are taken to encourage usage of renewable sources of energy in cooking at household level.

- Use of Biogas in cooking
- Use of solar Cookers for cooking

Biogas

Biogas is a mixture of methane and carbon dioxide. It is produced through the anaerobic fermentation of biomass such as cow dung, human waste and other organic wastes in the absence of oxygen in cylindrical digesters (fixed dome and floating drum). Biogas, thus produced, is taken from the outlet and used for cooking and other purposes. The gas can be burnt in specially designed stoves that produce little carbon monoxide (CO) and no smoke.

Biogas is considered to be a cleaner and efficient mean of cooking as compared to present cooking arrangements.

The National Project on Biogas Development (NPBD) was launched during 1981/82 for the promotion of family type biogas plants with the following objectives.

- To provide clean and convenient fuel for cooking and lighting in rural areas
- To provide enriched organic manure for use in conjunction with chemical fertilizers in agricultural fields
- To improve sanitation and hygiene by linking toilets with biogas plants
- To reduce the drudgery of women

The programme for promoting community and institutional biogas plants (CBP/IBP) was started in 1982/83 with the objective of setting up large-sized biogas plants in villages and

at institutions having assured and regular availability of large quantities of cattle waste and thereby benefit the weaker sections of society. It was supplemented by the scheme for setting up large-sized plants linked with community toilet complexes in 1993/94 in order to recycle human waste for improving sanitation.

The project is implemented through State Nodal Departments and Agencies, Khadi and Village Industries Commission (KVIC), national level Non-Governmental Organisations (NGOs) and National Dairy Development Board (NDDB). In turn, State Governments and KVIC involve a large number of grass roots level NGOs and trained village technicians in the construction and maintenance of biogas plants. Presently, 10 Biogas Development and Training Centres (BDTC) are running for training and publicity purposes. These centres are in Assam, Himachal Pradesh, Karnataka, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Uttarakhand. Central financial assistance is provided to these Centres for staff and training courses. BDTCs focus on the training of masons and entrepreneurs to improve quality of construction of biogas plants and to follow standard specifications and approved construction techniques.

Impact of NPBD

The following discusses the impact of NPBD on the energy savings of the household and the associated social and environmental impacts.

- As of 2006/07, over 3.89 million biogas plants have been supported under NPBD and the target for 2007/08 was set up to the limit of 102 000 plants.

- Adding 102 000 family type biogas plants in 2007/08 would result in an estimated saving of about 140 000 tonnes of fuel wood and production of about 1.4 million tonnes of organic manure

- The payback period of a biogas plant is now estimated at around two years, assuming its useful life as 10 years.

- Biogas plants are expected to reduce drudgery of women involved in collecting fuel wood apart from long distances and minimising health hazards on account of lesser kitchen smoke.

- Further, it is estimated that the construction of 102 000 biogas plants during the year will generate about 3.24 million person-days of employment for skilled and unskilled workers in rural areas.

- Use of biogas can improve the agricultural productivity also. The digester slurry so produced in the biogas system is rich in nutrient content, which is useful for the soil.

- It is believed that large-scale introduction of biogas in the country can bring about significant reductions in emissions associated with the combustion of biofuels, such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), total suspended particles (TSPs), and poly-aromatic hydrocarbons (PAHs) and thus regarded as efficient in respect of environment as well.

- Biogas is regarded as a cleaner fuel for cooking. It can reduce the likelihood of chronic diseases that are associated with indoor combustion of biomass-based fuels, such as respiratory infections, ailments of the lungs, bronchitis, asthma, lung cancer, and increased severity of coronary artery disease. At present, approximately half a million premature deaths and nearly 500 million cases of illness are estimated to occur annually as a result of exposure to smoke emissions from biomass use by households in India. Young children (under five years of age) and women are affected disproportionately.[97]

Solar cookers

A solar cooker is the simplest technology to cook food without the usage of any conventional fuels. They work on the basic principle of sunlight being converted to heat energy that is retained for cooking.

Ministry of New and Renewable Energy Sources (MNRE) has been promoting the usage of solar cookers by providing financial support. Following incentives are provided by MNRE for promotion of solar cooking.

- Payment of Rs 100 and Rs 200 to State Nodal Agencies (SNAs) for sale of each Non ISI box solar cookers and ISI box solar cookers respectively.
- Support of Rs 150 000 are provided for promotional activities such as publicity, solar cooking demonstrations and competitions, seminars, workshops, evaluation studies, development of improved models, etc., undertaken by various NGOs, institutions, regional test centres and SNAs.
- Reimbursement of the fees paid by manufacturers of solar cookers for obtaining approval from Bureau of Indian standards (BIS).

[97] Neha Misra, Ruchika Chawla, Leena Srivastava, R K Pachauri *'Petroleum Pricing in India, Balancing Efficiency and Equity' TERI 2005*

- 30% of total cost of dish solar cookers (up to maximum of Rs 1500) is paid to its users and Rs 250 is paid as service charge to SNAs.
- 30% of eligible capital cost of community solar cookers for indoor cooking (up to maximum of Rs 15 000) is paid to its users and Rs 2500 are paid as service charge to SNAs.

There are about 30 manufacturers of box solar cookers and 15 of concentrating type solar cookers with combined capacity of over 75 000 cookers per annum. A total of around 530 000 box solar cookers, 500 parabolic dish solar cookers, 60 community cookers for indoor cooking and 6 solar steam cooking systems have been sold/installed in India. The estimated potential demand for solar cookers in India is about 1 million.
The world's largest solar steam cooking system-capable of preparing meals for about 15 000 people per day was installed at a temple in Tirupathi, Andhra Pradesh and is functioning satisfactorily since October 2002.

Impact of promoting solar cookers

Table 5.1 indicates the estimated cost and fuel savings from usage of solar cookers in households.

Table 5.1 Features of different solar cookers

Model of Solar Cooker	Usage	Fuel saving	Cost (Rs)	Life (years)	Payback period (years)
Box Type Solar Cooker	4–5 people		1500–2500	15–20	3–4
Dish Solar Cooker	15 People	10 LPG cylinders/year	4500-5500	20	1.5–3
Community Solar Cooker for indoor cooking	40–50 People	35–40 LPG Cylinder/year	45 000–55 000	20	4–5

Source MNRE

Solar cooking has associated social and environmental benefits. Cooking using solar cookers do not result in any smoke emissions or deposition of soot in cooking utensils and thus utensils do not require much scrubbing. Nutrients of the food are highly retained due to slow cooking, which have positive impact on the health of the family. Although solar cooking could take twice as much time as traditional cooking but the time is offset by the freedom from the need to foray for fuel wood and attention to cooking that is required just once every hour to track the path of sunrays.

5.2.2.2 Usage of renewable sources of energy for lighting

Usage of solar lanterns is encouraged to promote usage of

renewable sources of energy in lighting at household level.

Solar lanterns

Solar lantern is a portable emergency light powered by sun energy. There is a solar panel of 10W, which has to be kept in the sun and through the cable plugged into the lantern. When the sun falls on the solar module, current is produced and it then charges the battery in the solar lantern.

The Ministry of Non Conventional Energy Sources implemented a country wide solar photovoltaic (PV) programme. The Programme aimed at developing cost effective PV technology and its applications for large-scale diffusion in different sectors, especially in rural and remote areas. As part of this programme usage of solar lantern was also promoted by providing financial support in the form of subsidies to its users.

The solar lantern promoted by MNRE would give adequate illumination for 4 hours everyday. The lantern consists of 7W component fluorescent light, giving a brightness of 350 lumens, which is sufficient for reading and writing in a room size of 100 sq. ft. The life of the solar panel is about 20–25 years, the battery is 3 years and the bulb is for 5 years. A subsidy of Rs 1300 per lantern was provided by MNRE on the price of solar lantern of Rs 4000 each. This makes solar lantern an affordable product.

Apart from MNRE providing subsidies for promotion of solar lanterns, some states also provided additional subsidies in this regard. For instance, The Energy Conservation Mission (ECM) of Andhra Pradesh State Centre, as part of its 'Grameena nitya deepotsavam' programme distributed solar lanterns at highly subsidised rates to 250 beneficiaries in 20 remote hamlets, which have no electricity supply. A three-watt lantern was given at Rs 250 (16% of the total cost) as against the cost price of Rs 1500.[98]

In 2003, the subsidy by MNRE for solar lanterns was completely removed with the understanding that the product is capable of being sold in open market without subsidies. However, to develop a market for solar lanterns after subsidies were removed, the manufacturers of solar lantern adopted the following innovative schemes.

1. Provision of solar lantern through a salary deduction scheme; for instance in case of Andhra Pradesh State Road Transport Corporation (APSRTC), its employees are

[98] http://www.hindu.com/2006/10/06/stories/2006100610400500.htm

provided with solar lantern through salary deduction scheme. The lanterns cost from Rs 2000 to 3500 but are made available on equal monthly payments over a period of one or two years and thus it become affordable. The employer repays the cost to the manufacturer of solar lanterns who in turn provides proper service during and after the loan period as part of the contract.

2. Scheme of providing gifts along with the lanterns: Utility items such as cameras and watches were offered as supplementary gifts. Usually, these gift items are available to the manufacturer at a relatively low price, but are expensive to the consumer, thereby giving him the feeling of having received good value for his money along with an additional benefit.

Impact of usage of solar lanterns in households

Solar lanterns were used among rural population as an improved source of lighting whereas in case of urban areas it is used as an emergency light in the event of power outages. About 4 441 481 lanterns were sold up to 31March 2003 under subsidy schemes. In addition, few thousand lanterns were sold in open market.

Replacing kerosene lamps with solar lanterns leads to large amount of savings and it is seen that when a household (or an enterprise) replaces kerosene based lighting device with a solar lantern, it avoids the usage of about 50–60 litres of kerosene annually. Thus, a solar lantern in its useful life of 10 years saves about 500–600 litres of kerosene, thereby mitigating about 1.5 tonne CO_2 emissions.[99]

Solar lanterns give better output than kerosene and hurricane lamps. The portability feature of the solar lantern also makes it ideal to serve both as indoor and outdoor lighting facility. There are no fumes from solar lanterns. This reduces the risk of respiratory damage from inhaling kerosene fumes. This is an ideal solution for villages and small towns, which are either untouched or semi-connected by the power grid.[100]

Box 5.2 Lighting a Billion Lives (LaBL)

Lighting a Billion Lives

In order to provide adequate lighting facilities to the rural population, The Energy and Resources Institute (TERI) has undertaken an initiative of Lighting a Billion Lives (LaBL), through the use of solar lighting devices. This campaign aims to bring light into the lives of one billion rural people by replacing kerosene and

[99] http://www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0080.pdf

[100] http://tata.com/tata_bp_solar/articles/20030617_sunny_days_ahead.htm

paraffin lanterns with solar lighting devices.

This will facilitate education of children; provide better illumination and kerosene-smoke-free indoor environment for women to do household chores; and provide opportunities for livelihoods both at the individual level and at village level. In addition, LaBL is expected to have a positive impact on the environment through carbon benefits. Each solar lantern from the campaign is expected to save 40–60 litres of kerosene per year thus mitigating 145 kg of carbon monoxide emissions per year. In terms of physical targets, it translates into 200 000 000 solar lanterns in use, assuming that each solar lantern benefits five members of a family.

Source TERI, details available at http://labl.teriin.org/

5.2.2.3 Barriers to promote renewable energy at household level

- Renewable energy technologies are capital intensive and households especially those from lower income groups do not have adequate financial resources to adopt RETs. For example, a biogas plant is capital intensive and may go beyond the reach of a number of households.[101]

- Lack of knowledge about RETs prevents households from switching to renewables. Rural population is largely unaware of the costs and benefits, maintenance, etc., of RETs that acts as a major barrier towards the dissemination of renewable energy.

- Lack of skilled professionals to build and repair RETS also acts as barrier towards adoption of RETS.

- Consumers may perceive risk in investing in renewable energy sources, as they may not be convinced of its technical soundness. A probable reason for this could be non-familiarity with RETs in a particular region. Prejudices may also be prevalent reinforced through past experience with RE systems that have not been installed properly or maintained properly.

- There are certain barriers that are inherent to some renewable energy technologies, for example, in case of solar cookers it may not be possible to cook after daylight in dark hours or cloudy days. Also, it is not possible to cook all types of dishes in a solar cooker.

5.2.2.4 Linkage of renewable energy sources with national energy security

Use of renewable sources of energy becomes important in the scenario of depleting energy sources. Increased usage of biogas plants or solar cooker for cooking and solar lantern for lighting

[101] http://eprint.iitd.ac.in/dspace/bitstream/2074/469/1/quabar95.pdf, accessed on 2 August 2008

purposes leads to better utilisation of renewable sources of energy. This in turn reduces the demand for other scarce energy resources, which can then be more judiciously used. By such optimum usage of energy resources, energy security of the nation is improved.

5.2.3 Other measures

There are certain other measures to ensure energy security at the household level. Such measures and their impact are discussed below.

5.2.3.1 Measures taken by household to ensure energy security

Besides the measures taken by the various government agencies to ensure access of cleaner fuels to households at affordable rates, that is, to ensure energy security at household levels, certain measures are taken by households themselves to ensure availability of energy for its lighting and cooking needs. Some of these measures are discussed in this section.

With regard to energy for lighting purposes, electricity is the preferred options due to its distinct advantage of being a cleaner fuel. However, the use of electricity for lighting purposes depends on its cost and availability. Although the tariffs paid by households for electricity are subsidized, they are still considered as unaffordable by a large section of the society. In response to this, hooking of electricity has become a prevalent practice in the households. Either people in the household hook electricity from wires on their own or they pay contractors to do so. According to a survey done by TERI in slums of Delhi, the contractor in these slums charge about Rs 1000–15 000 as upfront cost and Rs 100/month.

Although around 56% of households are electrified, the supply of electricity is not for long hours. Therefore, households used mostly candles and kerosene lamps as supplement to electricity. However, the light provided by a kerosene lamp is neither sufficient nor efficient. The light provided by kerosene lamps barely allows children to read after dark. Moreover, usage of these lamps create indoor air pollution, which is harmful.[102] Due to associated disadvantages with usage of kerosene lamps, the household at times are left with no other options than just to restrict the time of lighting, which again has social cost, attached to it.

5.2.3.2 Measures on use of Information Technology/Modern Technologies

The Ministry of New and Renewable Energy, which is the nodal agency for formulating policies and implementing programmes with respect renewable energy has taken various initiatives to

[102] http://energisticsystems.webkit.com/kerosene.html

promote the use of IT. These initiatives help in the speedy implementation of programmes and enable effective monitoring of programmes funded by the ministry. For the utilization of Information Technology (IT) and establishment of technology information system in the area of renewable energy, MNRE set up the 'Technology Information Forecasting, Assessment and Data Bank (TIFAD)' Division in May 1998. The activities were revitalized during the Ninth Plan in order to meet new challenges of globalisation through IT, implement the concept of electronic governance and to improve their effectiveness. MNRE became the first among central government ministries/departments, which initiated large-scale utilization of IT. 100% computerisation has been achieved by the MNRE at its headquarters, its regional offices and the solar energy centre.

Further the ministry is also in the process of implementing Renewable Energy Network (RENET) in the country, which is a wide area computer-communications network/intranet in the country connecting states, districts, blocks and major projects. The ministry is implementing 'RENET and creation of Renewable Energy Database' through CMC, New Delhi. Software has been developed for RENET and is being tested. Through this project 'Renewable Energy Electronic Processing System (REEPS)', has been developed for integrating an on-line receipt of project proposals from agencies/organizations through RENET and processing electronically by various wings of MNRE in an integrated manner using LAN of MNRE such that the projects are approved electronically and only cheques are sent physically.[103]

5.2.3.3 Measures on awareness/behavioural changes

Various measures have been taken by the government to create awareness among the general public regarding the efficient use of appliances, energy conservation, renewable energy. etc. These measures are summarized below.

Awareness on energy efficiency

The Ministry of Power and Bureau of Energy Efficiency launched the National Awareness Campaign in order to promote energy conservation in the country. The campaign includes initiatives that address the use of energy in industrial, agricultural sectors, as well as households and educational institutions. The objective of the campaign is to reduce energy cost by reducing demand for electricity, as well as increasing efficiency of electricity generation. The campaign focuses on the creation of consumer awareness and understating of the necessity and significance of the energy conservation. The campaign urges all energy consumers to be part of the energy

[103] http://mnes.nic.in/, last accessed on 1 August 2008

conservation efforts by optimizing the use of energy and making a habit of energy saving. The campaign also involves distinguished personalities and reputed organizations as role models.[104]

BEE has launched the National Energy Labelling Programme, initially for Frost Free (no frost) refrigerators and tubular fluorescent lamps. This programme will be gradually extended to other appliances in a phased manner. Awareness programmes are also organized during the course of the campaign to help the domestic consumers understand their star rating and thus help them realize the importance of energy savings. The awareness to consumers is communicated through print and electronic media.

PCRA is entrusted with the responsibility of creating awareness amongst the masses about the importance, methods and benefits of conserving petroleum products and emission reduction. The message is spread through print media and electronic media for mass communication. National and state level printed literature is available for specific target groups and publicity is also done through hoardings, bus panels, kiosks, and banner transliders. The focus of all the messages is easy to implement and practical conservation tips for the industrial, transport, agriculture and domestic sectors.

For effective communication to the target groups in semi-urban and rural areas, messages are made in regional languages. Field interactive programmes like seminars, technical meets, consumer meets, workshops, clinics, van-publicity, exhibitions, kisan melas are conducted for dissemination of conservation messages and demonstration of conservation techniques. To give impetus to the oil conservation movement, PCRA utilizes various platforms like the World Environment Day, World Energy Day, various festivals, etc., to bring out press advertisements. A quarterly journal called *Active Conservation Techniques* (ACT) is published by PCRA, which highlights the successful case studies related to petroleum conservation.

PCRA has also developed literature containing simple ready to implement conservation tips and techniques to benefit the relevant target groups. Special low cost green leaflets have also been developed to educate the masses on the ill effects of pollution caused due to incomplete combustion and its impact on health.[105]

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[104] http://www.bee-india.nic.in/NCEC2007/EnergisingIndia2007.pdf, accessed on 30th July 2008.
[105] http://www.pcra.org/English/education/default.htm, accessed on 29th July 2008

Awareness on Renewable Energy Sources

The Ministry of New and Renewable Energy is taking measures to create awareness among the masses about the benefits of renewable energy sources. In this regard, it is implementing a programme on information and public awareness using electronic, print and postal media, exhibitions and outdoor media like hoardings/kiosks/bus back panels, song and drama, etc., through DAVP, Doordarshan, All India Radio, Song and Drama Division, State Nodal Agencies, etc. The following are the main objectives of the programme.[106]

- To popularise and create awareness about new and renewable energy system and devices highlighting their benefits.
- To create mass awareness about technological developments and promotional activities taking place in Non-Conventional Energy Sector from time to time in the country especially with focus on rural areas.
- To make people aware about the availability of new and renewable sources of energy (NRSE) systems and devices, their proper use, repair and maintenance facilities, etc.
- To expand and promote the market for NRSE systems and devices.
- To raise awareness about NRSE amongst students, teachers, scientists and public at large

5.2.3.4 Impact of other measures

The measures described above have a far-reaching and long-term impact on the Indian household. However, it would be difficult to quantify their impact. Measures such as improvement in information technologies or creating awareness among households will inculcate lifestyle changes among the household and would motivate household to voluntarily adopt the energy efficiency or renewable energy sources. This shall surely help in improving the energy security of the households.

Conclusion

There is substantial rural urban divide among Indian households in terms of consumption of energy fuels. Households in urban areas consume more of cleaner energy fuels such as electricity and LPG, whereas rural household have a high dependence on traditional sources of energy. For instance, 88% urban households have access to electricity as against the 44% for the rural households. Also, about 48% of urban households consume LPG for cooking needs, whereas penetration of LPG among the rural households is very negligible. Due to consumption of more of commercial fuels that

[106] http://mnes.nic.in/adm-approvals/information_Public-2008-09.pdf, accessed on 31 July 2008

have market value attached to them, expenditure incurred by urban households on the energy fuels is far greater than the rural households. Moreover, the expenditure on energy fuels forms a larger proportion of the total expenditure of the household, which are in the lower expenditure class as compared to the households in the higher expenditure classes. Share of expenditure on energy fuels out of the total expenditure have almost doubled over a span of 32 years, both for rural and urban households. With rising energy prices and lack of access of energy fuels, the energy security at the household level seems bleak.

In realisation to the threats to energy security at the household level, measures are taken to improve the energy efficiency and increase usage of renewable energy sources at the household level. For cooking purposes, usage of improved chulhas, kerosene and LPG are promoted to bring energy efficiency and usage of renewable energy sources in form of biogas and solar cooking are promoted. For lighting purposes, CFLs are regarded as energy efficient form of lighting and usage of solar lanterns indicates increased usage of renewable sources of energy. There are policy level initiatives to promote such changes. Employment of such appliance and techniques are expected to bring the energy and monetary savings at the household level.

Chapter 6 Conclusions and Suggestions for the Next Phase of the Study

This study focussed on study energy security concerns specific to India and analysed the threats to energy security, measures taken to improve energy security and impact of these measures on energy security. This analysis has been carried out at both the national and household levels.

In the Indian context, energy security is defined as supply of lifeline energy to all our citizens irrespective of their ability to pay for it as well as meet their effective demand for safe and convenient energy to satisfy their various needs at competitive prices, at all times and with a prescribed confidence level considering shocks and disruptions that can be reasonably expected.

This chapter discusses the broad conclusions from the previous chapters. It also discusses further scope of work, which could be taken up by Global Network on Energy for Sustainable Development (GNESD) and discusses recommendations for policy making in India so as to contribute to preparation of effective policies that enhance energy security at national and household level.

6.1 Energy security at the national level

Considering the above definition of energy security and the energy scenario in India, it is observed that the country has still a long way to go to achieve its energy security. Physical threat to energy security relates to availability of energy sources. There are rising concerns over the depleting reserves for the energy resources, increasing gap between the demand for energy resources in the country and its domestic availability and the rising import dependency for meeting the energy needs in the country. For instance, although coal is regarded as a mainstay of the Indian energy sector, its reserves in India are depleting and are expected to last for just 45 years. Depleting coal reserves, leads to lesser production of coal, which in turn increases the demand supply gap of coal. About 9% of demand for coal is unmet by its supply in the country, which has led to imports of coal to reach about 38 MT in 2006/07 for India. Looking at the case of oil in the country, oil reserves are expected to last for 23 years. However, with the rising demand for crude oil, the import dependency of the country for meeting its crude oil requirement has reached to as high as 71% in 2006/07 and it is expected to

reach to 93% by 2031. Rising demand supply gap for energy resources and the subsequent import dependency have financial implications attached to it. Imports of the energy resources form a major component of the total imports of India. This puts the fiscal strain on the Indian economy, as these imports have to be financed from the export revenues of the country. Moreover, import of the energy resources leads to outflow of the scare foreign exchange in the country. Crude oil and coal imports together accounts for about 49% of the export revenues earned by the country and about 10% of the total income generated within the country.

Having realised the threats to the energy security at the national level, certain measures have been taken to improve the same. Ensuring energy security at national level requires both supply and demand side measures. Supply side measures include adoption of efficient and environment friendly technologies, improvement in generation parameters, diversifying fuel mix, increased use of renewable energy sources, etc. On the demand side, measures include increased penetration of energy efficient appliances, promoting energy conservation, energy efficiency and others.

There are policy level measures to promote energy efficiency. Electricity Act 2003, Energy Conservation Act 2001 and National Electricity Policy have provisions for promotion of energy conservation and energy efficiency in the electricity sector. Petroleum Conservation Research Association promotes strategies for promoting energy efficiency in sectors such as transport, domestic, industrial, agricultural and commercial. Implementation of energy efficiency measures are not expected to alter the energy mix of the country per se but it results in decrease in quantum of energy demanded in the country. Energy so saved through these measures has favourable financial impact. For instance, as mentioned in Chapter 4, audit of governmental building revealed that they have a potential to save 17.5 million kWh, which amounts to about Rs 4.4 million to the government. Measures taken by PCRA have resulted in saving of about 2700 thousand tonnes of fuel and about Rs 20.66 billion to the country.

In wake of depleting fossil fuels resources, use of renewable energy sources such as solar, wind, biomass, small hydro, etc., are emerging as alternative sources of energy. Government is promoting renewable energy resources through MNRE. Public sector enterprise, Indian Renewable Energy Development Agency Limited (IREDA) is promoting renewable energy technologies in the country. With such measures, share of renewable energy sources in the total electricity mix of the country has reached to about 8%. Increased usage of renewable

energy sources has favourable impact on the environment.

Apart from the above stated measures, measures such as diversification of energy mix, diversification of energy supplier, acquisition of equity in energy sector abroad, improving oil recovery or building strategic oil reserves contributes positively towards achievement of the energy security of the nation.

6.2 Energy security at the household level

There is substantial rural urban divide among Indian households in terms of consumption of energy fuels. Households in urban areas consume more of cleaner energy fuels such as electricity and LPG, whereas rural household have a high dependence on traditional sources of energy. For instance, 88% urban households have access to electricity as against 44% for the rural households. Also, about 48% of urban households consume LPG for cooking needs, whereas penetration of LPG among the rural households is negligible. Due to increased consumption of commercial fuels, expenditure incurred by urban households on the energy fuels is far greater than the rural households. Per capita monthly expenditure on energy fuels in urban household is Rs 105 as compared to Rs 57 for their counterparts in rural areas. The households in the lower MPCE classes have a larger share of expenditure on energy fuels as compared to the higher classes. For instance, in urban areas, the lowest MPCE classes spend about 13% of total expenditure on energy fuels as compared to 7% spent by the households in higher MPCE classes. Also, increase in consumption of energy fuels and rising energy prices have resulted in increase of total expenditure incurred on energy fuels, both for rural and urban households. Share of expenditure on energy fuels out of the total expenditure has almost doubled over a span of 32 years, both for rural and urban households. With rising energy prices and lack of access of energy fuels, the energy security at the household level seems bleak.

Certain measures have been taken at household level to improve energy security. To bring about energy efficiency in cooking activities, use of improved cookstoves, having higher efficiency, was promoted through NPIC. The programmes cater to installation of improved cookstoves in rural and semi urban households. As a result of the programme, about 35 million of improved cookstoves were installed by 2003, which were estimated to save 10 million tones of fuel wood per annum. Also, the government is promoting usage of kerosene and LPG through various programmes. Government incurs large amount of cost in the form of subsidies to make cleaner fuels like kerosene and LPG affordable to the households. Subsidy amounting to Rs 178 per cylinder of LPG and about Rs 16 per

litre of kerosene is provided by government to OMCs. For the purpose of promoting energy efficiency in meeting the lighting needs of the households, usage of compact fluorescent bulbs (CFLs) in place of incandescent bulbs is promoted. State level power utilities have also initiated programmes to promote usage of CFLs by making them affordable for the households. As a result programmes undertaken by power utilities in Bangalore and Maharashtra, approx 500 000 and 300 000 CFLs have been sold in respective cities/states. Employment of improved and energy efficient energy resources lead to energy and monetary savings at the household level. As mentioned in Chapter 5, at the all India level, there are about 320 million incandescent lamps. Assuming 25% replacement of theses lamps with CFLs, households in India can save 7884 million units of saving, which will approximately amount to Rs 23 650 million in monetary terms. Thus, improving efficiency in energy use leads to efficient utilization of scare resources and thus it is important from energy security perspective.

Another measure to improve energy security at the household level is the usage of renewable sources of energy for meeting the cooking and lighting needs of the households. For cooking needs, use of biogas and solar cookers is being promoted as they are regarded as cleaner and better fuels. National Project on Biogas Development was launched to promote family type biogas plants. Over 3.89 million of biogas plants have been supported till 2006/07 under the project. It is reported that adding another 102 000 of plant in subsequent year would result in estimated saving of about 400 000 tonnes of fuel wood and production of about 1.4 million tonnes of organic manure. Also, solar cookers are regarded as an efficient way of cooking since it does not involve use of any conventional fuels. MNRE has been promoting solar cookers by providing relevant financial support to the households. A dish type solar cooker and community based solar cooker leads to saving of about 10 and 35 LPG cylinders per year, respectively. These solar cookers last for about 20 years and their cost are recovered in just about 1.5 years for dish based solar cooker and about 4.5 years in case of community based solar cooker. Solar cooking has associated social and environmental benefits. MNRE is also promoting usage of solar lantern for meeting the lighting needs of the households by providing the financial support to the households. Each solar lantern promoted by MNRE is designed to operate for four hours every day for 300 days in a year and is able to save 1200 hours of a kerosene lamp. Apart from these measures certain measures are taken by the household themselves to procure energy for usage. Such measures may include hooking of electricity or usage of candles or kerosene lamps in place of electricity. All these measures have far-reaching and long-term impact on the Indian households.

6.3 Linkage between household sector energy policies/strategies and national energy security

Since household sector is the largest energy consuming sector in India, securing energy at the household level becomes an integral part of the overall energy security.

Energy efficiency measures aims to reduce the energy demand. For instance, with use of improved cooking stoves, lesser energy is consumed for cooking activities as ICS have better fuel efficiency than the traditional cooking stoves. Also, usage of lighting arrangements such as usage of CFLs as against the incandescent bulbs is regarded as energy efficient. Energy efficiency measures by reducing the demand for energy fuels, increases the net energy supply. If the increase in net supply capacity through energy efficiency is cheaper than installing new generating capacity, it leads to lower energy prices. This also delays investments in both network and generation capacity and in turn delays the negative environmental impacts associated with supply side investment. A unit of energy saved by a user is greater than a unit produced as it saves on production, transport, and transmission and distribution losses. Thus a 'Negawatt' (a negative megawatt) produced by reducing energy need saves more than a megawatt generated. Since, energy efficiency measures directly impact the availability of the energy and also help in keeping the energy prices in control; it positively impacts the energy security of the country.

Also, with the usage of renewable sources of energy such as biogas plants or solar cooker for cooking and solar lantern for lighting purposes leads to better utilisation of renewable sources of energy. This in turn reduces the demand for other scarce energy resources, which can then be more judiciously used. By such optimum usage of energy resources, energy security of the nation is improved. Also, use of renewable energy sources has a favourable impact on the environment and the health of the household people using such measures.

6.4 Limitations and further scope of study

One of the major limitations while undertaking the study was the non-availability of the required data at the household level. Non-availability of the data at the household level prevented the deeper analysis of the energy scenario at the household level. In particular the following data was not available.

- Income wise data at household level: India has data

based on the monthly expenditure pattern of the household. However, no data is available based on the income classes of the household. Thus, it becomes difficult to analyse the energy scenario in respect of poor or rich households.

- Data on impact of measures: There is lack of information regarding the actual impact of measures taken at the household level to energy security. Although there have been some analysis and data made available for the measures taken to promote renewable energy sources at the household level, there is serious lack of impact of energy efficiency measures taken at the household level. This makes it difficult to analyse the effectiveness of the measures taken.

Having completed a detailed study of the energy security at the national and household level, it is realised that theoretically there is lot of scope for bringing energy efficiency at the household level. However, the impact of the energy efficiency measures taken so far have not really been quantified or studied in detail. This can be a future area of work for GNESD. A detailed study can be conducted with the objective to measure the actual impact of energy efficiency at the household level. To analyse this, a case study based approach may be followed. A typical household area in both the urban and rural sector may be selected to analyse if there is any change in the energy consumption pattern before the usage of energy efficient appliance/measures and after it.

The study shall include the following.

- A primary survey to study the present usage pattern of energy appliance in the selected households.
- Based on the above survey, concerted measures should be devised to persuade the selected household area to move from energy inefficient appliance towards the efficient ones. Such measures should be strong enough to bring about the expected change in the energy consumption. It may include awareness campaigns, distribution of energy efficient appliance, etc. This may also require involvement of the respective utility in that area.
- After the introduction of energy efficient appliances at the household level through above measures, a primary survey shall be conducted to analyse the impact of such measures on the household energy consumption pattern, savings in terms of energy and monetary both and other related impact.

6.5 Recommendations

The study recommends the following for the policy makers in India, enabling them to prepare effective policies aiming at improving energy security at national and household level.

- Integrated approach to energy sector: The energy resources available in the country sector are closely linked to each other. For instance, energy resource such as coal is mainstay of the Indian electricity sector. Thus, the coal and electricity sector are closely linked to each other, where electricity sector is the major consumer of coal and coal is main fuel used in the electricity sector. Due to close linkage between the two sectors, any policy change in one sector will directly impact the other sector. Keeping this in consideration, it is recommended that the integrated approach to the energy sector, as a whole needs to be devised such that it aims at the overall improvement of the sector.

- Increase penetration of renewable sources of energy at household level: The energy scenario at the household level indicates the high dependence on traditional energy fuels. This indicates the large potential for penetration of renewable energy sources at the household level, both for rural and urban households. Moreover, the measures taken to increase the usage of renewable energy sources at the household level are well received by the targeted segment. However, there are certain barriers faced by households to move towards renewable sources of energy. These barriers relate to the financial cost involved while shifting from conventional to renewable sources of energy to renewable sources and the lack of knowledge or awareness about the renewable technologies available. Thus, it is necessary to address the barriers faced at the household level for the increase in penetration of renewable sources of energy. In the wake of depleting fossil fuels in the country, it is necessary to maximise the use of renewable sources.

- Targeted subsidies: The government faces huge financial burden while providing subsidies to promote the cleaner and efficient fuels at the household level. It is necessary that the subsidies provided by the government for improving energy efficiency at the household level, should be targeted at the appropriate sector of the country. Since the provision of subsidies by the government leads to immense financial burden on the economy of the country, it is necessary that the subsidies should reach and benefit the targeted beneficiaries.