ENERGY POVERTY:
ESTIMATING THE LEVEL OF ENERGY POVERTY IN SRI LANKA

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CONTENTS

Executive Summary

This paper examines the energy poverty status of Sri Lanka by taking Practical Action's international definition on energy poverty and by taking different variations to the definition. Quantitative thresholds using measuring energy poverty was 120kWh electricity for lighting and 35kg LPG equivalent for lighting. Two approaches and three different data sources were taken in measuring the energy poverty. Quantitative approach of measuring energy poverty was done by analyzing Sri Lanka Central Bank's Consumer Finances and Socio Economic Survey 2003/04 and pricing approach of measuring energy poverty was done by analyzing Department of Census and Statistics' Household Income and Expenditure Survey 2006/07 and by analyzing Census of Population and Housing 2001. The study shows a significant level of energy poverty in Sri Lanka, pricing approach shows 83% energy poverty while quantitative approach shows 92.1%. Quantitative approach shows a better position in energy poverty in lighting (33.5%) with respect to cooking (91.4%). Energy poverty in cooking is high due to high level of LPG consumption taken in measuring the energy poverty and due to high cook stove efficiencies. By considering average LPG consumption level of Sri Lanka, 28.3 kg, instead of 35kg LPG, the level of energy poverty decreases from 92.1% to 89.1%. Given a scenario of cook stove efficiency is neglected with 35 kg LPG threshold, it is identified that energy poverty in cooking reduces drastically from 91.4% to 11.4% resulting an overall decrease in national energy poverty level from 92.1% to 42%.

Usage inefficient cook stoves have been the major reason for the significant level of energy poverty in Sri Lanka. Dissemination of improved cook stoves, providing direct subsidies for the poor and improved access to energy services have identified as major interventions in dealing with energy poverty.

SECTION 01

01.1 Introduction

Energy is an essential requirement of today's day to day life. It is required to all of us for lighting, cooking, transportation, health services and fulfilling many of our basic needs. Lighting helps children to study at home when it is dark, women to cook at night, adult to read and engage in their livelihood activities. Having access to electricity would enhance telecommunication at household level, would help women in cooking, radio and television would give entertainment, knowledge and information dissemination. Electricity plays a major role in enhancing livelihood opportunities for all, including poor and non-poor. Clean and efficient energy sources can change most of the poor's life in a better way. Conventional non-efficient, unimproved energy sources results with in-door air pollution and consumes lot of women's time in cooking and collecting firewood. In-door air pollution gives life threats to women and children and it makes chronic diseases. Firewood collection for cooking consumes lot of time of women and hence it limits women in engaging in livelihood opportunities. Clean energy sources for cooking means improvement of living for poor, upgrading their living standards. Energy is needed for all of us; most importantly it is needed for the poor. United Nations (UN) has identified there is an urgent need in improving access to energy services in poor countries in order to meet each goal of Millennium Development Goals (MDG). Without investing enough in energy services, most of the poor countries will not meet the targets of MDGs within the given time frame. By scaling up the energy services, it will have effects on health services, education, income generation, telecommunication, transportation and for safe drinking water. (Modi, V., et al. 2006)

"Energy services are essential to both social and economic development and that much wider and greater access to energy services is critical in achieving all of the MDGs."
(Modi, V., et al. 2006 p.1)

Usually a country's socio-economic development is linked to its energy consumption. In terms of socio-economic aspects, a higher developed country consumes a higher amount of energy. Usage of energy goes over the past 13 000 years, and energy helped societies to move ahead from one level to another, from the hunter gathered societies to organised food agricultural societies. (Diamond J. 1999) Unlike the earlier days, in today's context fulfilling energy need of every human being has become very challenging. With the increasing population, emerging economies and economic development, global demand for energy is keep on increasing while supplies dwindle day by day.

Poverty analysis done by Department of Census and Statistics (DCS) in Sri Lanka has shown that by year 2007, poverty headcount ratio[1] of Sri Lanka is 15.2% where as Uva Province has shown the highest poverty headcount ratio of 27.0% while Western Province has shown the lowest of 8.2% (DCS, 2008a). There is a strong correlation between the level of poverty and energy consumption. That relationship goes in both ways. Poor households demonstrate low energy consumption, lack of access to clean, commercial energy sources, electricity and efficient equipment. (IEA, 2002) Households tend to depend much on biomass. Where as when a household moves out from poverty level, they access clean, efficient commercial energy sources with less domestic air pollution.

Researchers and policy makers have done many studies and policy implementation on both energy and poverty. They have studied the linkage between energy and poverty. They have analyzed how poverty influences in energy consumption and vice se versa (Barnett, A. 2000; Goldemberg, J., & Johansson, T. B. (Eds.). 1995). But what is referred as energy poverty? In general terms energy poverty refers to inadequate provision of minimum required energy services to a person or to a household. This required energy provision for a person might vary from a region to region or a country to a country based on the climate condition and/or the living status. In order to identify the possible interventions for energy services for the poor, a country needs to identify its level of energy poverty at the first place. Without knowing the level of energy poverty, its interventions or strategies might be less effective in ground.

There have been several studies which have tried to identify energy poverty globally and in different countries. Pachauri, S., Mueller, A., Kemmler, A., Spreng, D., (2004) have done a study on energy poverty in Indian households and Foster, V., Tre, J.-P., & Wodon, Q. (2000) have done a study on fuel poverty in Chillie. It is identified most of the world's energy poor live in sub-Saharan Africa and South Asia. (Modi, V., et al. 2006) Given a South Asian country Sri Lanka needs to identify its energy poverty in order to move ahead with its socio-economic development and move upwards inhuman development. However as far a known, there has not been a study on estimating the level of energy poverty in Sri Lanka. As a result, the level of energy poverty in Sri Lanka is not yet identified.

01.2 Aim/Objective

The holistic objective of this study is to take the first steps in eliminating energy poverty in Sri Lanka. However, the direct aim of this study is limited to few components. At first this study estimates the level of energy poverty in Sri Lanka. It will focus on households at each province and is trying to identify the level of energy poverty at provincial level. Further, it is trying to identify the level of energy poverty in year 2015 and it suggests some interventions in how to halve the energy poverty by year 2015 and how to eliminate energy poverty by year 2025.

01.3 Structure

Section 01: Introduction details the importance of energy in socio-economic development and the importance of identifying the energy poverty. **Section 02**: of this study discusses what energy poverty is in a broader perspective. It is trying to identify different possible definitions for energy poverty and limitations of different definitions. It is then discusses what the selected definition for this study is and what are its limitations. **Section 03**: of this study describes what are the data sources available for this study and the methodology used in determining the level of energy poverty. Then moving to **Section 04**: where the

[1] Poverty head count ratio has been defined by DCS as "the proportion of the national population whose incomes are below the official "

empirical analysis is explored. It examines what is the level of energy poverty at provincial level in year 2008 and what could be the level in year 2015 and 2025. **Section 05**: of this study is dedicated in identifying the possible interventions in halving the level of energy poverty by year 2015 and eliminating energy poverty by year 2025. Finally **Section 6**: gives the concluding remarks of this study. Latter parts are allocated for appendices and references.

SECTION 02:

02.1 Energy Poverty

> *"Take joint actions and improve efforts to work together at all levels to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the MDGs, including the Goal of halving the proportion of people in poverty by 2015, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty"*
>
> (ESMAP 2002, p. 2)

In simple terms energy poverty refers to poverty in terms of access and consumption of energy. Traditionally poverty is measured in terms monetary income or expenditure. With the time, the ways of measuring poverty has been changed. In Modern days poverty is directly linked to deprivation. Here deprivation is associated with not having access to one's choice of material goods, freedom, capabilities and opportunities. (Pachauri S., et al 2004). Therefore we can simply identify energy poverty as constraints in energy services for households to meet their basic needs.

Demand for energy increases with each passing second and the supply is dwelling. With the current global reality, increasing the consumption of energy poor in order to meet the minimum level of energy consumption is to meet the equity is energy services. Steps need to be taken for energy conservation and we need to look at sustainable means of energy usage. UN Millennium declaration has identified energy as a need of all human beings. Each individual and his family is having a right to a standard of living adequate for the health and wellbeing. Interventions for energy poverty are trying to address the people who can not meet the standard of living adequate for health and wellbeing. You and me might be having access to improve energy services to meet our needs, but the millions in Sri Lanka might not. Energy is for all, to meet our needs, attempt in energy poverty is to satisfy them with their basic energy needs and to maintain the equity in energy services.

When it refers to energy poverty, few areas need to be covered; namely, accessibility, consumption, efficiency and cleanliness.

Accessibility - Thought it is not the prominent case in the world, everybody should be having access to improved energy services. When somebody does not have access to grid or off-gird electricity, then that individual is deprived from most of the facilities. It is same with access to other sources of improved energy services. However having access to conventional or indigenous energy sources differs a lot from having access to improved energy services. Lighting can be generated by burning wood, but it is different to having light from a kerosene lamp which is again totally different from having light from electricity bulb. Can you or me think of living without having access to improved energy services? How many hours can we comfortably live without having electricity? Majority of world's poor need access to electricity more than you and me in order to improve their living standards or to move out from poverty.

Consumption - People should be able to consume a certain level of energy to meet their basic needs. The level of consumption might vary from their level of income and the level of expenditure on energy services. For less income families it will not be possible to consume the level of energy that they require. Further, the level of consumption is directly related to accessibility. When somebody is having the capacity for enough consumption, still they might not be able to consume as they need due to limited availability of energy services.

Efficiency - Efficiency too plays a major role in energy poverty. Firewood or biomass might serve as an energy source, but when it is used at domestic level in a traditional cook stove, its conversion efficiency goes as low as 8% (Bhattacharya et al. 1999). With the less efficiency, higher amount of firewood is required to cook a meal resulting women to spend more time in firewood collection and it makes lot of indoor pollution. As women stuck in the kitchen cooking and collecting biomass, they will not sufficient time for involve in income generation activities.

Cleanliness - Cleanliness of the energy service effects at domestic level as well as at global level. At domestic level, less clean energy source means high domestic pollution. Which again causes deadly threats to women and children who are exposed to emissions from burnt firewood most of the time. At the global level less clean energy source means increase in global warming.

Therefore when considering the level of poverty of a nation or a population all these aspects need to be considered.

Usually the definition of energy poverty has a strong correlation to how energy poverty is measured. However different researchers and institutes have defined ways of measuring energy poverty in different ways. The differences have risen mainly due lack of universally accepted measure of what is the amount of energy needed to meet one's basic human needs. (Pachauri S., et al 2004). Therefore different people interpret the required minimum level in different ways. It is argued that energy poverty can be measured in terms of expenditure levels of households, which is known as economics based approach. The second approach would be to quantify how much energy is used by a household, which is termed as engineering based approach. The third approach is to look at access to energy sources. (Pachauri S., et al 2004). In this study a quantitative analysis and pricing methodology is taken into considering. Where as quantitative analysis is more similar to engineering based approach suggested by Pachauri S., et al and pricing approach is more similar to economics based approach.

Pricing methodology measures the amount budget share spent on energy services. (UNDP/WB 2003). The definitions of fuel poverty line and energy poverty line are associated with that. Direct quantitative analysis measures the direct energy needed to meet the basic needs such as lighting, cooking, heating etc (Pachauri S., et al 2004).

Millennium Development Goal defines energy poverty as "The **minimum needs** correspond to about **50 kilograms of oil equivalent (kgoe)** of annual commercial energy per capita; this estimate is based on the need for approximately 40 kgoe per capita for cooking and 10 kgoe used as fuel for electricity" (Modi, V., et al. 2006).

There were two definitions came from the workshop Practical Action conducted together with energy experts[2] in Sri Lanka. These definitions can be categorized as consumption based definition and sustainability based definition.

Consumption based definition - A person consuming below the average level of energy consumption of the poor (poor is defined by using the official poverty line) for lighting, cooking transport and livelihood can be considered as a person in energy poverty

Sustainability based definition - A person consuming below per head sustainable energy available in Sri Lanka (Upper and lower boundaries can also be defined. This makes the definition more sophisticated.) can be categorized as energy poor

Practical Action at its global level has identified criteria in defining energy poverty. This paper serves the purpose of measuring the level of energy poverty as per the given definition of Practical Action. In section 02.3 we will be covering the limitations of definitions including the definition given by Practical Action.

02.2 Selected definition for this study

The definition used for this study is based on Practical Action's international study on estimating the level of energy poverty in few selected countries including Sri Lanka.

[2] To see the name of participants for the workshop, please refer Appendix 01

The definition goes as
"A person is in 'energy poverty' if they do not have access to at least:
(a) the equivalent of 35 kg LPG for cooking per capita per year from liquid and/or gas fuels or from ***improved supply of solid fuel sources and improved (efficient and clean) cook stoves***
and
(b) 120kWh electricity per capita per year for lighting, access to most basic services (drinking water, communication, improved health services, education improved services and others) plus some added value to local production

*An '****improved energy source'*** *for cooking is one which requires less than 4 hours person per week per household to collect fuel, meets the recommendations WHO for air quality (maximum concentration of CO of 30mg/M3 for 24 hours periods and less than 10mg/ M3 for periods 8 hours of exposure), and the overall conversion efficiency in higher than 25%. "*

The criteria (a) and (b) of this study shows this is more a quantitative based approach of measuring energy poverty. These quantities and/or its equivalent figures shows the minimum amount of energy needed for meet one's basic needs. However by adding time required in collecting firewood, air pollution make by the energy source and energy conversion efficiency, this definition has become multi-folded. Energy services needs to maintain its quantity, air quality, collection time and improved efficiency all the times.

In the given definition, 35kg of LPG equivalent for cooking and heating was taken by analyzing different studies taken place in different countries. Examples can be taken from Brazil, China and India. In Brazilian case, in year 2002, the LPG used for cooking and heating was accumulated up to 125 kg LPG per year per household. (Lucon et al., 2004). By considering average household size of 3.8, this means consumption of LPG in Brazil for cooking and heating is 33kg per capita, per year. (Goldemberg et al., 2004). Indian study shows in year 2002, a household consumes an average of 115.1 kg of LPG per year for their cooking and heating. (D'Sa and Murthy,2004) by considering average household size as 5.26, it gives a consumption of 22kg of LPG per capita per year. (Goldemberg et al., 2004). The Chinese study shows it is required 34 kg of LPG equivalent for cooking and heating per capita per year (Goldemberg et al., 2004). Thereby Goldemberg et al. (2004) argues that average 35 kg of LPG equivalent is required per capita per year to meet one's basic cooking and heating purposes.

In the given definition, electricity consumption is given as 120kWh electricity consumption per capita per year. The amount is derived by taking 50kWh electricity consumption by single household per month. Recent survey done by Sustainable Energy Authority Sri Lanka shows that 72% of households in Sri Lanka, who is connected to grid, uses less than 90 units per month (SEA 2007), which is less than 216kWh per capita per year (By assuming 5 members per household). Countries are considering lifeline rates for electricity in order to reduce the financial burden on poor electricity consumers. The lifeline rate is usually applies for 50-100 kWh per month per household (ESMAP 2003). These facts justify the figure of 120 kWh per capita per year which is taken as the baseline of electricity consumption of this study.

02.3 Limitations of the definitions

Different scholars and researchers have commented both positively and negatively on these different measures on energy poverty. As discussed, pricing methodology measures the amount of budget share spent on energy services. However the budget share on energy services differs from different social levels. Eg, poor and high income household, where a poor household would spend a higher budget share on energy and a high income household would spend a lower budget share (Leach 1987, ESMAP 2003).

One of the main arguments against quantitative approach of energy poverty is that it is based on minimum amount of energy needed for fulfill one's basic needs, but there is no universally accepted definition on what basic need is? Basic needs of a person could change from area to area and country to country. Hence the energy poverty result coming from quantitative analysis is also subjected to changes (Pachauri S., et al 2004).

According to Practical Actions definition, it consider the efficiency of cook stoves and if a cook stove's efficiency is falling under a certain level, then it defines that as energy poor. But what is missing from there is one's desire on using the firewood for cooking. Especially in Sri Lanka, some households tend to use

firewood in cooking some meals because they believe there is a special taste associate with the meal if it's cooked by using firewood. So in such cases, people tend to use firewood not because they do not have access or they do not have financial capability in using efficient energy sources, but because of their willingness. These kind of human behaviors are not considered in this definition of energy poverty.

This definition serves the purpose of developing an international definition for energy poverty and estimating each countries level of energy poverty accordingly. However, it is worth rethink on how relevant this definition to Sri Lanka? Most of the Sri Lankan use biomass as their primary source of cooking. Only very few households have access to improved cook stoves which are having higher efficiency than 25%. Once this definition is taken it automatically shows that almost 85% of Sri Lankan households are energy poor. So the question is do we need to look for a more realistic definition which will suit more to Sri Lanka?

The cooking requirement quantity and the lighting requirement quantity of this study were derived from some of the international studies. Probably these quantities might not be the appropriate quantities for Sri Lanka. Sri Lankan households' energy need is different from the energy needs of India, China or Brazil. The energy need could vary from the life pattern of people and from climate. Cooking energy requirement could vary from how the meals are cooked and what kind of meals cooked in a society. Some cultures or countries cook food for a long time whereas some countries prefer more on less cooked food and some use more waterish food where as others use less waterish food. So energy required for these types of different cooking styles differs to each other. Therefore internationally derived figures on minimum energy requirement for poor might be varying from that of Sri Lanka. Hence research needs to be done on identifying the minimum energy requirement for people in Sri Lanka and a definition for energy poverty need to be derived from there.

Another major argument comes against the whole concept of energy poverty and its definitions is whether at this era of energy crisis, do we need to look for energy poverty or do we need to look for energy wealth? Fossil fuel reserves in the world are decreasing day by day and the people's demand is keep on increasing. Therefore the question is how are we going to meet the future energy demand? When the whole world is facing such a huge challenge, is it worth looking at which households use the minimum amount of energy and looking at possible interventions in increasing their energy consumption. These arguments mainly direct us in looking at a society which utilizes very limited amount of energy and trying to survive with the limited resources available. It argues, let us not talk about the energy poverty, and instead let us talk about the energy wealth. Instead of looking at ways of increasing the energy consumption, we need to look at ways in which we can minimize the energy consumption.

SECTION 03: DATA AND METHODOLOGY

03.1 Data Sources:

As far is known, there has been very little research done in Sri Lanka quantifying the level of energy used for cooking and lighting at household level. At policy making level and research level most of the researchers highly depend on the data compiled from Department of Census and Statistics (DCS) Sri Lanka and Central Bank Sri Lanka's data. With respect to energy studies DCS produces two sets of data, Household Income Expenditure Survey (HIES) and Census of Population and Housing.

Apart from these two data sources, Sri Lanka Sustainable Energy Authority (SEA) has conducted a survey covering 3000 households including all Sri Lanka to measure the energy consumption pattern of the population. However, at the time of compiling this report, findings of SEA survey has not been published.

Data from most resent census and survey of DCS; namely Census of Population and Housing 2001 and HIES Survey 2006/07, and Central Bank Consumer Finances and Socio Economic Survey 2003/04 were incorporated in compiling this report.

HIES Survey:
DCS has been conducting HIES since year 1990. The most recent survey of this kind was conducted in year 2006/07. HIES survey provides information on household income and expenditure. It observes the consumption patterns of people and it measures the living condition of the people. It is usually taken 25,000

households for the survey and by taking data in twelve monthly rounds. It is designed to capture seasonal variations of income and expenditure patterns of the household. HIES 2006/07 was carried out in all parts of the country excluding Northern Province and Trincomalee district in eastern province due to ongoing conflict in the area. Therefore no data is available for those areas.

Census of Population and Housing:
DCS is conducting Census of Population and Housing in every 10 years covering the whole country where last census was in year 2001. The 2001 census was totally carried out in 18 districts out of 25 districts in Sri Lanka. Enumeration was not able to carry out in Northern Province comprising Jaffna, Killinochchi, Mannar, Mulathivu and Vauniya districts due to the ongoing conflict in the area. And the same with Batticaloa and Trincomalee districts in the Eastern Province. However estimation was made to the eastern province by using the partly collected data from Trincomalee and Batticaloa districts.

2001 census data is compiled in different administrative levels and also as per the sectors, mainly Urban, Rural and Estate.

Consumer Finances and Socio Economic Survey 2003/04:
This survey was conducted by the Central Bank of Sri Lanka with the sampled population of around 11700 households representing all the provinces in the country. The information on sources of energy for lighting and cooking for each household and quantity consumed with monthly expenditure for the selected items are available in this survey data.

Limitations of Data:

HIES, National census and Central Bank Consumer Finances and Socio Economic Survey have not conducted directly to get energy related information. They are conducted to cover some other specific areas excluding energy. Therefore these data sources are poor in terms of energy data. With HIES survey and Census of Population and Housing, sufficient data are not available to calculate the amount and quantify energy source utilized for cooking at each household in Sri Lanka. Both HIES and 2001 census analyze the type of energy source used for cooking at district level and at provincial level, further it quantify the utilization of this energy source for a average household or person and its associated cost. They categorize households as per their primary source of energy used for lighting and for cooking. Here these two information sources miss the fact that most of the Sri Lankan households use a fuel mix for cooking. The fact of fuel mix is totally neglected all through out the survey and it acts as a major limitation of data for this study. It presents an average energy consumption pattern of a household in that district or province. Hence they do not give directly the provision in calculating the exact number of households using a specific quantity of energy source. In other words, only with these two surveys it is not possible to calculate the exact number of households falling under section (a) and (b) of our definition and a methodology need to be adopted in order to extract data from these data sources and generate the level of energy poverty in Sri Lanka,

Another major limitation of all these data sources is they do not gathered data from the households on quality of energy service that household use and the firewood collection time of each household. Hence they do not have information on domestic air pollution, the exposure of women to the smoke from the kitchen and the time women spent at kitchen. All these factors limit ability of estimating the households with energy poverty.

Another limitation with respect to electricity is that these surveys do not provide information on the level of electrification of the province or district and information on off grid energy services and how many have benefited from that. HIES is designed in such a way that it can be used in doing the estimates at district level, provincial level or national level. Since the sample size is small, the survey findings can not be used to do the estimates in Divisional Secretary (DS) level or at Grama Niladari (GN) level.

Though there are limitations, together with these surveys and other available information, it is possible to estimate the level of energy poverty in Sri Lanka. As survey information is comprehensive and census information covers the whole country, the energy poverty estimates done in this study maintain well accuracy. Given these data limitations are minimized, the exact picture of energy poverty status of Sri Lanka can be derived.

For the purpose of this study, CEB data was not available. That acts as a major limitation of data sources of this study. Provided if we have accessed the CEB data on electricity consumption at household level, more

accurate country level analysis could have been done in order to measure the energy poverty level in Sri Lanka.

03.2 Methodology:

In calculating the level of energy poverty, two approaches are taken into consideration, a quantitative approach and a pricing approach. In quantitative approach, it is looked at the amount of energy consumed at household level for lighting and cooking. In pricing approach, it is looked at one's financial ability in meeting the energy needs as per the selected definition.

The quantitative method is applied directly by taking the data from Central Bank Consumer Finances and Socio Economic Survey 2003/04. By accessing the raw data, the quantity of energy used by surveyed households was calculated, separately for lighting and cooking.

Estimating the energy poverty by pricing approach has taken a long way. In gaining data from each household it is needed to combine Census of Population and Housing with Household Income and Expenditure Survey. Where census will give a complete coverage of the country and a survey will provide in detail information of the selected sample. Thereby for each household we can analyze the characteristics of energy consumption.

In determining the level of energy poverty at provincial level, we will follow a methodology where we categorize people as per the sectors (urban, rural and estate) and as per the expenditure deciles. When analyzing with expenditure deciles, we will identify which households belongs to which energy source as per their expenditure decile and as per the energy ladder. Then we will adapt a pricing methodology for each decile to analyze whether the households from that decile can meet the quantities of the energy sources as per the given definition.

The concept of energy ladder is generally discussed as when income increases, people move from less efficient energy sources (such as biomass) to move efficient clean energy sources (such as LPG/electricity) "*The energy ladder refers to the phenomenon of households and firms—and so, in aggregate, countries—shifting from low-efficiency fuels to high-efficiency ones as income per capita increases. Biomass fuels such as dung and fuelwood are at the bottom of the energy ladder and electricity at the top"* (World Bank 2003 p.31). Usually energy ladder describes three stages of fuel choices/fuel switching. The first stage is high dependency on biomass and then in the next stage people move into a transition stage, where they use fuel like Kerosene, coal, charcoal etc. At the third stage move goes towards electricity, LPG (ESMAP 2003). The concept of energy ladder helps us to identify the link between the income and energy source.

Further analyzing the cooking component of the definition, we look at each household at the provincial level. With respect to households utilize biomass, rather than analyzing the quantity utilized for cooking at each household, we will look at the characteristics of the cook stoves at each household. From this we can analyze which households do not meet the criteria of improved energy source as per our given definition; hence they can be categorized as energy poor.

A combination of this sector distribution, expenditure deciles and pricing methodology together with qualitative analysis of energy source will give us how many households can be categorized as energy poor in each province.

In sector distribution, we will categorize people as per Urban, Rural and Estate sectors. DCS definition on urban, rural and estate sector goes as below. Where urban sector includes all the population falls under Municipal and Urban Council areas. A plantation more than 20 acres or more and where it is having 10 labors or more belongs to estate sector. Any area which is not falling under those two categories is defined as rural sector (DCS 2008)

SECTION 04: EMPIRICAL ANALYSIS

04.1– Quantitative Analysis:

Different stakeholders were involved during the course of this study; Officials from Sri Lankan government energy agency, SEA, Ministry of Power and Energy, Ministry of Science and Technology, Center for Poverty Alleviation (CEPA) and scholars from Sri Lankan universities; namely, Open University Sri Lanka, University of Moratuwa, and University of Colombo. Among the stakeholders CEPA has played a major role in working together with Practical Action South Asia for this study. Stakeholder consultation with CEPA has given the opportunity for Practical Action to conduct the quantitative analysis of this study together with CEPA. By using the Central Bank Consumer Finances and Socio Economic Survey 2003/04, CEPA has conducted the quantitative analysis of this study. CEPA staff has worked closely with Practical Action team in order derive the figures for energy poverty in Sri Lanka and they have assisted Practical Action in looking at energy poverty from different perspectives and from different definitions.

As discussed in the methodology, quantitative analysis was done by accessing raw data from Central Bank's Consumer Finances and Socio Economic Survey 2003/04. From the available data on the survey, energy amount each household consumed for lighting and cooking were calculated separately. During the quantitative analysis, data on a particular item was not collected separately whether it was for cooking or lighting. By studying the distribution of source of energy and consumption of fuel item, the approximate expenditure for cooking and lighting was estimated with considerable margin of error. For example when electricity was not specified as main source of energy for cooking, the total consumption of electricity was assumed for lighting as the consumption of electricity for cooking was negligible. Eventually, households who do not meet the minimum amount of energy required as per the definition were treated as energy poor.

In calculating the energy source used for lighting, value of electricity was taken directly and value of kerosene was calculated by considering the electricity equivalent of kerosene[3]. The calculations has shown that 33.5% of samples from all around the country are not accessing 120kWh per capita per year meaning 33.5% of samples are energy poor. The lowest amount of energy poverty in terms of lighting was shown in western province stating 18.5% and the highest level of 49.7% was shown in Uva province. (Table 1)

Table 1: Energy poverty in lighting by province

Province	Non Poor	Poor	Total	Non Poor %	Poor % due to non availability of Grid	Poor % with availability of Grid	Total Poor %	Total %
Western	2620	595	3215	81.5	1.4	17.1	18.5	100.0
Central	936	596	1532	61.1	7.2	31.7	38.9	100.0
Southern	890	617	1507	59.1	7.8	33.2	40.9	100.0
Northern	254	106	360	70.6	10.0	19.4	29.4	100.0
Eastern	522	325	847	61.6	10.9	27.5	38.4	100.0
North West	1004	501	1505	66.7	9.8	23.5	33.3	100.0
North Central	429	335	764	56.2	16.4	27.5	43.8	100.0
Uva	394	389	783	50.3	23.4	26.3	49.7	100.0

[3] See Appendix 2 for conversion calculations.

Sabaragamuwa	741	468	1209	61.3	12.9	25.8	38.7	100.0
Total	7790	3932	11722	66.5	8.6	24.9	33.5	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

The survey data shows 8.6% of sample households energy poor for lighting due to non availability of electricity connected to grid. As same with the total energy poverty status, here too Western province shows the lowest energy poverty status due to non availability of grid connected electricity and Uva province shows the highest.

However the total level of energy poverty status on lighting 33.5% shows a manageable level of energy poverty status in Sri Lanka. Majority of the population is living above the energy poverty and interventions are needed to be taken for the people belong to this 33.5%. Looking carefully at the data shows majority of the energy poor are connected to grid connection. Therefore interventions such as subsidized tariff or providing a life line rate for these consumers need to be considered. Further details on interventions are considered in section 5 of this study.

63.5% of sample households are above the energy poverty means Sri Lanka is on the way of eliminating energy poverty in terms of lighting. And actions are already taken from the government side in order to improve access to the electricity. Current CEB (Ceylon Electricity Board) tariff gives a subsidized price for households which consume less than 90 units per month, which is approximately 257 units (kWh) per capita per year. Meaning government of Sri Lanka has identified 257 kWh per year per capita is a minimum amount of energy requirement for a person in the country. Which is above than the limit given in the definition considered, 120 kWh. Adding more to that, the level of electrification by year 2007 is 80% and electrification is increasing at a rate of 1.9% where the population growth shows 1.1% (CEB 2007). Government of Sri Lanka together with CEB is planning to expand its electrification up to 85% by year 2010 with the current electrification rate (CEB 2007). This gives the hope for the people who are not connected to grid that they will have the access to electricity soon in the future.

Many sources are used as the energy source for cooking including firewood, saw dust, paddy husk, LPG, kerosene, electricity and biogas. However only few types of energy sources are used in common; firewood, LPG and kerosene. As discussed in the methodology, the level of energy poverty with respect to cooking was derived by calculating the equivalent value of energy source in LPG kg. Central bank Consumer Finances and Socio Economic Survey 2003/04 shows very significant figures of energy poverty in Sri Lanka. It shows 91.4% of sample households from all over the Sri Lanka are falling under energy poverty and Sabaragamuwa shows the highest percentage of energy poverty in cooking, 97.8%, while Colombo shows the lowest percentage of energy poverty in cooking, 81.2% (Table 2)

Table 2: Energy poverty in cooking by provinces

Province	Non Poor	Poor	Total	Non Poor %	Poor %	Total %
Western	603	2612	3215	18.8	81.2	100.0
Central	86	1446	1532	5.6	94.4	100.0
Southern	66	1441	1507	4.4	95.6	100.0
Northern	48	312	360	13.3	86.7	100.0
Eastern	68	779	847	8.0	92.0	100.0
North West	58	1447	1505	3.9	96.1	100.0
North Central	19	745	764	2.5	97.5	100.0
Uva	28	755	783	3.6	96.4	100.0

Sabaragamuwa	27	1182	1209	2.2	97.8	100.0
Total	1003	10719	11722	8.6	91.4	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

The analysis shows an alarming picture of energy poverty status in Sri Lanka with respect to cooking. Many reasons caused making such a high figure of energy poverty for cooking.

Table 3: Main source for cooking by provinces

Province	Firewood	Gas	Kerosene	Electricity	Bio gas	Saw dust	Others	
Western	60.8	34.1	4.7	0.0	-	0.2	0.2	100.0
Central	88.6	9.6	0.9	0.1	0.1	0.1	0.5	100.0
Southern	91.9	7.6	0.4	0.1	-	-	-	100.0
Northern	83.9	4.4	10.8	-	-	0.6	0.3	100.0
Eastern	83.1	11.3	2.8	0.2	-	2.4	0.1	100.0
North West	93.0	6.1	0.8	-	-	0.1	-	100.0
North Central	93.3	6.6	0.1	-	-	-	-	100.0
Uva	93.1	6.8	0.1	-	-	-	-	100.0
Sabaragamuwa	95.8	4.0	0.2	-	-	-	-	100.0
Total	82.8	14.6	2.1	0.1	0.0	0.3	0.1	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

The first factor is cook stove efficiency. As per the Consumer Finances and Socio Economic Survey 2003/04, 82.8% of total samples use firewood as their primary energy source for cooking (Table 3). Majority of the Sri Lankan still use the traditional cook stove for cooking and only a marginal percentage uses the improved cook stoves (further details on this is given in Section 04.3 of this study). However, the required efficiency level of cook stoves in order not to become energy poor is more than 25%. With the very limited number of cook stoves available with that efficiency level, the analysis has taken all the firewood using households as energy poor since they do not meet the cook stove efficiency. This has resulted in showing a very high level of energy poverty status for cooking. In section 04.3 of this study by taking the Department of Census and Statistics data on National Housing and Population 2001, the number of households with biomass usage in each province was considered against the exact number of cook stoves with is having more than 25% of efficiency level. Thereby section 04.3 is trying to calculate the exact number of households who falls under energy poverty in cooking. Further, section 04.5 takes different scenarios in calculating energy poverty and shows the level of energy poverty with different thresholds.

High level of LPG consumption per capita per year mentioned in the definition is also considered as one of the major reasons in having such a high percentage for energy poverty in cooking. Consumption of 35kg of LPG per capita per year means approximately 147 kg of LPG per household per year (assuming 4.2 members in a household). This shows us, in order not be energy poor as per the given definition, an average household who is using LPG as their primary source for cooking will replace a 13.5 kg LPG cylinder in every 5 weeks. This is slightly a high figure for LPG consumption in Sri Lanka compared to a normal household with 4 members replacing their 13.5 kg LPG cylinder in every 10 weeks. Central Bank Consumer Finances and Socio Economic Survey 2003/04 shows the average LPG consumption per capita per month is 2.36 kg, meaning per capita per year consumption 28.3 kg LPG (Table 4) which is a lower figure than the 35kg of LPG as discussed in the definition. Therefore having such a high threshold of 35 kg of LPG for a year might be the reason on having 81.2% energy poverty level in cooking for western province where 34.1% population uses LPG as their primary source for cooking. In section 04.5, energy poverty analysis is given by considering 28.3 kg LPG consumption instead of 35 kg of LPG.

Table4: Average per capita per month consumption of fuel for cooking and lighting.

Province	Per capita LPG (kg)	Per capita kerosene for cooking (ml)	Per capita kerosene for lighting (ml)	Per capita electricity units (kWh)	Per capita firewood (kg)
Western	2.49	722.27	2,438.82	27.06	26.54
Central	2.24	501.00	1,825.88	16.17	40.15
Southern	2.04	327.88	1,478.54	14.76	23.75
Northern	3.08	1,828.62	1,668.84	18.75	28.81
Eastern	2.84	865.64	1,642.54	17.01	33.51
North West	1.89	403.77	1,653.84	17.07	42.02
North Central	1.99	305.56	1,363.56	14.71	34.30
Uva	2.45	376.05	1,274.21	13.16	28.75
Sabaragamuwa	1.92	310.50	1,518.30	14.75	30.07
Total	2.36	569.28	1,629.37	18.84	31.94

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

Further studies are needed in estimating the minimum amount of LPG needed to meet one's basic needs and from there this study can be developed further.

By looking at both lighting and cooking aspects, a combined table for energy poverty was generated. If a household do not meet the minimum level of energy consumption for lighting or for cooking then that household is considered as energy poor.

Table 5: Energy poverty by considering both factors by province

Province	Non Poor	Poor	Total	Non Poor %	Poor %	Total %
Western	566	2649	3215	17.6	82.4	100.0
Central	76	1456	1532	5.0	95.0	100.0
Southern	63	1444	1507	4.2	95.8	100.0
Northern	41	319	360	11.4	88.6	100.0
Eastern	62	785	847	7.3	92.7	100.0
North West	50	1455	1505	3.3	96.7	100.0
North Central	17	747	764	2.2	97.8	100.0
Uva	27	756	783	3.4	96.6	100.0
Sabaragamuwa	24	1185	1209	2.0	98.0	100.0

Total	926	10796	11722	7.9	92.1	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

Though the energy poverty status with respect to lighting is low, the combined energy poverty status in Sri Lanka shows a very high figure in energy poverty as the energy poverty status for cooking is high. The combined energy poverty status shows 92.1% of total sample households are energy poor. This level of energy poverty is definitely an alarming figure for Sri Lanka. Western province being the province with highest socio-economic development and improved access to energy sources demonstrates an energy poverty level of 82.4%. As we have discussed above, the reason behind having such a high level for energy poverty might due to high energy consumption levels maintained in the definition. Once the definition is adjusted more appropriately to Sri Lanka, the level of energy poverty might show a more Sri Lankan friendly picture.

Further detailed analysis on biomass usage and electricity is discussed in below sections followed by possible interventions in reducing the level of energy poverty.

04.2 - Pricing Methodology:

As discussed above, quantitative analysis of measuring energy poverty was done by taking Central Bank Consumer Finances and Socio Economic Survey 2003/04 into consideration. In this section, a pricing methodology is adopted to analyze the energy poverty status by taking Department of Census and Statistics Census (DCS) on National Housing and Population and Household Income and Expenditure Survey 2006/07 into consideration. Two methodologies are adopted in order to compare the findings from both methods and to avoid errors that might come from one data source. Completely two data sources are taken into consideration for two methodologies. It is expected that by using two methodologies and two different data sources, we can get a more accurate picture on the level of energy poverty in Sri Lanka and hence the interventions will make a positive impact on the society.

According to DCS data there are few major types of energy sources for cooking at domestic level. This includes firewood, gas, kerosene, saw dust/paddy husk. The survey has classified households as per their principal type of energy source for cooking. For simplicity of this study, both categories of firewood and saw dust/paddy husk are considered as a single unit, biomass.

As per DCS, lighting is mainly from electricity, kerosene, solar and other sources of energy. This “other” source of lighting and cooking is the energy sources different from electricity, LPG, kerosene or biomass. Further there are some households who have not reported what is their principal type of energy source for cooking. In order to avoid complexity, these two components were not considered in calculating the level of energy poverty. There is no defined path of measuring what is meant by *other source* of energy source and no defined way of collecting the information from the households who have not reported in the original census. Therefore taking those two components will complicate our energy poverty calculations. This “other” category and the group who haven’t reported represent a very minor percentage when it is compared with the other categories[4]. Therefore not taking those categories into calculation will not make a significant different to the final result. Hence the households are listed as per the major energy source used for lighting (Table 6) and for cooking (Table 7)

Table 6: Household categorization as per the principal energy source for lighting

	Principal type of lighting (# of households)			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
Western	196,379	1,008,448	1,408	1,206,235
Central	210,445	358,342	1,198	569,985
Southern	174,335	358,418	723	533,476
Eastern	66,690	68,666	351	135,707
North Western	262,135	286,387	2,224	550,746

[4] 1.56% from the total households have not reported their principle type of cooking and 0.23% of total households have reported they consume “other” source of cooking fuel (DCS 2001)

North Central	143,174	133,547	1,114	277,835
Uva	137,035	142,474	2,352	281,861
Sabaragamuwa	212,702	221,837	1,645	436,184
				3,992,029

(Census of Population and Housing 2001, DCS)

Table 7: Household categorization as per the principal energy source for cooking

	Principal type of cooking fuel (#of households)				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
Western	695,039	398,824	100,357	3,337	1,197,557
Central	499,000	60,140	8,311	2,006	569,457
Southern	479,738	48,856	3,501	666	532,761
Eastern	121,197	10,953	2,718	755	135,623
North Western	514,858	30,444	4,445	601	550,348
North Central	261,495	14,202	1,249	514	277,460
Uva	264,933	14,522	1,502	1,025	281,982
Sabaragamuwa	411,623	22,169	1,694	636	436,122
					3,981,310

(Census of Population and Housing 2001, DCS)

DCS categorization of population in Sri Lanka as per the sectors; urban, rural and estate is given in Table 8.

Table 8: Sector and province wise population distribution

Province	**Urban households**	**Rural households**	**Estate households**	**TOTAL**
Western	395,119	887,474	10,964	1,293,557
Central	57,922	418,054	121,060	597,036
Southern	47,307	493,531	9,469	550,307
Eastern	26,604	113,584	0	140,188
North Western	25,572	527,133	2,255	554,960
North Central	14,136	279,322	339	293,797
Uva	12,600	233,595	41,667	287,863
Sabaragamuwa	18,752	390,073	39,267	448,092
				4,165,800

(HIES 2006/07, DCS)

Western Province Energy Poverty Calculation

By analyzing the above provincial level distribution, we can get the percentage of household's energy consumption in western province as per their energy source used for cooking and lighting.

	Principal type of cooking fuel (%)				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
Western	58.04%	33.30%	8.38%	0.28%	100.00%

	Principal type of lighting (%)			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
Western	16.28%	83.60%	0.12%	100.00%

(Census of Population and Housing 2001, DCS)

As per the energy ladder, the highest income earners are moving to much cleaner and efficient energy sources such as electricity or LPG for cooking and lighting. And lowest income earners are remaining with the least efficient energy sources such as biomass for cooking and kerosene for lighting. Thereby looking at

the expenditure decile of western province we can see where each of the households lies along the energy ladder. From there we can analyze whether the households from one decile are financially capable in utilizing energy as mentioned in our given definition.

In order to get more specific data on energy poverty status of the province, we need to divide the western province population as per the sectors; urban, rural, estate and as per expenditure decile.

Analyze of western province urban sector as per the expenditure decile

Expenditure decile	1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs (HIES 2006/07)	8535	13455	16785	19977	23435	26970	32189	40786	59422	141367

Electricity used for cooking is generally negligible compared to other energy sources (in the case of western province its 0.28%). Also, solar energy source used for lighting is also generally negligible compared to other sources used for lighting (in the case of western province its 0.12%). Therefore, through out the whole calculation process, both solar energy for lighting and electricity used for cooking were not taken in for the energy poverty calculations.

DCS has defined the expenditure deciles separately for urban, rural and estate sectors. They have not defined expenditure deciles as per the provinces. However there could be differences from western province rural sector to rural sector of north central province. Since DCS has not defined expenditure deciles separately for each province's sector, three expenditure deciles were taken uniformly for all the provinces.

By analyzing the Census of Population and Housing 2001 and HIES 2006/07, we can obtain the average expenditure ratio on western province for cooking and lighting as 4.82%.

Population from lower deciles might be spending more percentage on cooking and lighting expenditure than the population from higher deciles. However data are not available in order to calculate the expenditure ratio spent on lighting and cooking at each expenditure decile. Therefore it is assumed the same expenditure ratio on lighting and cooking expenditure exists for all the expenditure deciles.

In case of western province, it is assumed 4.82% of expenditure ratio on lighting and cooking is constant with all the deciles in urban sector. By integrating this percentage into the expenditure decile we get the financial allocation for cooking and lighting at each expenditure decile. Together with this we can do the analysis on each expenditure decile by looking at which energy source the decile uses as per the energy ladder

Lighting	Kerosene	16.28%								
	Elect		83.72%							
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
allocation for urban sector cooking and lighting Rs		**411**	**649**	**809**	**963**	**1,130**	**1,300**	**1,552**	**1,966**	**2,864**	**6,814**
Cooking	Bio	58.04%									
	Kerosene							8.38%			
	LPG							33.30%			

Arguing with the concept of energy ladder, households in expenditure decile 10, 9, 8 and 7 use electricity for lighting and LPG for cooking. However there is a percentage of households in decile 7 who use electricity for lighting and kerosene for cooking. From decile 2 to 5 households use electricity for lighting and biomass for cooking. At the lowest expenditure decile, households use kerosene for lighting and biomass for cooking.

We can now compare whether the households from each expenditure decile can enjoy the energy consumption level as given in our definition. For an example, we need to check the affordability of using 35kg of LPG for cooking and 120 kWh electricity for lighting per capita per year for a person belongs to expenditure decile 10.

The definition gives us energy consumption per capita per year. In order to compare with this expenditure decile, we will look at per household energy consumption per month.

In order to do the comparison, let's calculate the associated costs of energy sources for the quantities given in our definition:

Lighting –
Electricity cost for household per month – 120kWh*4.16[5]* Rs 8.10[6]/12
-Rs. 336.96

Kerosene cost for household per month - 0.1l[7]*120*4.16*Rs57.44[8]/12
- Rs 238.95

Cooking –
Electricity cost for household per month - 13.77[9]*35*Rs 8.1*4.16/12
- Rs. 1353.32

LPG cost for household per month - 35*Rs 78.83[10]*4.16/12
- Rs. 956.49

Kerosene cost for household per month - 1.34[11]*35*4.16*Rs 57.44/12
- Rs 933.90

We will not follow the pricing methodology for biomass, instead we will follow the cook stove efficiency of biomass using households and from that we will determine the level of energy poverty in each province.

Therefore we can get combine expenses for both lighting and cooking

	Lighting	
	Electricity	Kerosene
LPG	1,293.45	
Kerosene	1,270.86	

Given these expenses, we can now compare it with each expenditure decile. When we take into consideration decile 10, we need to look the scenario of LPG for cooking and electricity for lighting. If a household is meeting the minimum quantities given in our definition, then that household needs Rs 1293 for

[5] Average number of persons per household (DCS, 2008)
[6] Average domestic tariff of CEB for the year 2006/07. It is assumed this tariff applies for all the units. The general subsidized tariff rates offering by CEB are not considered in order to make the calculations simple.
[7] Equivalent of kerosene to electricity. For further breakdown see Appendix2:
[8] Average price of liter of kerosene for the year 2006/07 (DCS, 2008)
[9] Equivalent of electricity to LPG. For further breakdown see Appendix2:
[10] Cost of 1 kg of LPG in year 2006/07 (DCS,2008)
[11] Equivalent of kerosene to LPG. For further breakdown see Appendix2:

LPG electricity combination. This decile allocates Rs 6814 for lighting and cooking expenses. Therefore it can be clearly argued households falling under this decile can be considered as non energy poor.

If we follow the same procedure for deciles 7, 8, 9 and 10; the fuel combination is electricity for lighting and LPG for cooking. Even with the lowest decile, 7, households are having enough financial allocations to meet their energy quantities as per the definition. And with the scenario of kerosene electricity for cooking and lighting respectively, it requires Rs 1270 and the allocation is Rs 1552. Hence all four deciles are non-energy poor.

This analysis confirms us there are no energy poor households in western province urban, non-biomass using sector.

We will be analyzing all the expenditure deciles dealing with biomass in a separate section.

Analyze of western province rural sector as per the expenditure decile

We can repeat the same analysis here as we have done in western province urban sector.

Lighting	Kerosene	16.28%									
	Elect		83.72%								
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of rural sector Rs		5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting		0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
allocation for rural sector cooking and lighting Rs		**251**	**400**	**486**	**576**	**679**	**792**	**943**	**1,162**	**1,521**	**3,138**
Cooking	Bio	58.04%									
	Kerosene							8.38%			
	LPG							33.30%			

Considering different deciles;

Decile 10 – Allocated amount for lighting and cooking is Rs 3138, where as the cost for fulfilling the minimum quantity will be Rs1293 for LPG for cooking and electricity for lighting combination. Therefore this decile can be considered as non energy poor.
Decile 9 – Allocated Rs 1521, required Rs 1293. Therefore this decile is also not energy poor.
Decile 7/8 – Allocated Rs 943 and 1162 respectively, required Rs 1293 or Rs 1271. Therefore both deciles are energy poor.

Analysis of western province rural sector reveals 2 expenditure deciles are energy poor. In expenditure deciles, each decile is comprised of equal number of households. In western province rural sector, a decile is comprised of 88,747 households (HIES 2006/07, DCS). We can conclude, there are 177,494 energy poor households in Western province rural sector.

Analyze of western province estate sector as per the expenditure deciles

Lighting	Kerosene	16.28%									
	Elect		83.72%								
Expenditure decile		1	2	3	4	5	6	7	8	9	10

avg expenditure of estate sector Rs	4705	7345	8994	10355	11657	12814	14106	15337	17661	26546
avg exp ratio on province for cooking and lighting	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
allocation for estate sector cooking and lighting Rs	**227**	**354**	**434**	**499**	**562**	**618**	**680**	**739**	**851**	**1,280**
Cooking	Bio	58.04%								
	Kerosene						8.38%			
	LPG						33.30%			

Decile 10 – Allocated Rs 1280, required Rs. 1293
Decile 7/8/9 – Allocated Rs 680, Rs 739, Rs 851 respectively, required Rs 1293 or Rs. 1271

This analysis shows that all above mentioned deciles do not have enough financial allocations to meet the energy consumption level as mentioned in the definition. That adds up to 4 deciles which fall under the category of energy poor. In western province estate sector, a decile is comprised of 1096.42 households (HIES 2006/07, DCS). Hence we can conclude in western province estate sector all together 4386 households are energy poor.

Summary of Energy Poverty Status of Western Province, Sri Lanka (Excluding biomass using households) [12]

Energy poor households			
Urban	Rural	Estate	TOTAL
0	177,494	4386	181,880

Western Province Energy Poverty Status
Households with biomass usage:

Total biomass used households	695,039
Energy poor households	690,545
% of poor from total biomass used	99.35%

Total households summary, Western Province:

Total households	1,293,557
Energy poor households	872,425
%of energy poor from total households	67.44%

Similar calculations are done for all the provinces. Energy poverty statuses for all the provinces are given in below section 04.5.

04.3 - BIOMASS as Household Cooking Energy:

> *"Cooking as an enjoyable pastime and passion for a privileged minority – on an electric range or a gas stove in a stylish kitchen in New York, Paris or Tokyo. Cooking as a chore and threat to the lives of the great majority – on an open fire in a shabby hut in rural Africa, south Asia or Latin America"*
> (WHO 2004 p.9)

[12] Refer Section 04.3 for further details and calculations.

Usage of biomass at household level:
Majority of Sri Lanka's population still depends on biomass as their primary source of cooking. Usage of biomass is decreasing in Urban sector while stating a figure of 37.6% in 2006/07 and biomass plays dominantly in both rural and estate sector which shows the usage of 84.8% and 96.7% respectively (DCS 2008b). Survey conducted on Millennium Development Goals in year 2006/07 by DCS has shown 79% of the whole Island's population depends on biomass as their primary source of cooking. Among the districts Colombo district shows the lowest consumption biomass of 33.8% and Monaragala shows the highest consumption of biomass adding up to 97% (Table 1) (DCS 2008b).

Table 10: Sri Lanka's biomass usage at Province/District level

Sri Lanka		**79.0**
Province	Western	54.5
	Central	86.5
	Southern	90.2
	Eastern	77.9
	North - western	91.0
	North - central	94.6
	Uva	94.8
	Sabaragamuwa	92.7
District	Colombo	33.8
	Gampaha	62.2
	Kalutara	80.4
	Kandy	82.9
	Matale	91.9
	Nuwara-eliya	90.1
	Galle	88.0
	Matara	89.6
	Hambantota	94.6
	Batticaloa	72.1
	Ampara	82.9
	Kurunegala	93.8
	Puttalam	84.5
	Anuradapura	94.2
	Polonnaruwa	95.5
	Badulla	93.5
	Moneragala	97.0
	Ratnapura	92.7
	Kegalle	92.7
Sector	Urban	37.6
	Rural	84.8
	Estate	96.7

(Survey on Millennium Development Goals -2006/07, DCS)

As per the energy poverty definition taken for this study, in order for a household not to become energy poor, per capita energy consumption per year should be more than 35 kg of LPG or equivalent. However, the minimum efficiency of the cook stove should be 25%. Therefore rather than calculating the LPG

equivalent of biomass used for cooking, by measuring the efficiency of cook stoves, we can identify how many households are energy poor.

From the Sri Lankan biomass users, most of them use less efficient traditional 3 stone cook stoves. Low but increasing amounts of households use medium efficient cook stoves. Only a marginal percentage uses the efficient, improved cook stoves. The efficiency of improved cook stoves are given as below,

Type of Stove	**Efficiency - %**
Three stone hearth (TCS)	8
Single & two pot mud stove (TCS)	13
Anagi stoves 1 & 2 (ICS)	18
Ceylon Charcoal Stove (ICS)	30
Sarvodaya two pot stove (ICS)	22
CISIR single pot stove (ICS)	24
IDB stove (ICS)	20
NERDC stoves (ICS)	27
NERDC wood gas stove (ICS)	35

(Leelarathne. M.W. 2008)

From the efficiency chart it can be clearly seen only NERDC cook stoves are having more than 25% of efficiency from all type of cook stoves in Sri Lanka.

It is estimated that so far only 21,000 NERDC cook stoves has been sold[13]. If we assume a proportionate basis distribution of NERDC cook stoves province wise, then we can see the pattern as,

District	No of households principal type of cooking, biomass	TOTAL	Distribution of NERDC cook stoves	Households without NERDC cook stoves
Colombo	167,927			
Gampaha	325,963			
Kalutara	201,149	695,039	4,494	690,545
Kandy	248,643			
Matale	102,131			
Nuwara Eliya	148,226	499,000	3,226	495,774
Galle	201,109			
Matara	158,115			
Hambantota	120,514	479,738	3,102	476,636
Ampara	121,197	121,197	784	120,413
Kurunegala	358,699			
Puttalam	156,159	514,858	3,329	511,529
Anuradhapura	175,434			
Pollonnaruwa	86,061	261,495	1,691	259,804
Badulla	172,706			
Monaragala	92,227	264,933	1,713	263,220
Rathnapura	228,344			
Kegalle	183,279	411,623	2,661	408,962
TOTAL			**21,000**	**3,226,883**

[13] As per the sales records of Spectra Industries Pvt Ltd. The only authorized manufacturer for NERDC improved cook stoves

With this it can be argued that from all the households, which uses biomass as principal source of cooking, a total of 3,226,883 households do not meet the minimum cook stove efficiency of 25%. **Hence by only considering the cooking factor of determining the energy poverty we can say a total of 3,226,883 households are energy poor. As a percentage, 99.35% of households whose principal source of cooking is biomass are energy poor.**

However both DCS and Central bank surveys do not include data on household cook stove efficiencies. Therefore from the data sources used, direct quantitative analysis can not be taken with respect to households vs cook stove efficiencies. Further, much data is not available on quantifying the amount of cook stoves used in Sri Lanka. Study done by Amarasekara, R.M., Atukorala, K (2002) was the only source found quantifying the cook stoves usage as per the households.

Somebody might argue if we get the firewood free of charge from the village or from our surrounding and if we can access to plenty of them, then the cook stove efficiency is not a major issue. It is argued that people should not be treated energy poor by taking cook stove efficiency into consideration. However, it is not rather a question of efficiency of cook stoves; it is a question of survival and wellbeing of majority of Sri Lankan who use biomass as their primary source of cooking. It is about providing a deadly smoke free kitchen to them; it is about better health for children and women and about empowerment of women. With the astonishing figure of energy poverty status among the biomass users, interventions have to focus them in order to maintain equity in energy services and improve the living condition of majority of Sir Lankan.

Implications of Biomass Usage at Household Level:

> *"Opening the door to their (the poor's) homes makes for a hazy welcome: thick grey smoke fills the air, making breathing unbearable and bringing tears to the eyes "*
>
> (WHO 2004 p.9)

Inefficient burning of biomass produces a mixture of pollutants containing Carbon Monoxide, Nitrogen Oxides, Sulfuric Oxides and many other chemicals including small particles(with a diameter up to 10 microns). These toxic particles and chemicals make serious dead threats to women and children who are mostly expose to smoke from the kitchen. These small particles can go deep into the lungs and airways and cause various health deceases. World Health Organization (WHO) studies have shown that smoke from the kitchen doubles the risk of pneumonia and other acute infections of lower respiratory tract among children under 5 years age and of women it gives three times high risk than the women who cook from cleaner fuel such as electricity or LPG from suffering chronic obstructive pulmonary disease, such as chronic bronchitis or emphysema (WHO 2000). The list of health hazards coming out as a result of indoor air pollution is keep on increasing including asthma, adverse pregnancy outcomes, low birth weight...etc. From a study conducted in year 2000, WHO has announced indoor air pollution as one of the top 10 global health risks where in year 2000, it has been responsible for death of 1.6 million people all around the world (WHO 2000).

With a high efficiency of cook stoves, emissions of biomass could be minimized and hence it can give a better life hope for the poor. Not only the level of emissions, but also the exposure for the pollutants needs to consider when we look at health implications from indoor air pollution. The energy poverty definition taken for this study describes the maximum level of exposure for the pollutants allowed in order not to be energy poor *(maximum concentration of CO of 30mg/M3 for 24 hours periods and less than 10mg/ M3 for periods 8 hours of exposure).* There are few studies conducted on the level of exposure and emissions in the region (Bhattacharya et al. 2000) however not sufficient data are available to calculate the exposure level within the Sri Lankan households. Study done by University of Moratuwa, Sri Lanka on firewood cook stoves (Perera K.K.C.K, Sugathapala A.G.T, 2000), has analyzed the emissions caused by different cook stoves. Further, the study has shown the lack of available data and research done on the level of exposure. Further research needs to address the exposure level in order to get an accurate picture on level of exposure for the pollutants in Sri Lanka. Hence, the level of exposure was not taken into consideration for this study.

Different types of biomass are used for cooking in Sri Lankan households mainly firewood, paddy husk and saw dust. Considering firewood, there are many varies of firewood is used for cooking. There are some common types of firewood are available for purchase at the market. However women and children collect different types of firewood from various sources; including their own garden, natural forest, forest plantation etc. The concern is whether emissions from all these different types of firewood are the same? Neither there

has been a former study to address this issue nor is data available in Sri Lankan context to include that information to this study. As a result, information on emissions from different types of biomass is not considered in measuring the energy poverty under this study.

Biomass using households access the biomass in two methods. One to purchase them and the second is to collect the biomass. With the increasing cost of firewood and other biomass, women tend to collect the firewood when it is possible. The collected biomass is treated as "free". However, when considering the women's time utilized in collecting the biomass, it can be seen the biomass collected are not actually free, but the opportunity cost of the time spent is not calculated. The poor households can not escape from their poverty circle as far their women, one of the main income generation sources of the family, do not involve in income generation. With the time spent on biomass collection, being involved in livelihood activities has become only a dream for the women. Adding to that, less efficient cook stoves consume more fuel to cook a meal resulting women to spend more time in collecting the biomass (Goldemberg, J., et al 2004). In most cases not only the women but the young children also tend to go for free biomass collection with their mothers. This results in lack of education opportunities for the children. Education is considered as one of the key ways of coming out of poverty, with the lack of education opportunities for the children, poor are losing their hope of escaping from poverty even in the next generation. Adding to that, sudden accidents and deaths can be seen at villages during the biomass collection by women and children. Eg. Snake bites

Identifying the importance of time spent on biomass collection, the definition taken in this study to measure the energy poverty has included a measurement of cooking fuel collection. Energy source "*for cooking is one which requires less than 4 hours person per week per household to collect fuel*". In Sri Lankan context no research has done on measuring the women's and children time spent on collecting the biomass for household consumption. Even the surveys conducted by Central Bank of Sri Lanka, DCS or Sustainable Energy Authority do not include information on biomass collection time. Therefore with the lack of available data, biomass collection time was not taken into consideration of this study. Future research and surveys needs to focus on collecting the information around this matter in order to improve the life standards or majority of population in Sri Lanka who uses biomass.

In year 1998, 9327kt of firewood consumed for domestic cooking (Perera K.K.C.K, Sugathapala A.G.T 2000). With passing day by day with the increasing population, the amount of firewood required is increasing and more trees are falling down to meet the human needs. Sri Lanka's forest cover is decreasing and afforestation is not happening at the same phase as deforestation. Many factors influence the ongoing trend of deforestation including development projects, chena cultivation and firewood consumption (Perera K.K.C.K, Sugathapala A.G.T 2000). Increase in cook stove efficiency means decrease in firewood consumption which will reduce deforestation at the end.

Though we did not consider carbon dioxide as a toxic emission in indoor air pollution, carbon dioxide emissions from biomass cooking causes global warming and it acts as a green house gas (GHG). Studies have shown improved cooking sources emit less carbon monoxide to the atmosphere than the less efficient cook stoves (Goldemberg, J., et al 2004). High efficient cook stove means less GHG and less global warming. However improved and efficient energy sources for cooking mean LPG or electricity. Generation of electricity might occur from burning of fossil fuels. And LPG comes as a by-product of crude oil extraction. There is an issue arises whether GHG emissions occur from the process of improved energy sources are lesser than the GHG emissions from the less efficient cook stoves around the world. More research needs to be done comparing those two and until that the exact implication is not yet known.

04.4 – Impact of Electricity on Poor Households:

Electricity services for the poor households are multi folding. It helps in income generation, safe improved energy source for lighting, improved health services, direct benefits to women and children... etc. Having access to electricity for a household uplifts the living condition and living status of all members of the household. It helps in improving their livelihood opportunities and this directly affects to the national economy positively. Having electricity will improve the human development, gender empowerment specially women and poverty alleviation. With the electricity people can work for extended hours and improved technology saves time, this gives the opportunity for both men and women to involve in political activities and hence it will enhance the good governance at village level. From a holistic point of view, having electricity will enhance the living of poor and will benefit the country as a whole.

Having electricity at rural areas would add further benefits. It will provide attractive opportunities to investors and village level men and women would get better employment opportunities as a result. Urbanization and village people migration to cities in search of jobs will be reduced subsequently.

Electricity helps immediately for households by providing a clean, safe and efficient source of energy for lighting. It will extend poor's available hours for working. Electricity is much cleaner than the ordinary kerosene lamp. There are evidence from Sri Lanka on deaths which incurred by accident fires caused by kerosene lamps. Replacing electricity with kerosene lamp will provide a safer energy source for all the poor households. Electricity would bring a television or radio to poor's home giving them the opportunity in entertainment and knowledge. Proper light will allow children to study safely and for longer hours. Electricity will help them in enhancing income generation activities at domestic level.

Apart from direct benefits at household level, there are some other benefits of electricity such as improved health services. Village level health clinics and rural hospitals provide a great service to the village. Vaccinations and other medicines at village health clinics play a major role in keeping the good health of the poor. Without having refrigeration, keeping vaccinations and other medicines which needs to be stored in a cool dry place will not be possible. With lighting from electricity, health clinics and rural hospitals will be able to function at night providing an improved service.

Electricity and improved education services goes hand to hand. As identified earlier, electricity will give better opportunities to children to study under a proper light for a long time. It will allow will schools to improve new education methodologies to the school, such as use of audio visual techniques. Electricity will allow poor school children to link with the rest of the world by using computers, internet and information communication technology. Improved laboratory facilities and being able to access the advance technologies will take the school to the next step of science and technology.

Electricity would reduce women's time spent in grinding milling and processing. This will give women to engage in other livelihood activities as be a support for their husbands in income generation. With the heavy workload at home, unless men, women do not get the opportunity to expose to the rest of world other than her usual mates who goes for firewood collection and fetching water together. Television and radio will give women to expose to the rest of the world. Hence it will expand their thinking and will empower them.

Therefore it is time to consider than electricity is not a privilege that we are having. But rather it is a basic need for all human beings. It helps you and me tremendously in our daily life; but it will help more for the poor people. Energy poverty in terms of lighting needs to eliminated in order to bring human prosperity to one own mother land.

04.5 – Energy Poverty Status in Sri Lanka

In above section 04.2, the energy poverty status of western province was calculated in detail. Similar type of calculations shows the energy poverty status of all provinces[14]. By analyzing the energy poverty calculations of all the provinces in Sri Lanka we can come to an overall picture of energy poverty status of Sri Lanka (Table 11).

Table 11 – Current Energy Poverty status of Sri Lanka (as per pricing approach)

Province	Total Households	Energy Poor Households	% of Energy Poverty
Western	1,293,557	872,425	67.44%
Central	597,036	520,907	87.25%
Southern	550,307	497,642	90.43%
Eastern	140,188	120,637	86.05%
North Western	554,960	512,706	92.39%
North Central	293,797	260,321	88.61%
Uva	287,863	267,876	93.06%
Sabaragamuwa	448,092	413,649	92.31%

[14] Please refer Appendix 3 for further details.

	4,165,800	3,466,163	83.21%

This analysis shows that Western Province shows the lowest percentage of energy poverty status, 67.44% and Uva Province shows the highest percentage of energy poverty status, 93.06%. The average level of energy poverty status in Sri Lanka is 83.21%. This result shows energy poverty status of Sri Lanka is alarmingly high. However the high number of energy poverty prevails mainly due to lack of efficiency in biomass cook stoves and due to high LPG consumption level mentioned in the definition. Apart from the western province, all other provinces show energy poverty status more than 87%. Having such high level of energy poverty shows us urgency in launching new interventions to deal with energy poverty immediately.

04.5.1 Comparison of Pricing Approach and Quantitative Approach

Comparing the two approaches, quantitative approach shows a higher level of energy poverty than pricing approach. Table 12 given below shows the total energy poverty status of Sri Lanka as per the quantitative approach is 92.1% and as per the pricing approach total energy poverty level goes as 83.21%. Both approaches show the minimum level energy poverty exists in western province. Quantitative approach shows Sabaragamuwa province with highest level of energy poverty, 98% and pricing approach shows Uva province with the highest energy poverty level, 93.06%. Thereby we can see the results came from two data sources by using two methodologies are having similar results pattern to each other. However there are some differences, and it can be argued that one of the main reasons for having such differences is that quantitative analysis has assumed all the firewood using households are energy poor due to very limited availability of cook stoves with higher efficiency. And the pricing methodology has analyzed what is the current level of distribution of cook stoves with higher efficiency and then the level of energy poverty was derived from the firewood using households.

Table 12: Combined table linking results from both approaches

	Energy poverty status	
Province	**Quantitative approach**	**Pricing approach**
Western	82.40%	67.44%
Central	95.00%	87.25%
Southern	95.80%	90.43%
Northern	88.60%	Not available
Eastern	92.70%	86.05%
North Western	96.70%	92.39%
North Central	97.80%	88.61%
Uva	96.60%	93.06%
Sabaragamuwa	98.00%	92.31%
TOTAL	92.10%	83.21%

04.5.2 Looking at Energy Poverty with Variations to the Definition

04.5.2.1 – Calculating energy poverty without considering the cook stove efficiency

In earlier sections it is discussed, energy poverty in cooking is high due to high efficiency level considered in measuring energy poverty. Therefore it is worth considering how energy poverty will look like if we do not consider cook stove efficiency in energy poverty calculations. This calculation is possible with quantitative approach of calculating energy poverty. There we calculate the level of energy poverty by looking only at the quantity of energy consumed and not by linking it with the cook stove efficiency. In doing so, we get a very low level of energy poverty in Sri Lanka with respect to cooking, a percentage of 11.4% (Table 13). This is much lesser than the previous level of energy poverty (91.4%, Table 2) where we looked at 25% efficiency level. Interestingly this analysis shows that western province shows the highest level of energy poverty in cooking (23.9%) once we neglect the cook stove efficiency. And North western province shows the lowest level of energy poverty in cooking, 3.6%. In other words this analysis shows us majority of people from north western, north central and Sabaragamuwa provinces consumes the required quantity of energy sources to meet their needs. Further this analysis shows us utilization of firewood or biomass is not a major issue for

the households from rural sections of the country. Whether its purchased r freely collected, people do have access and people do consume energy sources to meet their needs. In the earlier sections these provinces were treated as high energy poor provinces due to the fact of cook stove efficiencies. Given the fact of improved cook stoves provided to these provinces, eliminating energy poverty from these provinces much easier than that of western province.

This proves the fact that cook stove efficiency plays a major role in energy poverty in Sri Lanka. There we can identify dissemination of improved cook stoves serves as one of the key interventions in dealing with energy poverty in Sri Lanka.

Table 13 – Level of energy poverty with respect to cooking by neglecting the cook stove efficiency

Province	Non Poor (%)	Poor (%)	Total (%)
Western	76.1	23.9	100.0
Central	93.3	6.7	100.0
Southern	93.2	6.8	100.0
Northern	90.0	10.0	100.0
Eastern	89.0	11.0	100.0
North West	96.4	3.6	100.0
North Central	95.5	4.5	100.0
Uva	90.8	9.2	100.0
Sabaragamuwa	93.5	6.5	100.0
Total	88.6	11.4	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

If we combine both lighting and cooking factors of energy poverty with this new scenario, not considering the cook stove efficiency for energy poverty, then we get an overall low level of energy poverty for Sri Lanka. (Table 14)

Table 14 – Level of energy poverty in Sri Lanka by neglecting the cook stove efficiency.

Province	Non Poor (%)	Poor (%)	Total (%)
Western	61.3	38.7	100.0
Central	56.7	43.3	100.0
Southern	55.0	45.0	100.0

Northern	65.3	34.7	100.0
Eastern	54.8	45.2	100.0
North West	64.1	35.9	100.0
North Central	52.9	47.1	100.0
Uva	46.0	54.0	100.0
Sabaragamuwa	57.8	42.2	100.0
Total	58.0	42.0	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

This analysis shows a very low amount of energy poverty (42%) than our previous scenario where we have considered 25% of efficiency level (92.1%, Table 5). Even after linking lighting and cooking, north western province was able to maintain a relatively low figure for overall energy poverty, 35.9 %. However provinces like Sabaragamuwa and north central were not able to maintain low level of overall energy poverty due to their high level of energy poverty in lighting. This analysis shows the lowest level of energy poverty in Northern Province 34.7%, while western province was maintain the second least level of energy poverty with 38.7%.

With a less figure for energy poverty, it can give motivation in bringing up interventions in reducing the existing energy poverty. Therefore the question is whether 25% of efficiency level is a realistic or rather relevant figure in Sri Lankan context.

04.5.2.2 – Calculating energy poverty with 18% cook stove efficiency

Past analysis (Amarasekara, R.M., Atukorala, K., 2002) shows that an increasing number of households use the Anagi cook stoves which generally demonstrate efficiency of 18%. Further Amarasekara, R.M., Atukorala, K. reveal that the distribution of Anagi cook stoves are goes over 300,000 units annually covering 14 districts and 60% of the country and from the total households in Sri Lanka approximately around 18% of biomass using households are using Anagi cook stoves. Somebody might argue 18% efficiency is appropriate for a cook stove and the level of energy poverty should be measured based on that. If we calculate the level of energy poverty based on 18% cook stove efficiency, then we get 18% of biomass users are above the poverty line and 82% of biomass users can be considered as energy poor. This is relatively low level of energy poverty considered to previous evaluation where we looked 25% efficiency level and we got 99.35% (Table 15) is energy poor. Therefore when we consider 18% efficiency level, for the whole country we get 69.1% of energy poverty level. This figure is relatively smaller than the figure of 83.21% which was derived by considering 25% cook stove efficiency.

Table 15: Overall energy poverty by considering 18% of efficiency level (pricing approach)

Province	Total Households	Energy Poor Households	% of Energy Poverty
Western	1,293,557	751,812	58.12%
Central	597,036	433,392	72.59%
Southern	550,307	394,332	71.66%
Eastern	140,188	99,382	70.89%
North Western	554,960	422,409	76.12%
North Central	293,797	214,460	73.00%
Uva	287,863	221,412	76.92%
Sabaragamuwa	448,092	341,458	76.20%
	4,165,800	2,878,656	69.10%

With that, we can get a comparison of energy poverty with 18% and 25% cook stove efficiency levels, by considering all biomass users as energy poor and by neglecting cook stove efficiency.

	Efficiency Level			
	By considering all biomass as energy poor	25%	18%	By neglecting cook stove efficiency
National Energy Poverty Status	92.10%	83.21%	69.10%	42%

There we see a huge difference with neglecting cook stove efficiency and by considering all biomass as energy poor. This figure shows us how important role plays by cook stove efficiency in energy poverty estimation of Sri Lanka.

04.5.2.3 – Calculating energy poverty with average LPG consumption of Sri Lanka, 28.3 kg

Both quantitative analysis and pricing analysis has shown a high figure for energy poverty with respect to cooking while maintaining a low level for energy poverty in terms of lighting. Analysis did with Central bank Consumer Finances and Socio Economic Survey 2003/04 reveals 28.3 kg LPG as the average LPG consumption per capita per year and 226 kWh as the average electricity consumption per capita per year. In section 04.1 it is identified high level of energy poverty with respect to cooking is established due to the fact that 35 kg of LPG consumption per capita per year is relatively a high threshold in measuring energy poverty for Sri Lanka.

In order to look at energy poverty with average LPG consumption, instead of 35 kg of LPG, 28.3 kg of LPG is taken into consideration in measuring energy poverty. However, as international definition's electricity consumption level lies below the Sri Lanka average figure, 120 kWh of electricity consumption was considered in measuring energy poverty with respect to lighting.

By taking the new threshold of 28.3 kg, we get the overall level of energy poverty in Sri Lanka as 89.1% (Table 16) it is slightly lesser than the previous level of energy poverty (92.1%, Table 5) with the threshold of 35 kg of LPG.

Table 16 – The level of energy poverty by considering 28.3 kg of LPG as the threshold

Province	Non Poor (%)	Poor (%)	Total (%)
Western	24.7	75.3	100.0
Central	6.8	93.2	100.0
Southern	5.2	94.8	100.0
Northern	13.9	86.1	100.0
Eastern	9.2	90.8	100.0
North West	4.9	95.1	100.0
North Central	3.3	96.7	100.0
Uva	4.9	95.1	100.0
Sabaragamuwa	2.9	97.1	100.0
Total			

	10.9	89.1	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

However even with the 28.3 kg LPG threshold, the cook stove efficiency was taken into consideration. Meaning, cook stoves which are less than 25% efficiency level were considered as energy poor. In this analysis also as in analysis done in Table 5, since very few cook stoves are distributed in Sri Lanka which exceeds 25% efficiency level, all biomass using households are considered as energy poor. Another scenario of looking at the energy poverty is we will be taking the 28.3 kg of LPG as the threshold and we will be assuming all the cook stoves are efficient. In other words we will not be take cook stove efficiency into consideration. From that scenario, we get a low level of energy poverty for Sri Lanka than in the previous analysis (Table 17)

Table 17 – Level of energy poverty by taking 28.3 kg LPG as threshold and by neglecting the cook stove efficiency.

Province	Non Poor (%)	Poor (%)	Total (%)
Western	68.7	31.3	100.0
Central	58.2	41.8	100.0
Southern	56.4	43.6	100.0
Northern	68.1	31.9	100.0
Eastern	57.4	42.6	100.0
North West	65.0	35.0	100.0
North Central	53.9	46.1	100.0
Uva	48.0	52.0	100.0
Sabaragamuwa	59.1	40.9	100.0
Total	61.1	38.9	100.0

(Table was generated by CEPA by using Central Bank Consumer Finances and Socio Economic Survey 2003/04)

Table 16 and 17 proves us the high level of energy poverty in Sri Lanka exists due the fact of high LPG consumption level required and due to high efficiency level required in the cook stoves. Once the LPG level is reduced to the average level and once the efficiency level is not considered, we can see a low energy poverty level as 38.9% compared to previous level of 92.1%.

04.5.3 Estimating Energy Poverty by 2015 and 2025

Some factors needs to be considered in estimating energy poverty by 2015 and 2025. Namely population growth rate of the population, fluctuations in per capita income, fluctuations in fuel prices and prices of other energy sources, availability of energy sources both conventional and alternative. Further global initiatives on climate change and global energy crisis will also affect in energy poverty estimation of Sri Lanka by 2015 and 2025.

With these diverse and dynamic variables, it is almost impossible to do the estimation for energy poverty for year 2015 and 2025. It is almost impossible to evaluate external and internal factors influencing the above variables and their trends hard to be estimated. These challenges make energy poverty estimation 2015 and 2025 very challenging.

In order to look how these factors influencing energy poverty let us randomly consider a household from 9th expenditure decile in western province rural sector. There the lighting and cooking combination is electricity and LPG respectively. There its required Rs 1293 and allowed for fuel/lighting is Rs 1521. Imagine with the increasing prices of fossil fuel, LPG prices increases drastically and households will not be able to fulfil their energy needs with the allowed financial allocations. Then they fall into energy poverty. But lets assume, average household income also increase and the expenditure levels in expenditure deciles increase. Therefore even with the increase of LPG price, household will be able to fulfill their energy needs with the allowed financial limit. With years to come this pattern could change from time to time and the percentage of energy poverty could vary from time to time. Therefore it can be predicted with all these different variables it not practically possible to do an accurate estimation for energy poverty by 2015 and 2025.

In order to make the estimation much simpler, only the population growth rate is considered in estimating the energy poverty. If proper interventions are not initiated to combat energy poverty, then we can get the following energy poverty figure for year 2015 and 2025;

	Population	**No of households**	**Energy poverty %**	**Households in energy poverty**
2015	21,963,488	5,229,402	83.24%	4,352,954
2025	24,526,886	5,839,735	83.24%	4,860,995

Interventions need to be designed in such a way to halve the energy poverty by 2015 and to totally eliminate the energy poverty by 2025.

SECTION 05

05.1 How to halve the energy poverty by 2015 and eliminate by 2025

With the alarming figure for energy poverty, interventions need to be identified and implemented immediately. As discussed above, to improve the living of thousands of poor, the majority of Sri Lanka's population, energy poverty needs to be minimized. Unless proper interventions are taken now, the level of energy poverty might further increase and the living of the poor might deteriorate more.

Combat against energy poverty could be multi-dimensional. Various aspects need to be considered in dealing with energy poverty. Some interventions could address directly to minimize energy poverty with respect to lighting or with respect to cooking. Where as some interventions might address energy poverty from a holistic point of view. In this section it is tried to identify few interventions which influence the energy poverty status in cooking and lighting directly and some intervention which will influence from a holistic point of view.

Specific intervention to address the energy poverty with respect to cooking; Cook Stove Efficiency – From the earlier sections we have identified cook stove efficiency plays a major role in energy poverty in cooking. Having high efficient cook stoves for households who are using biomass means less energy poverty in cooking and less level of energy poverty in Sri Lanka. Therefore what needs to be done is to maximize the usage of high efficient cook stoves.

There have been couples of initiatives in Sri Lanka on distribution of improved cook stoves. From the time of 1970's, Industrial Development Board and different organizations had worked in developing improved cook stoves and mass scale cook stove distributions has started by CEB and they have launched Anagi-1 and Anagi-2 stoves (Amarasekara, R.M., Atukorala, K., 2002). Similar mass scale cook stove dissemination is

required in order to eliminate the current energy poverty issue in Sri Lanka. However, there we need to go beyond Anagi-2, and need to disseminate similar stoves designed by NERDC which exceeds 25% of efficiency.

Goldemberg, J. et al have suggested a methodology in strategizing such an intervention.

1. Identify the populations that must be served
2. Identify what are the possible fuels and stoves (via technology assessments) that might be provided,
3. Identify what are the specific infrastructure issues that must be addressed
4. Identify possible fuel/stove providers -- including scope in fuel/stove distribution for ‘‘women entrepreneurs’’,
5. Do cost estimates for providing fuels and stoves
6. Determine he ability/willingness to pay for clean fuels as a function of income.

Policy-makers would then use this information to formulate appropriate interventions. (Goldemberg, J. et a 2004) In such a specific intervention information dissemination plays a major role; people need to be aware on the health risks they are facing and possible solutions they might get. Improved access plays a role there too; if firewood is a less efficient energy source what could be an alternative improved energy source for that.

Direct Subsidies for the poor

Poor might be aware of the benefits of improved energy sources and they might have the access. But what happens if they still can not afford buying that energy source. Therefore subsides needs to be given for the poor and poorest of the poor allowing them to get the benefits of clean improved energy sources. In Sri Lanka subsidies are already available for grid connected poor consumers. Similar subsidies need to be given to consumers who do not have grid connection and looking for off-grid renewable energy sources (UNDP 2007). Some countries are adopting cross subsidies where they reduce prices of clean energy products like LPG and increase the prices of other related products. It is argued that poor consumers still would not be able to access to clean energy sources and middle class and rich people will get the benefit of subsidies where they will utilize energy for unintended purposes (for the uses other than the basic needs of a human being) (Goldemberg, J. et al 2004). There by it is that identified direct subsidies for the poor will be more effective way of improving the energy usage of the poor. Providing a LPG subsidy for the poor in Sri Lanka is one of the best ways which we can reduce the energy poverty with respect to cooking. Adding further to that, providing direct subsidies for the poor on improved cook stoves can be also treated as one of the best interventions in improving the energy poverty with respect to cooking.

Improved access

Rural and urban poor population needs to have the access to improved energy sources. Millennium Development Goals has identified a standard of living adequate for the health and well-being of an individual and of his family as a right of everybody (Goldemberg, J. et al 2004). Therefore it is a responsibility of each government to provide access to improved energy sources for each household to meet their adequate level of health and wellbeing.

In terms of electricity, extending grid connected electricity is one way of improving access to each household. And for the off-grid households, renewable alternative energy sources needs to be considered such as Mini-hydro, pico hydro, solar power, bio gas…etc. While using existing energy sources, the mission in searching for new energy sources needs to be improved, untapped energy sources needs to be tapped.

Apart from providing existing alternative energy sources, searching for new energy source also serves as a good option in providing improved access for the poor. With the improved technology, there is a hope for Liquid Natural Gas (LNG) in the future. These will serve as an improved energy source in the future. Similarly ethanol can also serve as a future clean energy source for transportation and also as a cooking fuel. It is identified that there are many challenges associated with providing improved access of energy services for all. However if joint collaborative actions are taken together with private sector, government, civil society and donor organizations some challenges on providing improved access can be minimized.

Information Dissemination

Information dissemination plays a major role in eradicating energy poverty. Most of the village level people are not aware on the benefits that they will get from improved energy sources. They were not forced to think on how their living could be improved by having access to improved energy sources. They are not aware on the health hazards caused by traditional cook stoves; they do not realize how much they risk the lives of

women and children by exposing them to the toxic emissions. Different ways of information dissemination can be used in passing these massages to poor households. Awareness needs to be created among energy poor households on these aspects. Village level community meetings, information seminars and poster campaigns can be used to communicate with the villagers. From a national level, the help of printed media, radio and television needs to be taken to pass this information to the whole country. Only when people are aware on benefits of improved energy sources and risks they are facing with traditional energy sources, people tend to switch on more improved, efficient and clean energy sources.

Knowledge Management
Importance of energy services for the poor has been discussing since 90's. With Millennium Development Goals launched in year 2000, more attention was given to energy services for the poor as it will provide a supportive role in achieving all MDGs. Though there has been an interest within the international community, and policy makers on importance of energy, no sufficient, direct information is available on energy status in country (UNDP 2007). Therefore more surveys needs to be conducted on energy services, its accessibility and its consumption patterns in order to get a broad picture on energy usage of the country. Energy related assessments mainly focus on electricity (UNDP 2007), assessments need to be focus other sources of energy such as biomass, solar etc and they should contact in regular manner. Once proper information is available on energy, proper interventions can be designed.

Gender Involvement
Women are the key target group in energy poverty with respect to cooking. Their time and effort allocated for firewood collection, their exposure to toxic emissions and long spend in the kitchen makes women the most prominent target group. However lack of women involvement in decision making, management and operational relating to decision making has made earlier intervention less successful (UNDP 2007). Women need to be actively engaged in rural energy activities and decision making. Women need to have the ownership of village level energy initiatives and they need to play a major role in monitoring such projects.

Village level capacity building
In reducing the level of energy poverty, village level capacity building plays a major role. Than bringing energy services from outside of the village, if it can be generated from the village itself, sustainability of energy services goes up. Entrepreneurship opportunities can be given for the poor. Through entrepreneurship, poor can be part of energy supply itself (UNDP 2007). Village level micro credit programs on energy related activities would enhance the poor's participation in energy supply and improved energy usage. Again promoting rural investments would enhance the capacity of energy generation at village level.

SECTION 06: CONCLUSION

This paper estimates the level of energy poverty in Sri Lanka according to Practical Action's international definition on energy poverty. Further, calculation of energy poverty was done by taking different variations to the Practical Action's definition. As an average, economically most developed western province shows a least level of energy poverty in Sri Lanka while economically least developed Sabaragamuwa and Uva provinces shows the highest level of energy poverty. Sri Lanka is better in energy poverty in terms of lighting than energy poverty in terms of cooking.

Energy poverty calculations were done by taking different variations to the original definition. It has shown that in Sri Lankan context cook stove efficiency and LPG equivalent energy consumption for cooking plays a major role in the level of energy poverty. Due to lack of availability of data, women's time spent on firewood collection and indoor air pollution was not taken into consideration of measuring energy poverty. Given these two criteria's were taken into consideration; level of energy poverty could further have gone up.

There are limitations with the definition used in measuring the energy poverty. Cooking energy consumption level mentioned in the definition, 35 kg of LPG or LPG equivalent is relatively a higher consumption level for Sri Lanka. Energy consumption figures per capita per year used in the definition were adopted from international studies done on household energy consumption. However, there is no direct link between the minimum Sri Lankan household energy needs with the consumption figures mentioned in the definition.

It is identified; immediate interventions need to be taken to address the energy poverty in order to lift up the living standards of energy poor households in Sri Lanka. Dissemination of improved cook stoves, direct subsidies for the poor and improved access for the energy services were identified as some of the interventions to deal with energy poverty. If proper actions were not taken into consideration, the percentage of energy poor households could increase in the country by year 2015 and 2025.

This paper examines only the energy poverty status of Sri Lanka by taking the given definition and by suggesting variations to the definition. Further studies can be carried out in evaluating what are the basic energy needs of a Sri Lankan and then calculating the level of energy poverty based on those thresholds.

APPENDICES

APPENDIX 1 - List of participants of workshop on "Energy Poverty in Sri Lanka", September 4, 2008.

Mr P G Joseph	Ministry of Science & Technology, Sri Lanka
Mr M.Goonethileke	Ministry of Power & Energy, Sri Lanka
Ms Karin Fernando	Center for Poverty Alleviation, Sri Lanka
Mr Gamini Senanayake	Industrial Development Board, Gamini Senanayake Associates, Sri Lanka
Mr Anura Widanagamage	Industrial Service Bureau, North Western Province, Sri Lanka
Mr Sampath Karunarathne	Practical Action, South Asia
Mr Bandula Chandrasekara	Energy Forum, Sri Lanka
Mr M W Leelarathne	National Engineering Research Development Centre, Sri Lanka
Mr W S Chandrasekara	SPARC
Dr K A Udayakumara	Open University, Sri Lanka
Mr Upali Daranagama	United States Agency for International Development, Sri Lanka
Mr Harsha Wickremasingha	Sustainable Energy Authority, Sri Lanka
Dr Visaka Hidellage	Practical Action, South Asia
Mr Upali Pannilage	Practical Action, South Asia
Mr Rohitha Ananda	Practical Action, South Asia
Ms Prajapa de Silva	Practical Action, South Asia
Ms Ramona Miranda	Practical Action, South Asia
Mr Dileepa Witharana	Open University, Sri Lanka
Mr Damitha Smarakoon	Practical Action, South Asia
Mr Dhanushka Tennakoon	Consultant, Energy Poverty Country Study, Practical Action, South Asia

APPENDIX 2 – Energy Source Conversions

02.1Calculating the LPG equivalent of firewood

1 kg of LPG = 47 cubic feet of natural gas
1 cubic feet of natural gas = 252 kcal
∴1 kg of LPG = 47*252 kcal
=11844 kcal, 11.84 Mcal

1 tonne of firewood = 0.3115 toe
1 toe = 10034 Mcal
∴ 1 tonne of firewood = 10034*0.03115 Mcal
= 3225.93 Mcal

∴LPG equivalent of firewood = 11.84/3225.93
= 3671.5 kg
per firewood 1kg = 3671.5/1000

∴1kg LPG equivalent value of firewood = 3.67 kg

02.2Calculating the LPG equivalent of Kerosene

Calorific value of Kerosene = 8.86 Mcal/l
1 kg of LPG = 11.84 Mcal
∴LPG equivalent of Kerosene = 11.84/8.86
= 1.34l

∴1 kg of LPG equivalent value of kerosene = 1.34l

02.3Calculating the kWh equivalent of Kerosene

1kWh = 3.6 MJ
Calorific value of Kerosene = 37.1 MJ/l
∴kWh equivalent of Kerosene = 3.6/37.1

∴1kWh of electricity equivalent value of Kerosene = 0.1l

APPENDIX 3 – Pricing Methodology Calculation

Analysis of Central Province

The energy consumption of central province households for lighting and cooking goes as follows,

	Principal type of cooking fuel %				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
Central	87.63%	10.56%	1.46%	0.35%	100.00%

	Principal type of lighting %			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
Central	36.92%	62.87%	0.21%	100.00%

(Census of Population and Housing 2001, DCS)

As discussed above, electricity for cooking and solar for lighting is negligible compared to other energy sources, therefore they are not considered for energy poverty calculation.

Analyzing the central province urban sector as per the expenditure decile

expenditure decile	1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector	8535	13455	16785	19977	23435	26970	32189	40786	59422	141367

(HIES 2006/07, DCS)

HIES 2006/07 shows us the average expenditure ratio on lighting and cooking from the total expenditure is 4.61%. By linking this data with cooking fuel source, lighting fuel source and with expenditure decile then we get,

Lighting	Kerosene	37.00%								
	Elect				63.00%					
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
allocation for urban sector cooking and lighting Rs		**393**	**620**	**774**	**921**	**1,080**	**1,243**	**1,484**	**1,880**	**2,739**	**6,517**
Cooking	Bio	87.94%									
	Kerosene									1.46%	
	LPG										10.60%

As discussed in western province analysis, we can get combined expenses for lighting and cooking. These expenses represent the consumption of energy as per the given definition.

		Lighting	
		Electricity	Kerosene
	LPG	1,293.45	
Cooking	Kerosene	1,270.86	

Decile 10 – Allowed amount per household is Rs 6517. If a household uses LPG for cooking and electricity for lighting then the required expenses level is Rs. 1293. Given this situation, households from decile 10 do have financial capability in enjoying the energy level mentioned in the given definition.

Decile 9 – Allowed amount per household is Rs 2739. Given the combination of electricity for lighting and Kerosene for cooking, then the required amount is Rs 1270. Even if the combination of electricity and LPG taken into account, the required amount is Rs 1293. Therefore we can identify all the households in decile 9 are not energy poor.

Analyzing the central province rural sector as per the expenditure decile

Lighting	Kerosene	37.00%									
	Elect				63.00%						
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of rural sector Rs		5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting		0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
allocation for rural sector cooking and lighting Rs		**240**	**382**	**465**	**551**	**649**	**757**	**902**	**1,111**	**1,455**	**3,001**
Cooking	Bio	87.94%									
	Kerosene									1.46%	
	LPG										10.60%

Decile 10 – Allowed Rs 3001. Required for electricity for lighting and LPG for cooking combination Rs 1293. Therefore the households from this decile can fulfill the energy requirement as given in the definition.

Decile 9 – Allowed Rs 1455. Required at electricity LPG combination Rs 1293. Required for electricity kerosene combination Rs 1270. This shows that the households in this decile do have the financial capability in fulfilling the energy requirement as given in the definition.

Analyzing the central province estate sector as per the expenditure decile

Lighting	Kerosene	37.00%									
	Elect				63.00%						
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of estate sector Rs		4705	7345	8994	10355	11657	12814	14106	15337	17661	26546

avg exp ratio on province for cooking and lighting		0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
allocation for estate sector cooking and lighting Rs		**217**	**339**	**415**	**477**	**537**	**591**	**650**	**707**	**814**	**1,224**
Cooking	Bio	87.94%									
	Kerosene									1.46%	
	LPG										10.60%

Decile 10 – Allowed Rs 1224. Required for electricity for lighting and LPG for cooking combination Rs 1293. Therefore households in this sector do not have financial capability in fulfilling their energy needs as per the definition. Households under decile 10 of estate sector can be categorized as energy poor.

Decile 9 – Allowed Rs 814. Required for electricity LPG combination Rs 1293 and required under electricity kerosene combination Rs 1270. With insufficient fund allocation, these households can be categorized as energy poor.

In central province estate sector, a decile is comprised of 12106 households (HIES 2006/07, DCS). Hence we can conclude in central province estate sector all together 24212 households are energy poor

Summary of energy poverty status at Central Province

Households excluding biomass usage:

Energy poor households			
Urban	Rural	Estate	TOTAL
0	0	24,212	24,212

From the above calculation of determining the energy poverty of households with biomass usage,

Total biomass used households	499,000
Energy poor households	496,695
% of poor from total biomass used	99.54%

Total Households Summary, Central Province

Total households	597,036
Energy poor households	520,907
%of energy poor from total households	87.25%

Analysis of Southern Province

The energy consumption of southern province households for lighting and cooking goes as follows,

	Principal type of cooking fuel %				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
Southern	90.05%	9.17%	0.66%	0.13%	100.00%

	Principal type of lighting %			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
Southern	32.68%	67.19%	0.14%	100.00%

(Census of Population and Housing 2001, DCS)

As discussed above, electricity for cooking and solar for lighting is negligible compared to other energy sources, therefore they are not considered for energy poverty calculation.

HIES 2006/07 shows us the average expenditure ratio on lighting and cooking from the total expenditure is 3.974%. By linking this data with cooking fuel source, lighting fuel source and with expenditure decile we can analyze households t each expenditure decile.

Analyzing the southern province urban sector

Lighting	Kerosene	32.72%									
	Elect				67.28%						
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
allocation for urban sector cooking and lighting Rs		**339**	**535**	**667**	**794**	**931**	**1,072**	**1,279**	**1,621**	**2,361**	**5,618**
Cooking	Bio	90.16%									
	Kerosene									0.66%	
	LPG										9.18%

Analysis,

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	5618	1293	Not Energy Poor
	Elect	Kerosene	5618	1271	Not Energy Poor

Analyzing the southern province rural sector

Lighting	Kerosene	32.72%									
	Elect				67.28%						
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of rural sector Rs		5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting		0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
allocation for rural sector cooking and lighting Rs		**207**	**329**	**401**	**475**	**560**	**653**	**777**	**958**	**1,254**	**2,587**
Cooking	Bio	90.16%									
	Kerosene									0.66%	
	LPG										9.18%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	2587	1293	Not Energy Poor

	Elect	Kerosene	2587	1271	Not Energy Poor

Analyzing the southern province estate sector

Lighting	Kerosene	32.72%									
	Elect				67.28%						
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of estate sector Rs		4705	7345	8994	10355	11657	12814	14106	15337	17661	26546
avg exp ratio on province for cooking and lighting		0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
allocation for estate sector cooking and lighting Rs		**187**	**292**	**357**	**412**	**463**	**509**	**561**	**609**	**702**	**1,055**
Cooking	Bio	90.16%									
	Kerosene									0.66%	
	LPG										9.18%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	1055	1293	Energy Poor
	Elect	Kerosene	1055	1271	Energy Poor

Each decile in Southern Province state sector comprised of 947 households. Therefore total energy poor households are 947.

Summary of energy poverty status at Southern Province

Households excluding biomass usage:

Energy poor households			
Urban	Rural	Estate	TOTAL
0	0	947	947

From the above calculation of determining the energy poverty of households with biomass usage,

Total biomass used households	479,738
Energy poor households	496,695
% of poor from total biomass used	96.59%

Total Households Summary, Southern Province

Total households	550,307
Energy poor households	497,642
%of energy poor from total households	90.43%

Analysis of Eastern Province

The energy consumption of eastern province households for lighting and cooking goes as follows,

Principal type of cooking fuel %	**TOTAL**

Province	Biomass	Gas	Kerosene	Electricity	
Eastern	89.36%	8.08%	2.00%	0.56%	100.00%

	Principal type of lighting %			
Province	Kerosene	Electricity	Solar	TOTAL
Eastern	49.14%	50.60%	0.26%	100.00%

(Census of Population and Housing 2001, DCS)

As discussed above, electricity for cooking and solar for lighting is negligible compared to other energy sources, therefore they are not considered for energy poverty calculation.

HIES 2006/07 shows us the average expenditure ratio of eastern province on lighting and cooking from the total expenditure is 4.946%. By linking this data with cooking fuel source, lighting fuel source and with expenditure decile we can analyze households in each expenditure decile.

Analyzing the eastern province urban sector

Lighting	Kerosene	49.27%									
	Elect						50.73%				
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
allocation for urban sector cooking and lighting Rs		**422**	**665**	**830**	**988**	**1,159**	**1,334**	**1,592**	**2,017**	**2,939**	**6,991**
Cooking	Bio	89.86%									
	Kerosene										2.02%
	LPG										8.12%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	6991	1293	Not Energy Poor
	Elect	Kerosene	6991	1271	Not Energy Poor

Analyzing the eastern province rural sector

Lighting	Kerosene	49.27%									
	Elect						50.73%				
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of rural sector Rs		5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting		0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
allocation for rural sector cooking and lighting Rs		**257**	**410**	**499**	**591**	**696**	**812**	**967**	**1,192**	**1,560**	**3,219**
Cooking	Bio	89.86%									
	Kerosene										2.02%

	LPG	8.12%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	3219	1293	Not Energy Poor
	Elect	Kerosene	3219	1271	Not Energy Poor

Analyzing the eastern province estate sector

Lighting	Kerosene	49.27%									
	Elect						50.73%				
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of estate sector Rs		4705	7345	8994	10355	11657	12814	14106	15337	17661	26546
avg exp ratio on province for cooking and lighting		0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
allocation for estate sector cooking and lighting Rs		**233**	**363**	**445**	**512**	**576**	**634**	**698**	**758**	**873**	**1,313**
Cooking	Bio	89.86%									
	Kerosene										2.02%
	LPG										8.12%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	1313	1293	Not Energy Poor
	Elect	Kerosene	1313	1271	Not Energy Poor

Therefore all the sectors in eastern province can meet their energy needs as per the minimum requirement. Hence we can consider there aren't any households in eastern province who are energy poor.

Summary of energy poverty status at Eastern Province

Households excluding biomass usage:

Energy poor households			
Urban	Rural	Estate	TOTAL
0	0	0	0

From the above calculation of determining the energy poverty of households with biomass usage,

Total biomass used households	121,197
Energy poor households	120,637
% of poor from total biomass used	99.54%

Total Households Summary, Eastern Province

Total households	140,188
Energy poor households	120,637
%of energy poor from total households	86.05%

Analysis of North Western Province

The energy consumption of north western province households for lighting and cooking goes as follows,

	Principal type of cooking fuel %				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
North Western	93.55%	5.53%	0.81%	0.11%	100.00%

	Principal type of lighting %			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
North Western	47.60%	52.00%	0.40%	100.00%

(Census of Population and Housing 2001, DCS)

As discussed above, electricity for cooking and solar for lighting is negligible compared to other energy sources, therefore they are not considered for energy poverty calculation.

HIES 2006/07 shows us the average expenditure ratio of north western province on lighting and cooking from the total expenditure is 4.04%. By linking this data with cooking fuel source, lighting fuel source and with expenditure decile we can analyze households in each expenditure decile.

Analyzing the north western province urban sector

Lighting	Kerosene	47.79%									
	Elect					52.21%					
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
allocation for urban sector cooking and lighting Rs		**345**	**543**	**678**	**807**	**946**	**1,089**	**1,300**	**1,647**	**2,399**	**5,708**
Cooking	Bio	93.65%									
	Kerosene										0.81%
	LPG										5.54%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	5708	1293	Not Energy Poor
	Elect	Kerosene	5708	1271	Not Energy Poor

Analyzing the north western province rural sector

Lighting	Kerosene	47.79%									
	Elect					52.21%					
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of rural sector Rs		5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting		0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040

allocation for rural sector cooking and lighting Rs		**210**	**335**	**407**	**482**	**569**	**663**	**790**	**973**	**1,274**	**2,628**
Cooking	Bio	93.65%									
	Kerosene										0.81%
	LPG										5.54%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	2628	1293	Not Energy Poor
	Elect	Kerosene	2628	1271	Not Energy Poor

Analyzing the north western province estate sector

Lighting	Kerosene	47.79%									
	Elect					52.21%					
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of estate sector Rs		4705	7345	8994	10355	11657	12814	14106	15337	17661	26546
avg exp ratio on province for cooking and lighting		0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
allocation for estate sector cooking and lighting Rs		**190**	**297**	**363**	**418**	**471**	**517**	**570**	**619**	**713**	**1,072**
Cooking	Bio	93.65%									
	Kerosene										0.81%
	LPG										5.54%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	1072	1293	Energy Poor
	Elect	Kerosene	1072	1271	Energy Poor

Each expenditure decile in north western province estate sector is comprised of 225 households. As per this analysis, the energy poor household in north western province estate sector is 225 households.

Summary of energy poverty status at North Western Province

Households excluding biomass usage:

Energy poor households			
Urban	Rural	Estate	TOTAL
0	0	225	225

From the above calculation of determining the energy poverty of households with biomass usage,

Total biomass used households	514,858
Energy poor households	512,480
% of poor from total biomass used	99.54%

Total Households Summary, North Western Province

Total households	554,960
Energy poor households	512,706
%of energy poor from total households	92.39%

Analysis of North Central Province

The energy consumption of north central province households for lighting and cooking goes as follows,

	Principal type of cooking fuel %				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
North Central	94.25%	5.12%	0.45%	0.19%	100.00%

	Principal type of lighting %			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
North Central	51.53%	48.07%	0.40%	100.00%

(Census of Population and Housing 2001, DCS)

As discussed above, electricity for cooking and solar for lighting is negligible compared to other energy sources, therefore they are not considered for energy poverty calculation.

HIES 2006/07 shows us the average expenditure ratio of north central province on lighting and cooking from the total expenditure is 4.25%. By linking this data with cooking fuel source, lighting fuel source and with expenditure decile we can analyze households in each expenditure decile.

Analyzing the north central province urban sector

Lighting	Kerosene	51.74%									
	Elect						48.26%				
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
allocation for urban sector cooking and lighting Rs		**363**	**572**	**714**	**849**	**996**	**1,147**	**1,369**	**1,734**	**2,526**	**6,011**
Cooking	Bio	94.42%									
	Kerosene										0.45%
	LPG										5.13%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	6011	1293	Not Energy Poor
	Elect	Kerosene	6011	1271	Not Energy Poor

Analyzing the north central province rural sector

Lighting	Kerosene	51.74%									
	Elect						48.26%				
expenditure decile		1	2	3	4	5	6	7	8	9	10

avg expenditure of rural sector Rs	5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
allocation for rural sector cooking and lighting Rs	**221**	**352**	**429**	**508**	**599**	**698**	**832**	**1,025**	**1,342**	**2,768**

Cooking	Bio	94.42%
	Kerosene	0.45%
	LPG	5.13%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	2768	1293	Not Energy Poor
	Elect	Kerosene	2768	1271	Not Energy Poor

Analyzing the north central province estate sector

Lighting	Kerosene	51.74%
	Elect	48.26%

expenditure decile	1	2	3	4	5	6	7	8	9	10
avg expenditure of estate sector Rs	4705	7345	8994	10355	11657	12814	14106	15337	17661	26546
avg exp ratio on province for cooking and lighting	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
allocation for estate sector cooking and lighting Rs	**200**	**312**	**382**	**440**	**496**	**545**	**600**	**652**	**751**	**1,129**

Cooking	Bio	94.42%
	Kerosene	0.45%
	LPG	5.13%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	1129	1293	Energy Poor
	Elect	Kerosene	1129	1271	Energy Poor

Each expenditure decile in north central province estate sector is comprised of 34 households. As per this analysis, the energy poor household in north central province estate sector is 34 households.

Summary of energy poverty status at North Central Province

Households excluding biomass usage:

Energy poor households			
Urban	Rural	Estate	TOTAL
0	0	34	34

From the above calculation of determining the energy poverty of households with biomass usage,

Total biomass used households	261,495
Energy poor households	260,287
% of poor from total biomass used	99.54%

Total Households Summary, North Central Province

Total households	293,797
Energy poor households	260,321
%of energy poor from total households	88.61%

Analysis of Uva Province

The energy consumption of Uva province households for lighting and cooking goes as follows,

	Principal type of cooking fuel %				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
Uva	93.95%	5.15%	0.53%	0.36%	100.00%

	Principal type of lighting %			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
Uva	48.62%	50.55%	0.83%	100.00%

(Census of Population and Housing 2001, DCS)

As discussed above, electricity for cooking and solar for lighting is negligible compared to other energy sources, therefore they are not considered for energy poverty calculation.

HIES 2006/07 shows us the average expenditure ratio of Uva province on lighting and cooking from the total expenditure is 4.41%. By linking this data with cooking fuel source, lighting fuel source and with expenditure decile we can analyze households in each expenditure decile.

Analyzing the Uva province urban sector

Lighting	Kerosene	49.03%									
	Elect						50.97%				
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
allocation for urban sector cooking and lighting Rs		**377**	**594**	**740**	**881**	**1,034**	**1,190**	**1,420**	**1,799**	**2,621**	**6,236**
Cooking	Bio	94.30%									
	Kerosene										0.53%
	LPG										5.17%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	6236	1293	Non Energy Poor
	Elect	Kerosene	6236	1271	Non Energy Poor

Analyzing the Uva province rural sector

Lighting	Kerosene	49.03%									
	Elect						50.97%				
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of rural sector Rs		5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting		0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
allocation for rural sector cooking and lighting Rs		**230**	**366**	**445**	**527**	**621**	**725**	**863**	**1,063**	**1,392**	**2,872**
Cooking	Bio	94.30%									
	Kerosene										0.53%
	LPG										5.17%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	2872	1293	Non Energy Poor
	Elect	Kerosene	2872	1271	Non Energy Poor

Analyzing the Uva province estate sector

Lighting	Kerosene	49.03%									
	Elect						50.97%				
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of estate sector Rs		4705	7345	8994	10355	11657	12814	14106	15337	17661	26546
avg exp ratio on province for cooking and lighting		0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
allocation for estate sector cooking and lighting Rs		**208**	**324**	**397**	**457**	**514**	**565**	**622**	**677**	**779**	**1,171**
Cooking	Bio	94.30%									
	Kerosene										0.53%
	LPG										5.17%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	1171	1293	Energy Poor
	Elect	Kerosene	1171	1271	Energy Poor

Each expenditure decile in Uva province estate sector is comprised of 4167 households. As per this analysis, the energy poor household in Uva province estate sector is 4167 households.

Summary of energy poverty status of Uva Province

Households excluding biomass usage:

Energy poor households			
Urban	Rural	Estate	TOTAL
0	0	4167	4167

From the above calculation of determining the energy poverty of households with biomass usage,

Total biomass used households	264,933
Energy poor households	263,709
% of poor from total biomass used	99.54%

Total Households Summary, Uva Province

Total households	287,863
Energy poor households	267,876
%of energy poor from total households	93.06%

Analysis of Sabaragamuwa Province

The energy consumption of Sabaragamuwa province households for lighting and cooking goes as follows,

	Principal type of cooking fuel %				
Province	**Biomass**	**Gas**	**Kerosene**	**Electricity**	**TOTAL**
Sabaragamuwa	94.38%	5.08%	0.39%	0.15%	100.00%

	Principal type of lighting %			
Province	**Kerosene**	**Electricity**	**Solar**	**TOTAL**
Sabaragamuwa	48.76%	50.86%	0.38%	100.00%

(Census of Population and Housing 2001, DCS)

As discussed above, electricity for cooking and solar for lighting is negligible compared to other energy sources, therefore they are not considered for energy poverty calculation.

HIES 2006/07 shows us the average expenditure ratio of Sabaragamuwa province on lighting and cooking from the total expenditure is 4.61%. By linking this data with cooking fuel source, lighting fuel source and with expenditure decile we can analyze households in each expenditure decile.

Analyzing the Sabaragamuwa province urban sector

Lighting	Kerosene	48.95%									
	Elect					51.05%					
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of urban sector Rs		8535	13455	16785	19977	23435	26970	32189	40786	59422	141367
avg exp ratio on province for cooking and lighting		0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
allocation for urban sector cooking and lighting Rs		**394**	**620**	**774**	**921**	**1,081**	**1,244**	**1,484**	**1,881**	**2,740**	**6,518**
Cooking	Bio	94.52%									
	Kerosene										0.39%
	LPG										5.09%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	6518	1293	Not Energy Poor

	Elect	Kerosene	6518	1271	Not Energy Poor

Analyzing the Sabaragamuwa province rural sector

Lighting	Kerosene	48.95%									
	Elect					51.05%					
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of rural sector Rs		5203	8290	10084	11947	14083	16428	19559	24105	31554	65097
avg exp ratio on province for cooking and lighting		0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
allocation for rural sector cooking and lighting Rs		**240**	**382**	**465**	**551**	**649**	**757**	**902**	**1,111**	**1,455**	**3,002**
Cooking	Bio	94.52%									
	Kerosene										0.39%
	LPG										5.09%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	3002	1293	Not Energy Poor
	Elect	Kerosene	3002	1271	Not Energy Poor

Analyzing the Sabaragamuwa province Estate sector

Lighting	Kerosene	48.95%									
	Elect					51.05%					
expenditure decile		1	2	3	4	5	6	7	8	9	10
avg expenditure of estate sector Rs		4705	7345	8994	10355	11657	12814	14106	15337	17661	26546
avg exp ratio on province for cooking and lighting		0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
allocation for estate sector cooking and lighting Rs		**217**	**339**	**415**	**477**	**538**	**591**	**650**	**707**	**814**	**1,224**
Cooking	Bio	94.52%									
	Kerosene										0.39%
	LPG										5.09%

Decile	Lighting	Cooking	Allowed	Required	Status
10	Elect	LPG	1224	1293	Energy Poor
	Elect	Kerosene	1224	1271	Energy Poor

Each expenditure decile in Sabaragamuwa province estate sector is comprised of 3927 households. As per this analysis, the energy poor household in Sabaragamuwa province estate sector is 3927 households.

Summary of energy poverty status of Sabaragamuwa Province

Households excluding biomass usage:

Energy poor households			
Urban	Rural	Estate	TOTAL
0	0	3927	3927

From the above calculation of determining the energy poverty of households with biomass usage,

Total biomass used households	411,623
Energy poor households	409,722
% of poor from total biomass used	99.54%

Total Households Summary, Sabaragamuwa Province

Total households	448,092
Energy poor households	413,649
%of energy poor from total households	92.31%

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