Energy deprivation of Indian households: evidence from NSSO data

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Abstract:

This study examines the patterns of domestic energy consumption of households in India over the period of past two and half decades. The analysis shows that the use of energy varies across rural and urban households and also across the categories of low and high income groups. Although increase in income is accompanied with the change in household's fuel mix but total disappearance of fuel-wood for cooking purpose is uncommon. Households wait for threshold level of income in order to change their cooking energy preferences but their lighting energy preferences change constantly with income. Further, a puzzling pattern is noticed that monthly per capita consumption expenditure (MPCE) and average calorie intake from energy sources move in opposite directions in the considered second decade of the study which this paper intends to explain. Further, this paper makes an attempt to estimate Gini Coefficients to measure energy inequality in terms of energy consumption and expenditure. This is revealed that inequality is high in the consumption of LPG in rural areas and that of electricity in urban areas. In addition to this, various methods for estimating the energy poverty are also examined. Each one leads to the conclusion that energy poverty was sharply declined in India in the period 1999-00 and then suddenly increased in 2011-12.

Keywords: Energy Consumption, Energy Inequality, Energy Poverty

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1. Introduction

Domestic energy consumption has been an important policy issue as it has varied implications for health, environment and climate. The distribution of accessibility to energy sources are so unequal that while some countries are focusing on replacing the traditional energy sources by clean energy sources, some countries are trying hard to barely fulfill the necessary energy needs of its population. Catering the increasing domestic energy needs of a country as huge and populated as India is an onerous task and calls for the continuous development of the energy sector. Since independence the government of India has been focusing on the development of the energy sector domestic as well as commercial sector. These programs eventuated in the form of nearly 97 percent of the villages in India have electricity supply. Despite this there is huge consumption gap between rural and urban areas when it comes to accessibility to modern energy sources. More than 80 per cent rural households still bank upon the traditional energy sources for cooking and nearly 77 million rural households still use the traditional source kerosene for lightning. This lack of accessibility has an adverse effect on the productivity and health and ultimately puts extra burden on the household. Thus it indirectly leads to the enhancement of the prevailing social inequality. (Pachauri et. al., 2013).

In this backdrop, this paper intends to examine the nature of household energy consumption and its trend using three rounds of NSSO Consumption Expenditure Survey. It further attempts to analyze the behavior of energy inequality and also examine the various methods for measuring energy deprivation/poverty in the Indian context. The paper is categorized into five sections. Apart from introduction, data base and methodology are discussed in Section 2. Section 3 examines the nature and trends of household energy consumption in India whereas section 4 presents the

analysis of energy inequality and energy poverty in India. Section 5 concludes the paper.

2. Data and Approach

The paper is focused to study the nature and trends of domestic energy use in Indian households during the period 1987-88 to 2011-12. That is the period comprises twenty five years. The study is based on three rounds of NSSO (CES) data, namely 43rd (1987-88), 55th (1999-00) and 68th (2011-12).

There have been surveys other than NSSO which try to capture the phenomenon of the domestic energy consumption of the households. Two of these are mentioned hereby. First, was conducted by the National Council of Applied Economic Research (NCAER) namely "survey on rural energy consumption" in year 1962 but it was not followed by any such survey later on The second one, India Human Development Survey (IHDS) was conducted by University of Maryland in collaboration with NCAER recently. The IHDS which is creating a large panel data set asks questions regarding use and accessibility of energy resources. Two rounds of this survey are in the public domain, 2004-05 and 2011-12. The IHDS data does not suit yet to study the long term trend. The NSSO CES is presently the most suited data set for the purpose.

NSSO also poses some limitations to the study. It does not provide separate data related to energy consumption for cooking and lighting, which make it difficult to analyze these two separately. In order to overcome this problem we utilize two other variables in the data set namely "primary source of cooking" and "primary source of lighting". On the basis of these primary sources of cooking and lighting, it can be inferred that electricity and kerosene are mainly used for lighting and LPG and fuel-

wood are used for cooking purposes. In addition to this dung cake is also utilized for cooking purpose. But survey does not report its quantity consumed.

3. Household's primary source of Cooking and Lighting

Domestic energy consumption ranks third in the total energy consumption break up, preceded by transportation and industry (TERI, 2015-16) sector. Nearly ninety percent of the total energy consumed by households is utilized for cooking. Rest is used for lighting and heating (water or space) purposes. Modern (LPG or kerosene) as well traditional (fuel-wood or dung cakes), both, sources of energy are utilized for cooking purposes.

According to Census 2011, more than 65 per cent population resides in rural India and it consumes around 45 percent of the total domestic energy consumption. Disparity exists between rural and urban India in terms of source of fuels used as rural India is predominantly dependent upon the traditional sources of energy though the use of modern sources is recently on the rise (gone up from10 to 20 percent).The source of fuel used has a great impact on the human life. The traditional sources are more time consuming as well as pose more health hazards, especially to women and children, in comparison to modern sources. Women in the rural areas who use traditional sources of fuel for cooking spend a major proportion of their day in collection of fuel and cooking. So use of modern, clean and efficient fuel can revolutionize their lives.

Per capita income is showing rising trend in the urban areas. This inter-alia leads to increasing demand for energy from the modern sources. Even the urban poor demands and is mostly dependent upon energy from the clean or modern sources.

Table 1 provides information regarding primary source of energy for cooking in India. Tables 2 and 3 provide information regarding disparity in energy use pattern between different income groups.

Table 1: Primary source of energy for cooking in India

% of Rural Household				
Sl. No	**Fuel Type**	**1987-88**	**1999-00**	**2011-12**
1	Coke & Coal	2.09	1.61	1.13
2	Firewood & Chips	78.58	75.45	67.35
3	Dung Cake	15.01	12.11	11.95
4	Charcoal	0.01	0.04	0.03
5	**Traditional Energy (1 to 4)**	**95.69**	**89.21**	**80.46**
6	LPG	0.83	5.40	13.94
7	Kerosene (PDS+ Others)	1.07	2.01	0.60
8	Electricity	0.05	0.07	0.05
9	**Modern Energy (6 to 8)**	**1.95**	**7.48**	**14.59**
% of Urban Household				
Sl. No	**Fuel Type**	**1987-88**	**1999-00**	**2011-12**
1	Coke & Coal	11.73	4.48	2.47
2	Firewood & Chips	40.12	25.04	17.00
3	Dung Cake	3.76	2.65	1.85
4	Charcoal	0.25	0.15	0.06
5	**Traditional Energy (1 to 4)**	**55.86**	**32.32**	**21.38**
6	LPG	24.02	46.49	70.60
7	Kerosene (PDS+ Others)	16.96	19.05	4.54
8	Electricity	0.47	0.33	0.33
9	**Modern Energy (6 to 8)**	**41.45**	**65.87**	**75.47**
% of Total Household				

Sl. No	Fuel Type	1987-88	1999-00	2011-12
1	Coke & Coal	4.26	2.33	1.51
2	Firewood & Chips	69.93	62.78	52.96
3	Dung Cake	12.48	9.73	9.06
4	Charcoal	0.07	0.07	0.03
5	**Traditional Energy (1 to 4)**	**86.74**	**74.91**	**63.56**
6	LPG	6.04	15.73	30.13
7	Kerosene (PDS+ Others)	4.64	6.30	1.73
8	Electricity	0.15	0.14	0.13
9	**Modern Energy (6 to 8)**	**10.83**	**22.17**	**31.99**

Source: Authors' own calculation from various NSSO consumption expenditure rounds

At household level, energy is mainly used for cooking and lighting. Table 1 reveals that during the last two decades, under study, the energy consumption pattern in rural India has not changed in a significant manner as compared to urban India. Still 80 percent of the rural households depend on traditional energy sources for cooking as compared to 21 percent of the urban households

Despite the government's initiatives such as Rural Electrification, Improved Biomass Cook-stoves, *Unnat Chulha Abhiyan and Pradhan Mantri Ujjwala Yojana* nearly 668 million people rely on traditional energy sources for cooking and lighting (IEA, 2013). Intermittent and/or unreliable supply and lack of affordability of the modern fuels is the main reason resulting into the inaccessibility of the modern fuels (Gregory and Stern, 2014). In order to continue on the rapid and inclusive economic growth as well as achieve the target proposed by the United Nations, to provide sustainable energy for all (SE$ALL) by 2030, energy sector in general and its rural area aspect in particular calls for more comprehensive energy policy.

Table 2: Percentage of household whose primary source of lighting fuels across sectors and wealth quintiles

Energy Sources	**ALL1**	**ALL2**	**ALL3**	**ALL4**	**ALL5**	**All India**
	1987-88					
Electricity	14.9	28.2	40.8	56.5	75	35.9
Kerosene	83.7	70.4	58	42.2	23.6	62.8
	1999-00					
Electricity	33.8	49.3	64.5	78.3	91.9	58.7
Kerosene	65.3	49.8	34.7	20.8	7.4	40.4
	2011-12					
Electricity	55.4	74.8	87.4	93.5	97.8	78.4
Kerosene	43.8	24.4	12.1	5.8	1.8	20.9
	RQ1	**RQ2**	**RQ3**	**RQ4**	**RQ5**	**Rural**
	1987-88					
Electricity	11.9	21.9	30.5	42.7	57.4	25.1
Kerosene	86.6	76.7	68.3	55.8	41	73.5
	1999-00					

Electricity	31	44	57.1	68.7	81.7	48.5
Kerosene	68.2	55.1	42	30.1	17.1	50.5
	2011-12					
Electricity	52.3	70.8	84.2	89.8	94.7	71.2
Kerosene	46.8	28.5	15.2	9.3	4.8	28
	UQ1	**UQ2**	**UQ3**	**UQ4**	**UQ5**	**Urban**
	1987-88					
Electricity	41.22	58.97	72.93	83.05	92.54	72.93
Kerosene	57.67	40.01	26.13	16.05	6.36	26.06
	1999-00					
Electricity	61.49	77.93	88.02	95.15	98.31	89.01
Kerosene	37.56	21.25	11.33	4.46	1.31	10.44
	2011-12					
Electricity	82.24	93.76	96.69	98.57	99.37	96.29
Kerosene	16.81	5.45	2.91	1.08	0.38	3.27

Source: Authors' own calculation from various NSSO consumption expenditure rounds.

The energy consumption patterns depend on the expenditure patterns of the households which are mainly determined by the income level. When we probe further, we find that the lower income groups have been consuming merely half the amount of energy consumed by the highest income group (see appendix table 1). The pattern is less skewed in the rural areas which may be because of the lack of the access to the modern fuels as the fuel use is more dependent on local supply in the rural areas than budget constraints.

Table 2 depicts the nature of fuel being used in the rural and urban India. The country mainly uses either kerosene or electricity for lighting its surroundings. The dependence on kerosene has been on decline over time especially in the urban areas. Nearly a quarter of the urban households were dependent upon kerosene in 1987-88 which came down to approximately 3 percent in the year 2011-12.Rural areas have been more dependent upon kerosene. In 1987-88 nearly three fourth of the rural India was lighting its houses using kerosene which has come down to nearly 28 percent by 2011-12. Overall nearly 21 percent households of the country was still using kerosene to light its houses by 2011-12.The use of kerosene for lighting across income groups tells us an interesting story. More than 40 percent of the poorest households (ALL1) still use kerosene for lighting but number comes down quickly when we move across the income quintiles. This implies that the households have high preference for electricity over kerosene as income goes up. During 1987-88 this fact is not very evident for the rural areas which is because of lack of electricity supply. In the new millennium the generation of electricity and hence its supply to rural areas increased as government invested through programs such as *Rajiv Gandhi GrameenVidyutikaranYojana* (RGGVY), Remote Village Electrification, Jawaharlal Nehru Solar Mission, etc., and the trend of preference for electricity over kerosene in urban areas started to reflect well in the rural areas also..

Despite the programs to provide electricity in the rural areas there is still scope of improvement[2]. The country is still struggling with the lack of infrastructure. The main source of electricity generation in India is either by hydro-power projects or thermal power plants. The electricity generated by these sources has to be transmitted through national grids. In order to provide better electricity supply the capacity of the grids need to be enhanced as well as transmission lines. The government also needs to utilize its huge potential in the renewable energy[3].

Table 3: Percentage of household whose primary source of cooking fuels across rural and all India wealth quintiles

Energy Sources	**ALL1[4]**	**ALL2**	**ALL3**	**ALL4**	**ALL5**	**All India**
	1987-88					
Traditional Fuels	96.63	93.96	88.33	76.99	55.22	87.03
LPG	0.32	1.20	3.99	11.87	29.33	6.04
Kerosene	0.86	2.70	5.76	8.94	11.72	4.64
	1999-00					
Traditional Fuels	93.46	88.89	79.16	60.46	27.37	75.20
LPG	1.00	3.57	10.82	26.91	59.64	15.73
Kerosene	1.67	4.52	7.79	11.17	10.42	6.30

[2]According to 2011 census, only 67 percent of the households in the country have electricity facility whereas the figure for rural and urban areas was 55 and 95 percent respectively. This figure indicates high disparity the use of electricity between rural and urban area.

[3]In India, there is high potential for generation of renewable energy from various sources- wind, solar, biomass, small hydro and cogeneration biogas. The total potential for renewable power generation in the country as on 31.03.14 is estimated at 147615 MW (Table 1.3). This includes wind power potential of 102772 MW (69.6%), SHP (small-hydro power) potential of 19749 MW (13.38%), Biomass power potential of 17,538 MW (11.88%) and 5000 MW (3.39%) from biogas-based cogeneration in sugar mills.

[4]ALL1, RQ1 and UQ1 mean first quintile (bottom level) in All India, Rural India and Urban India respectively and so on in the same sequence.

	2011-12					
Traditional Fuels	89.59	78.52	64.90	42.45	17.40	63.69
LPG	4.25	14.92	29.73	52.48	74.83	30.13
Kerosene	0.62	1.58	2.12	2.65	2.44	1.73
Rural Quintile	**RQ1**	**RQ2**	**RQ3**	**RQ4**	**RQ5**	**Rural**
	1987-88					
Traditional Fuels	97.58	97.44	96.42	93.11	87.08	96.03
LPG	0.07	0.21	0.60	2.13	5.30	0.83
Kerosene	0.15	0.43	1.11	2.64	5.21	1.07
	1999-00					
Traditional Fuels	95.10	93.96	90.29	81.89	60.54	89.58
LPG	0.38	1.47	4.79	12.47	31.26	5.40
Kerosene	0.47	1.39	2.50	3.93	6.27	2.01
	2011-12					
Traditional Fuels	91.91	86.05	78.07	63.69	45.74	80.64
LPG	1.94	7.54	17.31	32.96	49.60	13.94
Kerosene	0.33	0.70	0.71	0.78	0.96	0.60
Urban Quintile	**UQ1**	**UQ2**	**UQ3**	**UQ4**	**UQ5**	**Urban**
	1987-88					
Traditional Fuels	88.15	77.2	63.35	45.93	23.53	56.01
LPG	2.6	5.96	14.49	30.65	53.24	24.03
Kerosene	7.2	13.66	20.14	21.08	18.19	16.95

	1999-00					
Traditional Fuels	77.45	61.54	43.44	22.73	6.63	32.39
LPG	7.03	14.91	30.16	52.34	77.39	46.49
Kerosene	13.29	21.39	24.77	23.91	13.02	19.05
	2011-12					
Traditional Fuels	69.1	43.3	27.11	12.71	3.14	21.4
LPG	24.62	49.43	65.33	79.83	87.52	70.6
Kerosene	3.23	5.71	6.17	5.27	3.19	4.54

Source: Authors'own calculation from various NSSO consumption expenditure rounds.

The traditional energy sources, firewood, dung cake and crop residue, continue to remain major components of the cooking fuel. This happens due to inadequate supply and lack of affordability of modern fuels and ease of availability of the traditional fuels[5]. If this keeps on happening for longer periods of time the population becomes more familiar with the traditional fuels as well as their tastes also develop for food cooked on such fuel. This leads us to stacking hypothesis which states that the households are reluctant to switch to the modern fuels i.e. ascend the energy ladder as the income grows, rather they stack modern fuels with the traditional fuels (Heltberg, 2004)* e.g. despite increase in income many households keep on using wood stove for cooking bread. It has also to do with the taste and preferences as well as familiarity with the traditional technologies. It is observed that households completely switch their cooking energy patterns after a threshold level of income is

[5]Population of India has been increasing over time and demands for more agricultural products. The three traditional fuel sources are bi-products of increased agricultural production as more land is created by cutting forest thus giving firewood. Animals are kept for dairy products and agricultural work thus providing the dung cakes and more crops leave more crop residue. Thus availability and supply of these fuels is adequate.

achieved. . This fact is established by using NSSO consumption and expenditure survey (CES) rounds over the period of time (table 3)

Traditional energy constituted 89 percent of the total fuel in the year 1987-88 which decreased to 65 percent in the year 2011-12. Major proportion of the traditional fuel is used in the rural areas due to the aforementioned reasons. In the urban areas dependence upon traditional energy sources has been lesser, which is further declining at a greater pace. Despite the declining trend poor people residing in the urban areas (UQ1 and UQ2) still leave a scope of huge improvement. The energy stack hypothesis can be seen at work for this class.

Although kerosene has not been dominant as a cooking fuel but its trend over time shows an interesting inverted U shaped pattern over the concerned time period for most of quintiles (barring ALL5 and UQ5). It may be because of the government's preference for incentivizing non-use of traditional fuels and the income threshold for switching from kerosene to LPG was small[6].

Per Capita Energy Consumption

Integrated Energy Policy Report (2006),brought out by Planning Commission of India, identified strong positive correlation between energy use and human development index and also indicated that per capita energy consumption or growth in the modern fuels is a sign of development in an economy. The use of modern energy has been increasing in India, especially in urban areas, but its per capita

[6]"Kerosene free India" programme of Ministry of Petroleum & Natural Gas (MoPNG) was launched under the 'Vision-2015 for Consumer Satisfaction and Beyond' and on 16th June 2014 Delhi was declared first kerosene free city in the country. Delhi became the first "kerosene-free city" in the country (The Hindu, 17th June 2014)

consumption still remains low, nearly at one third of the corresponding global average[7].

During the period 1987-88 to 1999-00 per capita consumption of LPG had increased by 22.7 percent while 1999-00 onwards it declined by 10 percent. The decline in household LPG consumption may be due to decline in household size, rapid migration, raising LPG prices, more commercial use of LPG and reducing the number of subsidized LPG cylinders in a year. Further a clear conclusive picture is difficult to get as the population keeps on migrating from rural to urban areas in search of better opportunities. Those who migrate take some time to get the clean energy sources due to the permits required.[8]In addition to this seasonal migrants may not prefer the use of clean energy sources due to effort and cost involved. They may be mostly dependent upon the traditional fuels at least for the cooking purpose.

Table 4: Per Capita Energy Consumption and Expenditure

Per Capita Energy Consumption and Expenditure			
All India			
Energy Types	**1987-88**	**1999-00**	**2011-12**
Coke (kg)	11.4	11.3	11.9
Firewood & Chips (kg)	16.5	18.0	20.7
Coal (kg)	11.2	12.9	10.7
Charcoal (kg)	4.7	4.0	3.6
Electricity (kwh)	7.1	12.8	14.9
Kerosene (liter)	0.7	0.8	0.5
LPG (kg)	1.7	2.2	2.0
Per Capita Expenditure on Energy (Rs.)	11.7	39.3	123.8
MPCE (Rs.)	167.5	535.1	1450.5

[7]In India, per capita energy consumption was 269 kilograms of oil equivalent (kgoe) in 1971 which marginally increased only at the rate 1.91 percent per annum and reached at 606 kgoe in 2013 (citation). In the same period per capita electricity consumption was 98 and 765 kwh respectively and grew at 4.9 percent per annum (IAE, 2013).

[8]E.g. in order to get an LPG connection one needs some identity and address proofs. These documents take time to get prepared. Further the LPG provided by the private vendors (those filling small portable cylinders) is nearly double the price of that provided by the government vendors.

Percentage of MPCE being spent on per capita energy	7.0	7.4	8.5
Rural India			
Energy Types	**1987-88**	**1999-00**	**2011-12**
Coke (kg)	12.9	12.1	12.3
Firewood & Chips (kg)	16.7	18.1	20.9
Coal (kg)	10.6	11.8	9.7
Charcoal (kg)	4.9	3.4	3.8
Electricity (kwh)	5.1	8.4	10.7
Kerosene (liter)	0.5	0.7	0.5
LPG (kg)	1.4	1.9	1.5
Per Capita Expenditure on Energy (Rs.)	10.8	33.4	108.3
MPCE (Rs.)	152.2	463.4	1199.8
Percentage of MPCE being spent on per capita energy	7.1	7.2	9.0
Rural India			
Energy Types	**1987-88**	**1999-00**	**2011-12**
Coke (kg)	10.4	11.0	11.6
Firewood & Chips (kg)	14.3	15.4	17.1
Coal (kg)	11.8	14.8	12.6
Charcoal (kg)	4.7	4.6	3.3
Electricity (kwh)	9.6	21.1	23.8
Kerosene (liter)	1.2	1.1	0.4
LPG (kg)	1.8	2.5	2.4
Per Capita Expenditure on Energy (Rs.)	15.1	58.8	165.3
MPCE (Rs.)	221.6	769.2	2122.0
Percentage of MPCE being spent on per capita energy	6.8	7.6	7.8

Source: Mentioned as above.

Despite continuous increase in the MPCE, per capita energy consumption has remained nearly constant over the considered period and major proportion of the energy needs are still being fulfilled by the traditional sources (Table 4 and 5). During the period 1987-88 to 1999-00 the energy consumption slightly increased but

became constant thereafter. The increase was basically backed by the modern energy sources. But there is slight fall in the energy from modern energy sources and meager increase in the energy from the traditional sources during the period 1999-00 to 2011-12. If the rising prices of the modern energy sources are the reason for this change then we can safely say that government intervention will be required to promote clean energy sources.

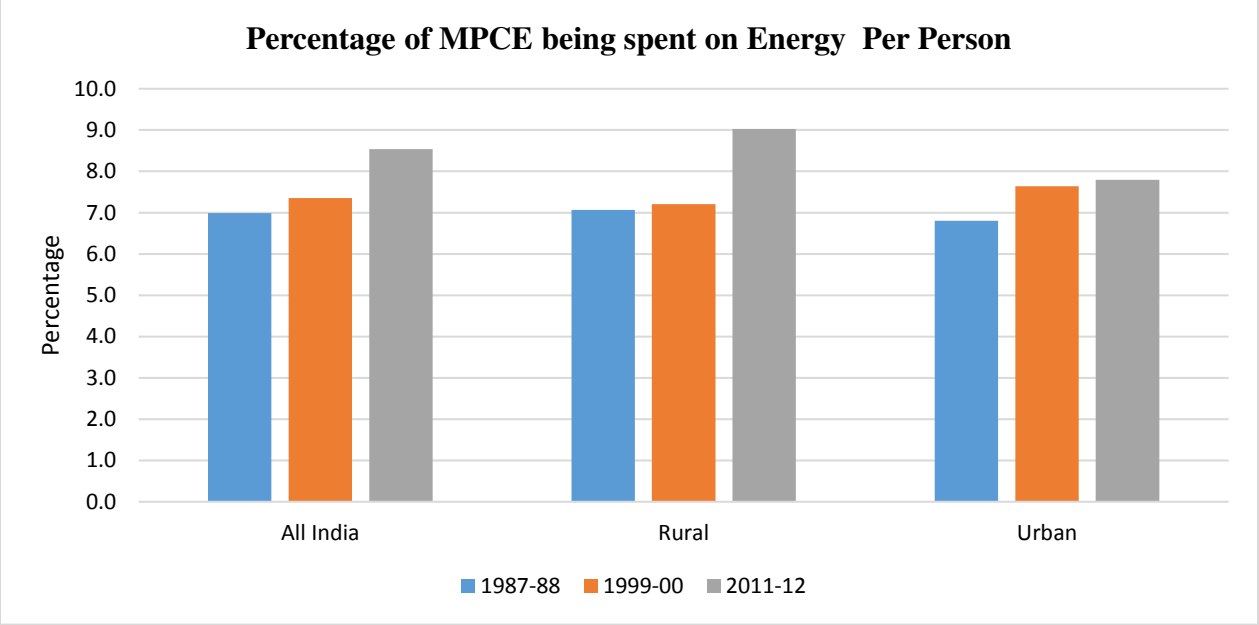
Table 5: Energy Consumption in Caloric Value

Year	1987-88	1999-00	2011-12
Per Capita Modern Energy consumption (Kgoe)			
ALL India	3.3	4.4	4.1
Rural	2.6	3.6	3.1
Urban	4.1	5.8	5.2
Per Capita Traditional Energy consumption (Kgoe)			
ALL India	19.7	20.6	20.8
Rural	20.3	20.1	20.8
Urban	18.6	20.4	19.7
Per Capita Total Energy consumption (Kgoe)			
ALL India	23.0	25.0	24.9
Rural	22.9	23.7	24.0
Urban	22.7	26.2	24.8

Source: Mentioned as above.

The percentage of MPCE being spent on energy is increasing over time (Fig. 1). Even then the use of traditional energy is not on decline. It implies that the cost of energy has been increasing over time. Further, as found earlier, despite the increase in the expenditure on energy it is difficult to (afford for) the modern energy fuel.

Figure 1: Percentage Per Capita Energy Consumption in response to MPCE



Energy and Human Development

Development is always accompanied with demand for more and better quality energy sources as they are necessary for fulfilling basic human needs of food and

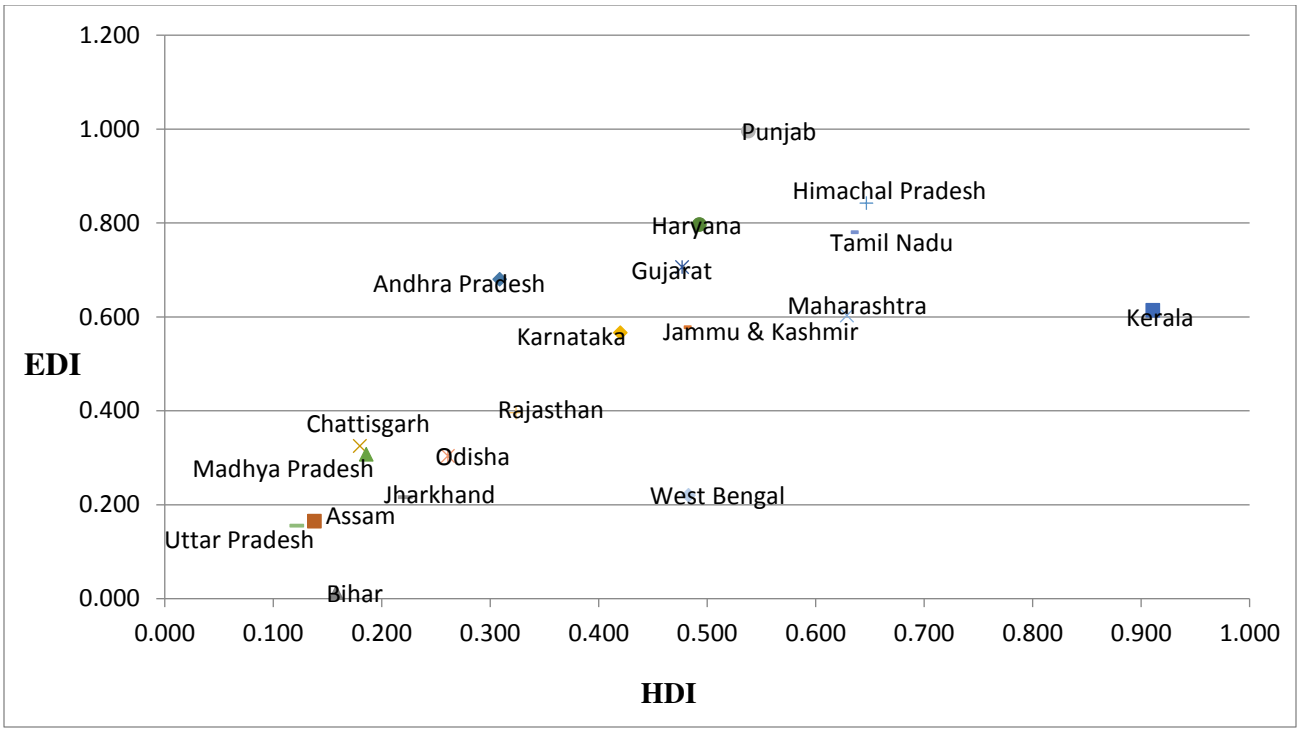
better health. The lack of modern energy may lead to health hazards such as malnutrition, cardiovascular diseases, etc. and hamper overall human development process. Use of traditional energy sources for cooking and heating cause over 4,00,000 premature deaths, mostly of women and children, in India every year (WHO, 2014). In order to understand the impact of energy on the human development the International Energy Agency (IEA) developed the concept of energy development index (EDI) in 2004 and updated in 2010 (see fig. 2).High correlation (0.80) is found between the HDI and EDI. It is attempted herein to calculate the EDI index for India and its 19 states using relevant dataset embodied in Census of India 2011.

Indicator	Minimum Value (state)	Maximum Value (state)
Per capita electricity consumption (Kwh)	134 (Bihar)	1799 (Punjab)
Percentage of Households electrified	10.4 (Bihar)	96.6 (Himachal Pradesh)
Households using electricity as their primary source of lighting (%)	16.4 (Bihar)	96.8 (Himachal Pradesh)
Households using modern fuels as their primary source of cooking (%)	1.9 (Jharkhand)	38.9 (Punjab)

EDI is arithmetic mean of four above mentioned indicators calculated using the following formula on a scale of 0 to 1, 0 being the worst.

$$Indicator = \frac{\text{Actual Value} - \text{Minimum Value}}{\text{Maximum Value} - \text{Minimum Value}}$$

Figure 2: EDI and HDI score across Indian states



Source: Authors' calculation of EDI; and HDI figures are taken from NIPFP working paper no. 139.

EDI results reflect that Bihar, Uttar Pradesh, Assam, Jharkhand, West Bengal, Madhya Pradesh, Odisha and Chhattisgarh are least developed states in terms of use and availability of energy, whereas Punjab, Himachal Pradesh and Haryana are frontrunners due to high rates of household electrification which results into limited use of traditional biomass.

Energy Inequality and Energy Poverty

Structural changes in the infrastructure are needed to fight the energy inequality and energy poverty.A recent study of Govt. of India submits that 668 million people, still, don't have access to modern sources of energy and it targets to bring this count down to 395 million people by 2030 (WHO, 2014). Persisting high reliability on traditional energy sources, notwithstanding the high government subsidies for LPG

and kerosene, is generally because of poor distribution of subsidies, which mostly benefit the richer households(IEA,2007).[9]

Figure 3 and 4 depict the energy inequality across rural and urban areas respectively. Figure 3 shows continuous fall in energy use inequality from different modern energy sources except electricity. There was slight rise in case of electricity use inequality during the period 1987-88 and 1999-00 and then a sharp fall during the decade 1999-00 and 2011-12. This is due to the fact that access to electricity has increased in the rural areas during this decade. While during the first decade of the study (1987-88 to 1999-00) rural electrification was in progress but not with rapid pace as was required. During the second decade under the study (1999-00 to 2011-12) the electrification rate was higher. It is quite evident from the results[10]. [what results ?] In case of LPG there is continuous fall in inequality (Which place?) but it is still higher as compared to the urban areas. This is so, because of both affordability as well as poor distribution facilities.[10]Overall, the energy inequality is declining in the rural areas.

Components India.

Figure 3: Gini Coefficient value of different components of energy in Rural India

[9]The report estimated that 40% of the subsidies for LPG and kerosene in urban areas go to the richest 7% of the population.

[10]In urban areas usually the distributor has door to door supply arrangements. In case of rural areas this facility is missing. One or two distributors cater a wider area due to sparse population, lesser demand, non-affordability of the households to pay for delivery costs and poor transport facilities. Then they are further lesser willing to bear higher cost due to option of fuel stacking.

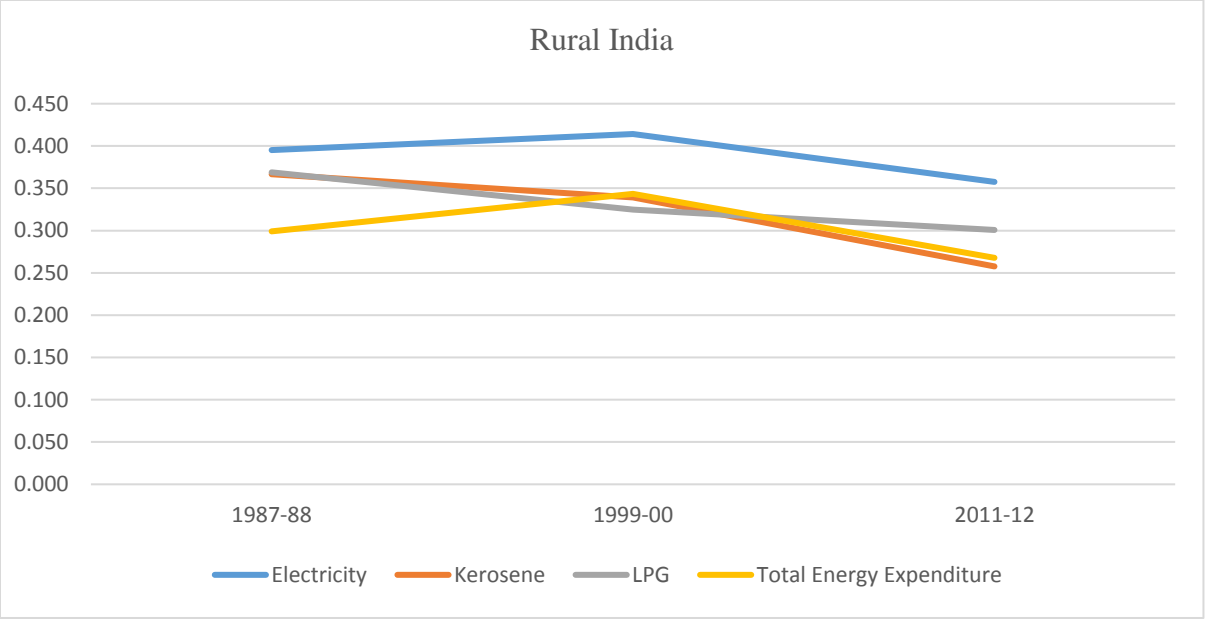


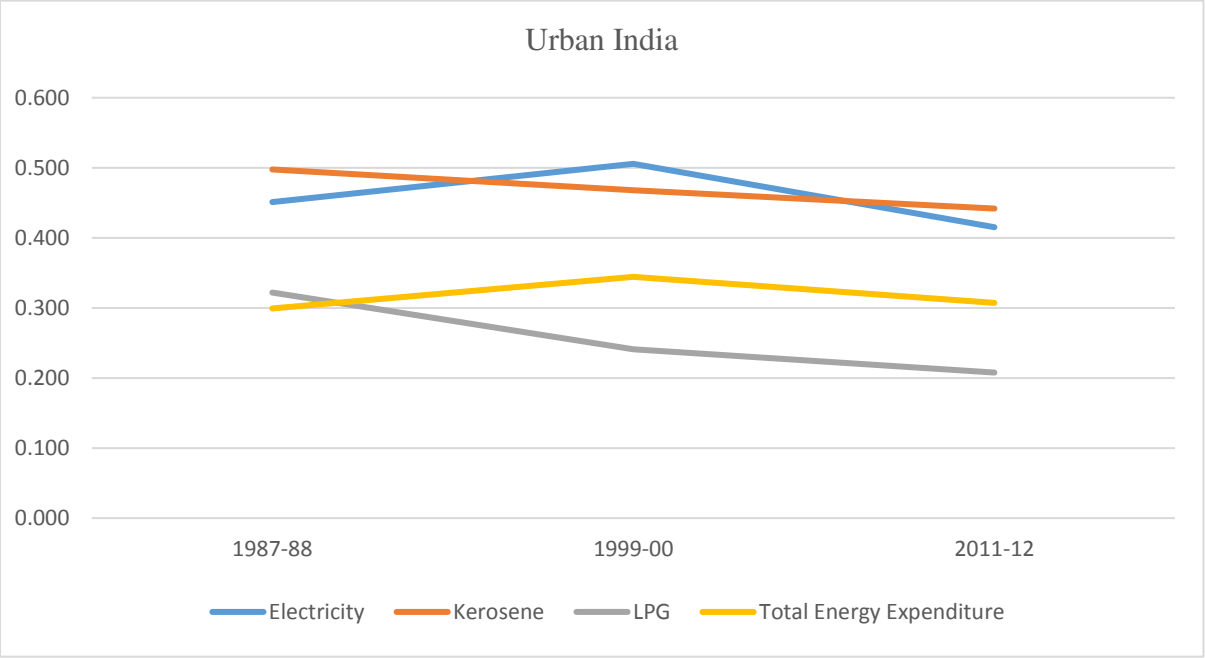
Figure 4 suggests that in urban areas the inequality in case of LPG has been lowest among the energy sources.The inequality has been declingover time but the rate of decline has decelerated in the second considered decade. In all the other categories the Gini coefficient has been falling over time. There is sharp fall in inequality in case of the kerosene use but the reason for which can be assigned to discouragement of kerosene use by government. So the households which may shift to other sources and avoid kerosene do so.[sentence looks incomplete]

There is high inequality in the urban areas when it comes to electricity use. This may be due to lack of supply of electricity (How ?). Over time the supply has been better hence the inequality has been declining. In addition to this the new millennium saw wider availabilityof electricity storage devices (e.g. invertor and battery use) at cheaper prices, which oversaw the decrease in inequality[11]. Further, the availability of electrical appliances at cheaper, affordable, prices has been on increase after country opened its market under new economic policy, so the demand for electricity

[11]Prior to invertor the only way to get electricity supply during power cuts was petroleum generators. The high price of the machine as well as fuel made it unaffordable to general public.

has increasingly move towards being comparable across households leading to lessening inequality despite the decline in Gini coefficient, the level of inequality is still considerably high, which can be ascribed to higher electricity prices.

Figure 4: Gini Coefficient value of different components of energy sources in Urban India



Energy Poverty

The term energy poverty is well known to the academia for long, But no standard method has, so far, been devised to track it globally. In India there is no methodology adopted by government to define a minimum level of energy requirement for a household.Further, there are no methods to differentiate between the energy poverty of rural and urban areas (Schuessler, 2014, Sadath and Acharya, 2017).

However, attempts are made to calculate energy poverty either using physical energy requirement or expenditure on energy. Both the methods have their own limitations e.g. the physical energy method considers same energy requirements for

rural and urban areas as well as across all geographic locations and climatic conditions. Energy expenditure method seems more scientific but it sets energy poverty line arbitrarily. This paper compiles all existing approaches which can be relevant in the pan Indian scenario (Table 6) and also computes poverty figures for physical methods, which are compatible with NSSO CES data set (Table 7). [12]

Table 6: Energy Poverty Methods

Sl. No	Approach	Method	Author	Compatibility with Data
Physical Energy Approach				
1.	Physical Energy Method	Energy poor if a person does have access to get about 27.4 kilograms of oil equivalent (koe) per capita in a month to meet the energy needs.	Bravo et. al. (1979)	**Yes**
2.	Physical Energy Method	32.1 koe energy is required for per person per month.	Goldemberg (1990)	**Yes**
3.	Physical Energy Method	50 koe per capita energy consumption in a month.	Modi et. al. (2005)	**Yes**
4.	Physical Energy Method	A person is considered as 'energy poor' if she consumes at least 35 kg of LPG for cooking and 120 kwh electricity for lighting in a year.	Agnihotri, (2015)	**Yes**
Energy Expenditure Approach				

[12]This paper does not calculate the energy expenditure approach due to two reasons. Firstly, the data for income is not available and using MPCE as proxy for income (which is usually done for other studies such as poverty and inequality) will overestimate the poverty. Secondly, there should be a predefined minimum amount energy need for a person to apply the expenditure approach, else this method will give spurious results.

5.	The Ten-Percent-Rule	Energy poor if the share of expenditure on energy relative to income exceeds ten percent.	Pachauri and Daniel (2004)	**No**
6.	Two times median expenditure share (2M)	Energy poor if the expenditure share on energy exceeds two times the median expenditure share in the overall population.	Boardman (1991) and Hills (2011)	**No**
7.	Low Income, High Cost (LIHC) indicator	Energy poor if household has expenditure on energy above the median and falls below the income poverty line after expenditure on all energy services.	Hills (2011)	**No**

Source: Author's compilation from different sources.

Table 7 delineates the energy poverty results in accordance with the methods compiled in the table 6. All the physical energy methods have different poverty head count ratios according to their poverty cut off value but show a similar trend that energy poverty first decreased in the first considered decade and then increased in the second considered decade. In case of LPG/ Electricity model the poverty has been decreasing over time. This is because the use of electricity and LPG have been increasing over time and the kgoe value of the amount of LPG and electricity considered is very less as compared with other methods.

Table 7: Incidence of energy poor in India

Method	Author	Energy Poverty Head Count		
		1987-88	1999-00	2011-12
All India				
Physical Energy Method	Bravo et. al. (1979)	34.7	27.8	44.0
Physical Energy Method	Goldemberg (1990)	43.3	35.6	49.5
Physical Energy Method	Modi et. al. (2005)	71.1	61.9	69.3
LPG/ Electricity	Agnihotri, (2015)	36.5	21.4	17.3
Rural India				
Physical Energy Method	Bravo et. al. (1979)	31.7	23.1	31.1
Physical Energy Method	Goldemberg (1990)	39.8	29.3	37.4
Physical Energy Method	Modi et. al. (2005)	68.6	56.0	61.1
LPG/ Electricity	Agnihotri, (2015)	48.1	36.2	26.4
Urban India				
Physical Energy Method	Bravo et. al. (1979)	45.1	42.0	56.3
Physical Energy Method	Goldemberg (1990)	55.7	54.3	69.8
Physical Energy Method	Modi et. al. (2005)	80.0	79.7	89.7
LPG/ Electricity	Agnihotri, (2015)	35.2	15.6	10.9

Source: Author's compilation from different sources.

Discussion:

The literature suggests that energy consumption goes hand in hand with the human development. As the results(what results?) suggest that India is energy deprived. Per capita energy consumption increased in the period 1987-88 to 1999-00 and then fell down. When it comes to use of modern fuels which are better and more healthy it is

found they form very lesser proportion of the total energy consumption of a person and country still predominantly banks on use of traditional fuel.

For cooking the modern fuel used is LPG. This paper finds that it comprises a very less proportion of the total energy used in rural as well as urban areas. Across income groups the disparity is more evident (see appendix tables). The dilemma is whether to try to replace the traditional fuel with the modern fuel or try to utilize traditional fuel with more efficiency and in less hazardous manner. When we probe into this we find that major proportion of LPG is imported by India.[13] Thus the LPG prices are dependent upon the global market prices and are not in control while MPCE does not have much dependence on the global market. So the use of LPG will keep on fluctuating unless government puts a ceiling price of a cylinder and caps the rest of the price by subsidies etc. Further in case of LPG one needs to buy a cylinder at a given price. It means the person has to pay a price in one go for a cylinder to be used over time. There are still many households in the country who work on the daily wages and plan their expenses for a very short time, shorter than the LPG cylinder lasts. They will find difficult to forego their expenses to buy an LPG cylinder and in case traditional fuel can be purchased on daily basis further discourages them against buying LPG cylinders. Further there are many infrastructural issues related to supply of LPG cylinders especially in the rural areas. Given in this scenario even the distribution of free cylinders are not going to help if the refilling of these cylinders are provided more easily and at competitive rates to that of traditional energy sources.[14]If this does not happen such programs may lead to black marketing of such

[13]Nearly 85 percent of the LPG is imported as the government reports suggest. (IISD, 2014).

[14]*Pradhanmantri Ujjwala Yojna*provides free cylinders to BPL households but no plan is proposed for refilling of those cylinders.

connections.[15]In this scenario it seems more impactful to focus on development of equipments which can utilize traditional fuel more efficiently.[16]

In case of electricity use which still shows high disparity in the rural as well as urban areas can be dealt with generation of more electricity and supplying it without disruption. Government has shown great efforts towards it by using solar and wind energy to generate electricity which in itself is cleaner than electricity produced using thermal and nuclear energy sources.[17] But these programs also need to be implemented at a wider scale and the infrastructural cost should be brought down may be even by providing subsidies to the needful households.

[15]There is an existing blac
k market for cylinder connections for domestic use in the market as the prices for the commercially used cylinders are higher and the businesses using them are more than happy to buy domestic use cylinders.

[16]Government of India is focusing on such programs in the form of *unnat chulha abhiyan,* etc. the per capita fund allocation and successful execution of such programs may give very fruitful results as these initiatives make traditional fuel comparable with modern fuel and are cost efficient.

[17]Currently India produces Kwh of electricity using solar and wind energy and targets to produce Kwh of electricity by 2020.

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Appendix A1

All India (1987-88) (In Kg.)										
Quintile	Firewood	charcoal	coke	coal	LPG	Electricity	Kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	14.3	3.9	11.0	7.1	0.9	3.3	0.4	8.5	85.4	9.9
2	16.9	4.8	11.6	10.4	1.2	4.4	0.6	11.0	128.1	8.6
3	19.4	5.0	12.2	12.0	1.5	5.8	0.8	13.4	171.0	7.9
4	21.5	4.7	12.9	12.3	1.8	8.0	1.1	16.4	239.2	6.8
5	26.6	6.0	16.2	17.8	2.2	15.4	1.6	23.3	483.2	4.8
All India (1999-00) (In Kg.)										
Quintile	Firewood	charcoal	coke	coal	LPG	Electricity	Kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	16.0	5.1	9.3	11.8	1.5	5.9	0.6	23.7	277.5	8.5
2	18.6	3.3	12.7	12.7	1.8	8.0	0.8	32.7	402.8	8.1
3	21.3	3.5	13.2	13.3	2.0	10.2	1.1	42.0	525.6	8.0
4	23.9	4.7	16.8	15.1	2.3	13.8	1.3	54.6	715.0	7.6
5	26.6	4.7	16.2	19.7	3.1	36.2	1.2	95.0	1392.9	6.8
All India (2011-12) (In Kg.)										
Quintile	firewood	charcoal	coke	coal	LPG	electricity	kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	19.1	3.4	14.8	9.6	1.5	7.5	0.5	85.5	706.7	12.1
2	22.4	3.1	10.8	10.6	1.6	10.4	0.6	111.0	1039.1	10.7
3	24.6	4.4	11.1	13.4	1.8	13.8	0.6	133.8	1377.9	9.7
4	25.2	3.3	13.2	15.0	2.2	19.5	0.5	161.2	1888.5	8.5
5	27.1	4.2	7.7	16.4	2.9	39.0	0.4	242.7	3962.9	6.1

Appendix A2:

Rural (1987-88) (In Kg.)										
Quintile	firewood	charcoal	coke	coal	LPG	electricity	kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	14.6	4.5	13.0	7.1	0.4	3.0	0.4	8.5	85.0	9.9
2	17.5	4.0	14.2	10.8	0.8	4.0	0.5	10.9	127.9	8.5
3	20.2	6.4	14.0	12.8	1.0	5.1	0.7	13.1	170.5	7.7
4	22.5	4.5	15.3	12.0	1.5	6.6	0.8	15.6	237.7	6.6
5	28.6	6.6	17.6	16.7	2.0	9.3	1.2	20.7	462.6	4.5
Rural (1999-00) (In Kg.)										
Quintile	firewood	charcoal	coke	coal	LPG	electricity	kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	16.3	3.7	10.5	11.0	1.3	5.7	0.6	23.4	276.2	8.5
2	19.1	1.1	14.3	13.0	1.8	7.5	0.8	32.0	402.2	8.0
3	22.2	3.1	13.8	12.0	1.7	9.3	0.9	40.8	523.9	7.8
4	25.0	4.6	16.8	15.2	2.0	11.9	1.1	52.1	709.2	7.4
5	28.3	7.7	16.8	16.6	2.6	18.1	1.3	72.2	1222.6	5.9
Rural India (2011-12) (In Kg.)										
Quintile	firewood	charcoal	coke	coal	LPG	electricity	kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	19.5	3.8	16.2	9.3	1.3	7.3	0.5	84.9	703.9	12.1
2	23.1	3.1	10.3	9.7	1.4	9.8	0.6	109.8	1035.2	10.6
3	25.7	4.8	8.5	13.9	1.6	12.8	0.6	132.7	1376.3	9.6
4	26.7	3.7	15.9	13.9	1.9	16.6	0.5	156.8	1893.1	8.3
5	28.7	4.3	6.4	21.6	2.3	25.8	0.5	198.5	3499.7	5.7

Appendix A3:

Urban (1987-88) (In Kg.)										
Quintile	firewood	charcoal	coke	coal	LPG	electricity	kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	11.0	3.1	7.7	7.1	1.1	4.0	0.7	8.8	88.8	10.0
2	13.1	5.8	9.4	10.2	1.3	5.1	1.0	11.6	129.3	9.0
3	15.4	4.2	10.8	11.6	1.6	6.8	1.4	14.4	172.3	8.3
4	17.3	4.8	11.6	12.4	1.8	9.4	1.7	17.8	242.0	7.3
5	19.6	5.9	15.6	18.3	2.2	19.3	2.2	25.9	503.6	5.2
Urban (1999-00) (In Kg.)										
Quintile	firewood	charcoal	coke	coal	LPG	electricity	kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	12.5	6.0	8.0	13.6	1.6	7.1	0.9	26.7	289.5	9.2
2	14.6	5.1	11.1	12.4	1.8	9.4	1.3	36.3	406.1	8.9
3	15.9	3.7	12.6	14.4	2.2	12.1	1.5	45.8	531.0	8.6
4	17.5	4.7	16.8	15.1	2.4	16.3	1.6	58.8	725.2	8.1
5	19.3	3.8	15.4	21.0	3.2	45.8	1.2	109.4	1499.5	7.3
Urban (2011-12) (In Kg.)										
Quintile	firewood	charcoal	coke	coal	LPG	electricity	kersoense	Per Capita Energy Expenditure	MPCE	Percentage of MPCE being spent on per capita energy
1	14.8	2.9	12.3	10.5	1.6	8.8	0.5	90.8	731.7	12.4
2	16.2	3.3	11.5	12.6	1.9	12.8	0.5	116.9	1057.4	11.1
3	16.8	3.5	14.6	12.8	2.2	16.4	0.5	136.9	1382.4	9.9
4	17.8	2.9	11.7	15.9	2.5	23.3	0.4	167.3	1881.9	8.9
5	19.9	4.2	8.3	13.4	3.1	45.3	0.3	264.9	4196.0	6.3