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Energy Consumption Pattern for Indian Households

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ABSTRACT

Supporting the lifestyles of households requires goods and services, which are interrelated with energy consumption. Analysis of energy consumption and income of rural and urban household types may provide insight into more sustainable consumption patterns. In this paper we evaluate the relationship between Indian household expenditures and energy consumption we combined input-output analysis with household expenditure data. Additionally, we used the concept of elasticity to determine the relationship between expenditures and income.

The total average energy requirement monthly per capita in the India in 1993-94 was 3 GJ, of which 53% was indirect. Of this total, 15% was required for food, 17% for durable product, 13% for the miscellaneous products and services,7% for clothing and footwear, 1% for pan, tobacco and intoxicants 47% for fuel and light(including petrol, space heating, electricity, and heating energy), Among the analyzed socio-economic variables, the net income was found to have the most important relationship with the total energy requirement. The elasticity of the energy requirement with respect to income was found to be 0.75 and the elasticity of the energy requirement with respect to expenditure was found to be 0.85 in fact households with a higher net income spend a smaller part of their net income than households with a lower net income . Further spread for the major energy consumption categories durable goods, miscellaneous services which includes recreation than basic requirements ie clothing, footwear and food.

The luxuries of life are larger than the spread for the other categories which contain the more basic needs of life.

Keywords: elasticity, expenditures, households, income, .recreation,

I.INTRODUCTION

The use of fossil energy sources is one of the main causes of pollution in the atmosphere. And the main source of pollution is carbon dioxide. There are many ways to reduce consumption of fossil energy but one of the best ways to reduce primary energy to reduce household energy requirements by influencing the consumption pattern. A household uses not only direct energy in the form of natural gas, electricity and petrol but also indirect energy embodied in consumer goods such as food, furniture and services. The fuel and electricity used by householders in their residences and in their cars, here called direct energy.

Changing consumer behavior is one of the approaches to reducing overall energy consumption in household. Commonly prescribed measures to this end include running dishwashers and washing machines only when they are fully loaded, avoiding rinsing dishes before putting them into the dishwasher, taking showers instead of baths, lowering indoor temperatures at night, turning off lights when leaving a room, pulling down blinds at

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night, using a kettle to boil water, and avoiding use of the car for short distances[1] (STEM 2003; KOV 2003). The limitation of such advice is that it focuses on just part of the household's total energy use, during the past decades it has become increasingly obvious that indirect energy use, the energy needed to produce the goods and services used in industries, in the transport sector, and in retail as a result of consumer demand, is equally important. To give a few examples, Herendeen (1978)[2]found that indirect energy in Norway accounted for approximately 1/3 of the total energy for a poor family and approximately 2/3 for a rich family. Vringer and Blok (1995)[3] found that of the total average energy demand for a Dutch household, 54% was indirect, and Lenzen (1998)[4] found that for an Australian household, 30% was indirect. Weber and Perrels (2000)[5]found that less than half was indirect when households in France, West Germany, and the Netherlands were analyzed. Reinders and colleagues (2003) matched Dutch energy intensities for goods and services with national household expenditure data from 11 European Union (EU) countries and found that total energy requirements per average household ranged from 180 gigajoules (GJ) Portugal) to 508 GJ (Luxembourg),1 of which 36–66% was indirect. A study of the total energy use in Indian households revealed that half was indirect (Pachauri and Spreng 2002)[6],and a study from Brazil showed total levels of 173 GJ per average household, with 61% as indirect energy (Cohen et al. 2005)[7]. The evidence is thus overwhelming that for households to realize their full energy-saving potential, indirect energy has to be considered.

Many researchers have forecasted the energy demand of India [8-9]. However, they are mostly based on an assumed economic growth, which is fluctuating and of great uncertainty in India's remarkable transition. Given the increasing energy demands, the authors want to discuss the basic energy demand for human livelihood, that is, how much energy will be needed to meet people's satisfaction in eating, housing, clothing, travelling, education and sports entertainment at a higher level of living standard? Such demand is the bottom line of total energy demand, less uncertain and rigid for socio-econo.The energy required for it would increase not only direct energy use but more significantly, indirect use of energy caused by family-using products and services. Usually, households consume more energy in the indirect way [10].

There is a need to evaluate past and future outlook of energy sources at a greater level of accuracy and detail. Use of energy at disaggregated analysis is also desirable in order to guide mitigation efforts, including policies towards increased efficiency. The study of direct and indirect energy use in India is major effort analysis of energy use patterns at the level of sub-sectors and end uses for all sectors.

The aim of this study is to obtain consumption pattern of urban and rural household and the energy requirement per consumption category. We also attempted to quantify the relationship of net household income, household expenditure; to obtain an overview of the cumulative energy requirement of Indian households, we analyzed the total consumption package for its cumulative energy requirement. This study focuses on energy requirement caused by household expenditure increment. So export and import, capital goods and investment, government consumption are not taken into account, their changes are assumed to be 0. Our work is to calculate energy consumption in of urban & rural Indian households from 1993- 2012 the most recent period for which data is available in India. We use a generalized input–output model to calculate the energy embodied in goods and services purchased by households in all states and union territories in India.

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The energy intensities of about 59 sectors were calculated using a input output analysis method. The energy requirement of Indian households was calculated by combining energy intensity of sectors with data from the Household Expenditure Survey of NSSO.

II.DATA SOURCES, DATA PREPARATION & METHODOLOGY

2.1 Data Sources

This study is largely based on a large consumer survey, carried out by National Sample Survey organization NSSO) of India between 1993 and 2011 (NSSO, 2000). In the survey the respondents were asked to state, among others, whose expenditure was recorded in a detailed manner. All purchases were noted by each household expenditure terms in the past 30 days.. The National Sample Survey (NSS) is periodically conducted to collect household budget data from a large nation-wide probability sample of households by the interview method which covers the entire area of the country, involving separate coverage of rural and urban areas, with the exception of some very interior areas, and the disputed regions of the State of Jammu and Kashmir. The MPCE (Monthly Per Capita Expenditure) classes are formed differently for rural and urban sectors.

The sources for the construction of the generalized input–output matrix in mixed (monetary and energy) units are the 1993-94 Indian input–output tables compiled Central Statistic Organization **(CSO)** and the Indian energy statistic produced by the National Statistic Organization, ministry of statistic and programmed Implementation The published input–output tables contain basic economic matrices describing more than 500 commodities in 58 sectors of the Indian Economy. The published energy balance contains energy data in physical units at a 58-sector level.

Expenditures for Indian households are partitioned into the different categories of indirect energy in forms of goods and services: The expenditure incurred by a household on domestic consumption during the reference period is the household's consumer expenditure. Household consumer expenditure is the total of the monetary values of consumption of various groups of items, namely (i) food, *pan* (betel leaves), tobacco, intoxicants and fuel & light, (ii) clothing and footwear and (iii) miscellaneous goods and services and durable articles.

- **Food** (cereals & cereal substitutes, pulses & their products, milk & milk products, edible oil, egg, fish & meat, vegetables, fruits, sugar and salt, spices, beverages, refreshments &processed food comestibles including alcoholic and nonalcoholic beverages and meals outside of home, but not the energy used for cooking, refrigeration, etc.)
- **Pan, Tobacco & Intoxicants:** it includes pan, intoxicants and tobacco product.
- **Clothing & Footwear** It includes bedding (pillows, quilts, mattresses, mosquito, nets, etc.), as well as rugs, blankets, curtains, towels, mats, cloth for upholstery, etc. This also includes charges paid to a cobbler for getting a pair of shoes or other footwear made. It excludes the cost of straps purchased separately
- **Misc. goods & services:** Includes education (paper product. Printing, education research), medical care.
- **Durable goods** Furniture and fixtures, "entertainment" durables such as radios, TV, VCR/VCP/DVD players, tape recorders and CD players, cameras, musical instruments, jeweler and ornaments, crockery and utensils, cooking and other household appliances such as fans, air conditioners, air coolers, sewing

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machines used for household work, washing machines, stoves, pressure cookers, fridges, water purifiers, electric irons, heaters, toasters and ovens, household transport equipment including two-wheelers, four-wheelers and their parts, therapeutic appliances, clocks, watches, computers for household use, mobile phone handsets, and bathroom and sanitary equipment

- **Fuel and Light:** It includes cooking energy transport sector (consumption of Electricity, petrol, diesel natural gas etc).

2.2 Data preparation and methodology

To obtain a picture of the total energy requirements of a set of Indian households, expenditure items are converted to energy requirements using energy input–output analysis, which is able to account for all energy consumed in the economy to support a certain activity. The use of input–output economics for obtaining energy embodied in goods and services, and their applications, has been describe in author's previous paper[11].

The source of household expenditure data used here is the most recent consumer expenditures survey carried out by the NSSO in 2011-12 This survey lists detailed, monthly expenditures per capita of rural and urban households. The list of the survey shown in appendix A & Appendix B separately for rural and urban area

The tables provided by NSSO are calculated using current prices. In order to make them comparable, we converted them on constant prices, taking 1993-94 as the base year. Wholesale price indices (WPI) by (Reserve Bank of India- Economic survey 2012) commodities were used for price adjustments for different commodity sectors, and Gross Domestic Product (GDP) deflators by sub-sectors were used for the service sectors. Therefore, for commodity sectors, which have undergone a change in composition over the years, we tried to maintain the same composition as far as possible. We recalculated the WPI values for those sectors we have followed the double-deflation method to for comparable 20014-05 onwards because WPI index is again set at 2004-05 to assume 100 bases price at 2004-05. The price at constant price 1993-94 is given in appendix C & D for urban and rural area respectively..

2.3 Methodology

We started by reviewing the consumption expenditure survey and energy intensity of different sectors we determined the cumulative energy requirement of the consumption items. We then considered how the energy requirement of households was calculated.

The energy requirement of a household (E) can now be calculated according to equation (1), because both the expenditure (ci) per category i and the energy intensities (ei) of the consumption categories are determine as follows:

$$E = \sum_{i=1}^{6} e_i * c_i \text{ ----------1}$$

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This calculation method is not used to calculate the energy requirement of the house and the amount of natural gas and electricity used. The energy requirement for these consumption categories is calculated on the basis of physical quantities. To calculate the energy requirement in different consumable items we start from the physical units used, as recorded in the expenditure survey.The value of energy intensity of year 1993-94 was used from paper(Jain)[11] .

The direct energy requirement of a household is defined in this paper as the sum of the energy required to obtain the energy carriers (electricity, natural gas, gasoline, petrol) as a fuel and light. Similarly the indirect energy requirement of a household is defined as the total primary energy required obtaining all the other products and services included in this study. The total energy requirement of households is the sum of the direct energy requirement and the indirect energy requirement.

During the last decades, total Indian population doubled from about 550 million people in 1970 to approximately 1.1 billion people in 2005, but the growth rate is decreasing. While the level of urbanization increased as well, the vast majority of Indian population still lives in rural areas. Data on household characteristics in India are collected regularly by the National Sample Survey Organization (NSSO) of the Ministry of Statistics and have been obtained from a variety of sources (IndiaStat.com, 2007; NSSO, 2004; World Bank, 1996).The OECD Environmental Out- look scenario (Bakkes et al., 2008; OECD, 2008) assumes a further increase in the Indian population towards almost 1.6 billion in 2050, of which 47% lives in urban areas.

III.RESULTS

3.1 Energy consumption in rural and urban area

Table 1 gives the average energy requirement of the Indian households per capita with respect to the main categories. The average monthly per capita energy use in Indian household 1.4 GJ per year in 1993 in which , 51% of which is in the form of direct energy carriers (natural gas and other energy carriers for space heating purposes, petrol and electricity) and 49% of which is the indirect energy requirement (goods and services).

Howsoever in 2003-04 average energy requirements monthly per capita was 5.8 GJ in which 52& of which in direct energy form and 48 % is in indirect form as shown in figure 1

Table 1 Expenditure and energy Consumption

Items	Monthly per capita Energy consumption	% share	Monthly per capita Energy consumption	% share
	Rural	**Rural**	**Urban**	**Urban**
Indirect forms				
Food	339	18	477	15.9
Durable goods	285	15	527	17.7

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Misc goods and services	150	8	382	12.7
Pan ,tobacco & intoxicants	24	1.35	28.2	0.9
Cloths and footwear	124	6.7	198	6.61
Direct forms				
Fuel & light	952	51	1612	46

.Further 18.11% energy consume in food sectors , while 15% in durable products ,8% in misc goods and services. While 51% energy consumed directly in fuel and light form. While for rural household for the same period energy consumption for durable goods and miscellaneous services is more than rural area. In contrast the consumption of energy consumption for miscellaneous and services for urban area is 12.7% against 8& in rural area and also energy consumption of durable product in urban area is more in compare to rural area. The pattern of energy consumption in rural area has been shown in figure 1

The comparison between rural and urban consumption expenditure has been shown in figure 2.

We will now proceed to discuss the relationship between energy requirement and household expenditure,

3.2 Energy requirement, household expenditure and net income

It is not surprising that the energy requirement increases with household expenditure and income level However, the relationship is not proportional

Table 2: shows the relationship between the total energy requirements, the household expenditure and monthly per capita income of rural is given at constant 1993-94 price.

Year	**Monthly per capita expenditure**	**Monthly per capita income**	**Energy consumption per capita (MJ)**
1993-94	474	640	3001
2003-04	698	983	4200
2011-12	805	1661*	6593

Source: NSSO (2011-12)

CSO (www.indiastat.com) *6% growth assume in monthly per capita income

To explore this further, we calculated the elasticity of the energy requirement; The elasticity of energy requirements in relation to expenditure level is calculated by relation using ratio of % change of energy consumption and % change expenditure level , the elasticity of energy requirements in relation to income level is calculated by relation using ratio of % change of energy consumption and % change of income level . Then a value of 0.85 is found for the elasticity in expenditure while 0.75 for elasticity in income level.

On the basis of the values calculated as above it concludes that elasticity of the energy requirement related to net income is lower than the elasticity of the energy requirement relating to expenditure due to the fact that

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households with a higher net income spend a smaller part of their net income than households with a lower net income.

The figures show that as expenditure increases the energy consumption is also increasing. Further the energy consumption in different category is given in figure 3.

The figure 3 shows that monthly per capita energy consumption for most of the consumption categories vary across the expenditure classes between 1993-2012. The energy requirement of the entire main categories increases with increasing household expenditure However monthly per capita energy consumption do not very significantly across expenditure ,major variation taking place in case of misc goods and services , fuel and light & in durable goods. The spread for the main consumption categories clothing & footwear, education, recreation, household effects, transport and communication, which include some of the luxuries of life, is larger than the spread for the other categories which contain the more basic needs of life.

3.3 Analysis of direct energy consumption in household sectors

Past analysis reveals that in direct energy consumption is more in compare to direct energy consumption. The analysis used over the period 1993 to 2005 and develops a baseline scenario to 2020. Moreover, it highlights available sources of data in India for the residential and transport sectors. In the transport sector, the rapid growth in personal vehicle sales indicates strong energy growth in that area. In addition, oil consumption used for freight transport will also continue to

increase. A large quantity of incremental electricity demand will come from the residential sector in India. Energy services examined in the residential sector include cooking, water heating, lighting, and appliance usage. Urban and rural homes are distinguished due to their difference in energy requirement. The number of urban and rural households is used as drivers for residential energy consumption.

3.4 Residential energy

Residential energy consumption associated with household living, including space cooling, water heating, cooking, refrigeration, lighting, and the powering of a wide variety of other appliances. Energy demand is depended by a variety of factors, such as geographic , climate , urban & rural . In developing countries such as India, it is important to divide households into rural and urban locales due to the different energy consumption patterns found in these locations. The NSSO survey provides detailed data on quantity of fuels used per capita and per MPCE class.

IV.CONCLUSIONS

Because at least 50% of the total energy requirement of households consists of an indirect energy requirement, there is a need for further research into this indirect energy requirement. Future energy policy will have to pay attention to the indirect energy requirement of households. The positive relationship between income and total energy requirement suggests that, with further increases in income levels, the average household energy requirement will probably rise as well. However, the large differences between the energy intensities of the

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various consumption categories indicate that the total household energy requirement can be reduced if we change our consumption patterns. The substantial spread in the total energy requirement of households within the same income category also supports this view. This analysis can form the basis for further research into ways of reducing household energy requirement. Attention needs to be given not only to the direct energy consumption (including the category 'petrol') but also to the consumption categories, 'transport', 'education' and 'recreation'. This is because these categories have a relatively large spread and form an important part of the indirect energy Requirement of households. Indirect energy consumption can be reduced through energy conservation and increased energy efficiency through fuel substitution. Energy conservation measures can be achieved through technological changes in manufacturing processes. Energy efficiency can be increased through appropriate fuel substitution, but additionally energy consumption from secondary sources needs to be analyzed along with emission scenario. At the policy level, measures required to reduce residential energy consumption involve two aspects: reducing direct as well as indirect energy consumption. Direct energy consumption can be reduced by practicing energy saving habits, use of energy star rated appliances and installing intelligent electrical systems. Car pooling and using public conveyance can reduce direct energy consumption for transport. Use of renewable energy like photo- voltaic panels for electricity generation for lighting, cooking and hot water can supplement electricity usage from the grid to some extent. Energy efficiency measures need to be considered to decrease energy intensity for sectors contributing to ''house building'' and ''recreation'' category.

Appendix: (A)

Table 3 Change in average value of consumption of broad group of items per person per 30 days over NSS round

all India (Urban)- Average value of consumption (Rs)

Items/year	1993-94	1999-2000	2001-02	2002-03	2004-05	2005-06	2006-07	2011
Food	250.3	410.84	402.31	429.01	447.41	467.82	517.25	1120.88
Clothing and Footwear	38.3	61.81	68.14	71.06	73.21	75.67	83.32	167.43
Miscellaneous goods & services	122.6	268.94	324.28	370.5	415.15	453.53	516.7	
Durable goods	12.2	30.85	38.09	41.5	47.17	46.83	59.21	139.36
Fuel and light	30.2	66.26	83.38	93.75	104.62	109.55	117.44	175.86
Pan ,tobacco and intoxicants	10.7	16.22	16.6	16.08	17.04	17.21	18.58	42.3
Total Expenditure	464.3	854.92	932.79	1021.89	1104.6	1170.6	1312.5	2399.24

Sources: 68 round reports (NSSO)

Appendix B

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Table 4 Change in average value of consumption of broad group of items per person per 30 days over NSS round all India (Rural)- Average value of consumption (Rs)

Items/year	1993-94	1999-2000	2001-02	2002-03	2004-05	2005-06	2006-07	2011
Food	177.8	288.8	276.35	298.57	307.6	333.15	363.42	573
Clothing and Footwear	24	38.65	40.16	44.43	44.91	45.47	48.95	97.16
Miscellaneous goods & services	48.1	95.43	104.54	127.42	133.05	147.71	172.85	338
Durable goods	6.6	12.76	18.49	18.24	21.74	21.95	26.18	78.14
Fuel and light	20.7	36.56	43.87	51.2	56.84	60.41	66.07	94.19
Pan ,tobacco and intoxicants	8.9	13.96	14.86	14.28	15.03	15.86	17.7	42.52
Total Expenditure	286.1	486.16	498.27	554.15	579.17	624.53	695.16	1430

Sources: 68 round reports (NSSO)

Appendix C

Table 5 Change in average value of consumption of broad group of items per person per 30 days over NSS round all India (Urban)- Average value of consumption (Rs) at 1993-94 constant price

Items	1993-94	1999-2000	2001-02	2002-03	2004-05	2005-06	2006-07	2011
Food	250	248.2417	228	240	240	237	240	334
Fuel and light	30.2	40.9	36.77	39.39	37.33	34.42	34.66	42.32
Durable goods	12.2	22.48	26.39	28.02	24.75	27.49	32.9	64.41
Miscellaneous goods and services	122.6	185	201	222	221.8	231.7	247.6	302
Pan ,tobacco and intoxicants	10.7	11.34	10.85	9.72	9.08	9.48	9.68	13.55
Clothing and Footwear	38.3	39.12	40.46	40.83	38.9	38.57	39.18	48.82

Source: Economic survey 2012

Appendix (D)

Table 6 Change in average value of consumption of broad group of items per person per 30 days over NSS round all India (Rural)- at 1993-94 constant price

Items	1993-94	1999-2000	2001-02	2002-03	2004-05	2005-06	2006-07	2011-12
Food	177.8	174.5	156.93	166.6	165.11	170.58	169.90	172.09
Fuel and Light	20.7	16.13	18.34	20.12	20.29	18.99	19.66	22.69
Durable goods	6.6	9.30	12.82	12.32	13.07	12.89	14.58	36.12

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Miscellaneous goods and services	48.1	65.68	64.81	76.39	71.04	75.95	79.69	96.32
Pan ,tobacco and intoxicants	8.9	9.61	9.21	8.56	8.02	8.113	8.48	15.93
Clothing and Footwear	24	24.46	23.85	25.53	23.88	23.29	22.84	28.39

Source: Estimated from IOTT and energy use data

Appendix E

Table 7 Change in average value of Energy consumption per person per 30 days over NSS round all India (Urban)- 1993-94 constant price –MJ

	Energy Intensity	Year							
Items	(MJ/Rs)	1993-94	1999-00	2001-02	2002-03	2004-05	2005-06	2006-07	2011
Food	1.9	476.86	473.51	434.91	457.79	457.8	452.1	457.79	637.1
Fuel and light	45.99	1389.13	1881.31	1691.33	1811.85	1717.1	1583.24	1594.28	1946.6
Durable goods	43.13	526.24	969.67	1138.33	1208.63	1067.6	1185.77	1419.13	2778.3
Miscellaneous goods & services	3.12	382.71	577.50	627.45	693	692.38	723.28	772.92	942.7
Pan ,tobacco and intoxicants	2.64	28.22	29.91	28.62	25.6	23.95	25.0	25.53	35.8
Clothing and Footwear	5.18	198.3	202.55	209.49	211.4	201.41	199.7	202.86	252.8
	Total	3001.47	4134.44	4130.11	4408.31	4160.2	4169	4472.5	6593.3

Appendix (F)

Table 8 Change in average value of Energy consumption per person per 30 days over NSS round all India (Rural)- 1993-94 constant price –MJ

Items	Energy Intensity	1993-94	1999-00	2001-02	2002-03	2004-05	2005-06	2006-07	2011-12
Items	MJ/Rs	MJ	MJ	MJ	MJ	MJ	MJ	MJ	MJ
Food	1.91	339.14	332.86	299.33	317.81	314.94	325.38	324.08	328.25
Fuel and Light	45.9	952.15	741.81	843.61	925.37	933.08	873.59	904.48	1043.98
Durable goods	43.13	284.69	401.16 2	552.70	531.24	563.88	555.99	628.76	1557.90
Miscellaneous goods &services	3.12 9	150.15	205.02	202.31	238.46	221.74 1	237.09	248.76	300.68

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Pan ,tobacco and intoxicants	2.63	23.47	25.33	24.29	22.57	21.16	21.39	22.37	41.99
Clothing & Footwear	5.183	124.26	126.65	123.47	132.21	123.61	120.42	118.25	147.02
		1873.87	1832.8	2045.74	2167.68	2178.44	2133.87	2246.72	3419.85

Figure 1: Energy consumption pattern in Indian urban household

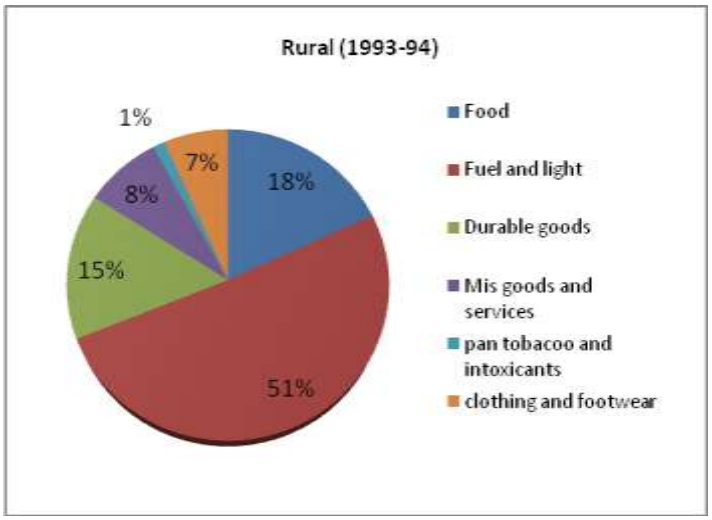
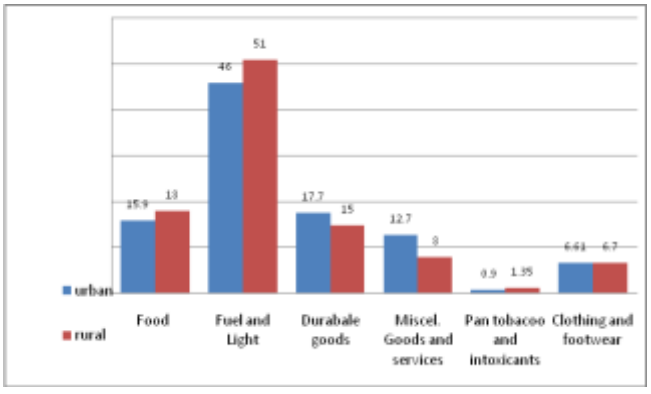


Figure 2 Comparison of energy consumption (%) between rural and urban area



Source: Estimated from IOTT and energy use data

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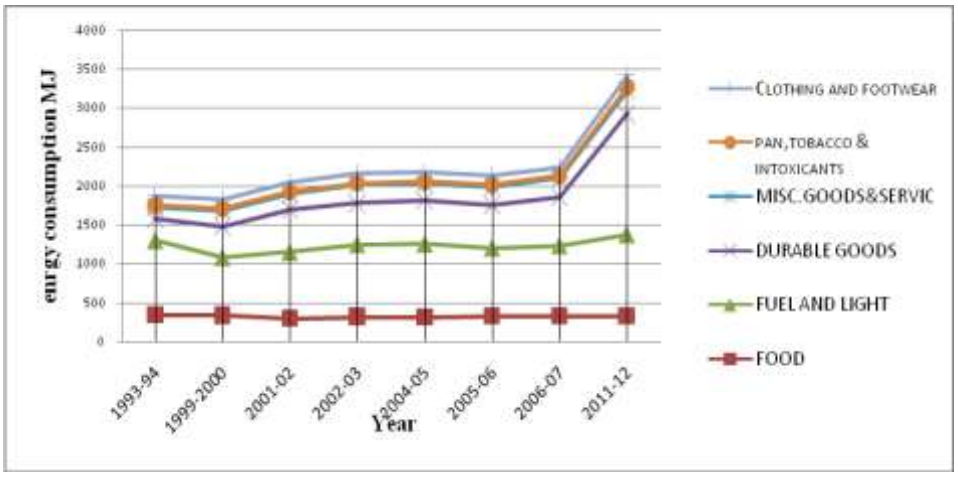
Figure 3 : The energy requirement of the main categories plotted



Against household expenditure

Source: Estimated from IOTT and energy use data

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