CHAPTER II

LITERATURE REVIEWS

This chapter reviews a broad range of literature relevant to the concept of energy, its social significance, studies on energy utilization and consumption in communities in developing countries, and approaches and methods employed in the study of community utilization of energy.

1. The concept of energy

1.1 What is energy?

Energy is commonly defined as "the capacity to do work" (Cook, 1976). **Work** is the quantity of energy transferred from one system to another without an accompanying transfer of entropy. It is a concept of mechanical work in mechanics. In the International System of Units, work is measured in joules. The conversion factors used in measuring of energy, power and work are presented in Table 1.

Energy is commonly classified as renewable and non-renewable energy. The main non-renewable energy sources are coal, oil, natural gas, and nuclear energy. The renewable sources are solar energy, photochemical energy (which is solar energy captured by plants) stored in the biomass of plants and animals (wood, agricultural residuals, manure), hydro-electric, geothermal, and wind energy (EIA, 2010; Cook, 1976).

Table 1 Energy values of different sources of energy and conversion factors

Type (Unit)	Kilocalories (kcal)	Megajoules (MJ)
Gasoline (litre)	7520	31.48
Kerosene (litre)	8,250	34.53
Diesel (litre)	8,700	36.42
Electricity (kW h)	860	3.60
Fuelwood (kg.)	3,820	15.99
Charcoal (kg.)	6,900	28.88
General		
1 kcal = 4,186 Joules		
1 toe = 10.093 Gcal		
= 42.244 GJ		
1 cu.m. of solid wood = 600 kg.		
1 cu.m. of charcoal = 250 kg.		
5 kg. of fuel wood 1 kg. of charcoal product		
1 litre of LPG = 0.54 kg.		

Source: Thailand energy situation from DEDE, 2006

1.2 Why is energy important?

Energy is essential to the functioning of all living systems, including human societies. Electrical energy is needed for lighting and to provide heat to cook food and warm or cool homes. Gasoline and diesel oil are used as fuel in internal combustion engines of vehicles used for transportation and to do work. Even our food is produced by agricultural processes that depend on gasoline or diesel oil to fuel farm machinery and on use of oil or natural gas to produce urea fertilizer. After that, food is

transported from farms to processing factories and from there to markets by trucks using gasoline or diesel oil. Industrial production also depends on the use of different types of energy such as electricity, coal, heating oil, gas, or biomass (Harold; 2002). Thus, almost all the goods and services that humans rely on depend on energy and the higher the level of economic development, the greater the need for energy. That means that as developing countries continue their rapid growth, total global energy demand will greatly increase.

2. The significance of energy in human society

2.1 Energy and social evolution

Energy is an essential element of human livelihood. It is ubiquitous in people's lives and all of our activities depend on using energy. Thus, White (1943) and Cook (1976) assert that human social evolution is driven by changes in our ability to capture and use energy. According to this theory, the higher the amount of energy used per capita, the more advanced the society will become. They see societies as evolving through three main stages of energy use: 1) the hunting and gathering stage, in which human muscle energy is dominant; 2), the agricultural stage, in which human muscle power is supplemented by animal power, with some use of wind and water power; and 3) the industrial stage, in which fossil fuel provides most of the energy. At each new stage, the amount of energy used per capita is greater than in the preceding stage.

According to Cook (1976), before the invention of agriculture, when people lived in small nomadic hunting and gathering groups, they used about two thousand kcal of energy per person per day. The rate increased to 10,000 or 12,000 kilocalories per person a day in early agricultural societies. During the early stages of the industrial revolution (1850-70), daily per capita energy consumption increased to about 70,000 kilocalories in U.S. and about 40,000 kilocalories in others developed countries. In recent years, daily per capita consumption in the U.S. has reached more than 230,000 kilocalories, whereas in the less-developed countries, people use only about 10,000 kcals/per capita/day. In the 1970s, the industrialized countries only had

30 percent of the world population, but consumed 80 percent of world energy (Cook, 1976). In 2008, total worldwide energy consumption was 118.36 mtoe with 80 to 90 percent derived from the combustion of fossil fuels (Anonymous, 2010). More recently, the developed countries, such as the U.S., Australia, France, Japan and United Kingdom consumed per capita 7.75, 5.69, 4.49, 4.02 and 3.9 tons of oil equivalent (toe) respectively, whereas developing countries, such as Thailand, China and India consumed 1.4, 1.13 and 0.51 toe per capita, respectively. The rapid economic growth of Asia, particularly China, has greatly increased per capita energy consumption there (IEA, 2007).

Along with increases in the amount of energy consumed per capita, the types of energy used have also changed in the course of social evolution. In small-scale "primitive" hunting and gathering societies, most energy is derived from human muscles, supplemented by heat energy obtained by burning fire wood. In traditional agricultural societies, human energy is supplemented by animal power, which considerably increases the total supply of energy available to do work. In the classical agrarian civilizations of Eurasia, human and animal powers were supplemented with wind and water power. Wind was used to propel ships and windmills; water power ran grain mills and small industrial processing plants. In such low energy societies, which until the end of the 20th Century were the dominant type in rural Asia, human and animal power remain the major sources of energy, however. Most energy is used in growing food and in household cooking and heating; transportation and manufacturing consume only a small share. In contrast, in modern high energy society, which is defined as "a society heavily dependent on machines powered by the burning of fossil fuels," the consumption of energy, mostly from fossil fuels, by industry and transportation represents the major share of energy use, and, consequently it has a greater impact on the environment.

2.2 A brief history of human use of different types of energy and changes in energy utilization

Ancient humans may have begun using fire as long as 1,400,000 years ago, but that fire had been started naturally by lighting and was kept going by the people.

Humans only learned how to make fire around 9,000 before present years (Harold; 2002). All primitive cultures used fire in order to keep warm; drive off dangerous animals, clear land for agriculture, cook food, dry wood and clay, and heat and split stones to make them easy to carry, and to provide light. The first fuel that humans relied on in large amounts was wood. Wood is a desirable fuel for small-scale household use because it is abundant in many places in the world so it is easy to get, handle, and store using only household labor. With wood, it is easy to make and control fire while other sources and the technology to use them were not yet well developed or were available only on a limited scale (Cook, 1976; Harold, 2002). Another advantage of wood is that it can be easily transformed into charcoal which is a cleaner and more easily transported fuel.

Although coal was used for fuel as early as 4000 BC in China, it did not become a major source of energy for cooking and heating in Western Europe until the 1830s and only became common by the 1850s. It is one of the most abundant energy sources and is relatively cheap compared to other energy sources but it is dirty and costly to transport. After World War II, petroleum rapid replaced coal in many uses (Harold; 2002, Cook; 1976).

According to Harold (2002), petroleum products have gradually displaced wood and coal as primary sources of household energy in developed countries. Kerosene became popular in the early 1900s as a fuel for oil lamps; later it was employed for space heaters that are still commonly used in Japanese houses. The rise of oil products for home use for heating began in the 1920s. After the Second World War (1939-1945), oil became more readily available because oil pipelines spread through the United States. Many households replaced their coal furnaces with cleaner oil burners. Natural gas and coal gas became popular fuels for household lighting and cooking after a network of distribution pipelines were constructed in large cities in Europe and America beginning in the late 1800s. Liquefied petroleum gas (LPG) has only become widely available recently. It is easy to use and has a high calorific value. Advantages of gas are its convenience of use and cleanliness, so that gas is generally preferred for home use over coal or oil. In 1959, there were about 40 million homes in the USA that used gas. The shift from wood and coal to oil and gas as preferred home

heating fuels involves a shift from home labor to specialized labor. That is why the latter fuels have a high price.

Electricity first began to be used for lighting in America the late 1870s and 1880s. It was most efficiently produced in large-scale centralized generators and then distributed to households by lengthy power lines which soon crisscrossed every urban street and were later extended to rural areas (Harold, 2002).

Coal, petroleum products (oil, kerosene, benzene, diesel and LPG) and nuclear energy became the main energy sources used by developed societies (Harold, 2002). Despite the growing demand for these products, supplies continued to increase until very recently because humans continued to develop new and better technologies for seeking crude oil; they also began to slowly expand use of alternative types of energy, including renewable energy (Senelwa and Sims, 1999; McKay, 2005; Omer, 2005; Prasertsan and Sajjakulnukit, 2005; Chen et al., 2008; REN21, 2006; Wald, 2007). As economic development accelerated, especially in Asia, and traditional lifestyles changed to become more and more modernized, the demand for energy increased tremendously, so that, even though more sources of energy have become available with the advancement of technology, global supplies are now having difficulty keeping up with the continuous increase in energy consumption, especially the ever greater use of nonrenewable energy in industry and services that are concentrated in the industrialized or developed regions or urbanized areas of the world (Cook, 1976; Pimentel and Pimentel, 1979; Harold, 2002; Shimoda et al., 2004; Urban Statistical Yearbook, 1990–2001 in Zhang, 2004; Nansaior et al., 2006; ETSU report, 1999 as a review in McKay, 2005; Ouedraogo, 2005; Devi et al., 2007; Cai and Jiang, 2008; Bravo, Kozulj, and Landaveri, 2008; Shrestha et al., 2008). The proportion of total energy supplied by renewable energy has continuously declined.

Nuclear power is produced through nuclear fission in reactors that produce steam to generate electricity. The first successful nuclear reactors were developed in the mid-1950s and were used to generate electricity first in the Soviet Union, followed by Britain and the U.S.A. (Harold, 2002). In 1954, Japan started a nuclear research program, and continues to use nuclear power on a widespread basis for electricity

generation; at present, nuclear energy provides 30% of the country's total electricity production (WNA, 2010).

2.3 Energy use in modern developed and developing countries

In modern societies, fossil fuels are the primary source of energy. People must travel by car, bus, train or aircraft that rely on gasoline, diesel or natural gas for fuel. People develop technology to produce electricity, which mostly comes from fossil fuels, although hydropower and nuclear power are important sources in some countries. People live in homes with electric heating, cooling, lighting, and cooking. Industrial manufacturing involves transforming raw materials into finished products using electrically powered machines in factories that are heated with coal, oil or natural gas. After goods are manufactured they must then be transported to stores and finally to their ultimate customers (Pimentel and Pimentel, 1979; Schobert, 2002).

Fossil fuels are currently the main source of energy, but the supply is limited and burning fossil fuels has negative effects on the environment. Therefore, the efforts to develop new technology to use renewable energy sources have grown dramatically recently because of the increasing concerns about the environmental impacts of the use of fossil fuel. Renewable energy resources are thus attracting a lot of interest right now.

In developing societies, however, there is still a heavy reliance on biomass fuels, both for household use and manufacturing, especially by rural people (FAO-RWEDP, 2002) who mostly use biomass for cooking and heating. The Regional Wood Energy Development Program in Asia (RWEDP) of FAO estimated that 70% of biomass energy (wood fuel, leaves and cow dung) is used by the residential sector for cooking. The Asian countries consume more than 80% of the total quantity of biomass energy used in the world.

2.4 Advantages and disadvantages of renewable and non-renewable energy

Although they are non-renewable, fossil fuels enjoy many advantages: Oil has a high heating value, is easy to transport and use, and, until recently, was relatively inexpensive. Coal is very abundant, and found in many countries. The technologies for extracting, processing, transporting and using oil and coal are well developed. Fossil fuel powered electrical generating stations can be constructed in almost any location since oil, gas, and coal can be easily transported to the power stations. They enjoy a large economy of scale because of their capacity to generate huge amounts of electricity in just a single location. However, with the exception of coal, the supplies of other non-renewable energy are limited. Moreover, air pollution is a major disadvantage of using fossil fuels since burning them emits carbon dioxide as well as sulfur dioxide, nitrogen oxide, and ash. Crude oil also contains toxic chemicals which cause air pollutants when combusted. Off-shore drilling poses especially great environmental risks with oil spills causing major damage to marine ecosystems. The mining of coal results in the destruction of wide areas of land and also is very dangerous to the lives of miners.

Renewable energy has many benefits when compared to using fossil fuels. These include environmental, health and cost advantages over fossil fuels. Renewable energy supplies will never be exhausted so can sustainably support human life indefinitely. Some types of renewable energy (wind, solar, and hydropower) are also generally clean sources of energy with no pollution but others, such as wood and charcoal, can be quite dirty and polluting. Renewable energy sources also tend to be widely available in contrast to oil and gas which are only found in a few countries. On the other hand, the disadvantages of renewable energy are: 1) Greenhouse gases produced by biomass burning, 2) High initial costs for installing wind solar energy systems 3) High expenses to collect, harvest and store raw materials of biomass, 4) Large scale production of energy crops will compete with food crops for scare land and water, 5) Solar and wind energy are also only available intermittently, e.g., solar energy is produced only during daytime and the wind only blows strongly in some places and sometimes fails completely (Harold, 2002).

2.5 The rural-urban continuum

The rural-urban continuum can be viewed as an idealized model of the spatial distribution of social units undergoing the urbanization process (Redfield, 1947; Miner, 1952; McGee, 1964). At the urban end of the continuum one finds cities, which are large, fully urbanized settlements with high population densities, urban based livelihoods and styles of living, and well-developed infrastructures, while at the rural end of the continuum one finds villages that retain wholly rural characteristics of low population density, agrarian-based livelihoods, limited development of transportation and communications infrastructures, and lack of access to services and amenities. In between these poles, one finds suburban communities in various states of transition from being more rural-like to more urban-like. Suburban settlements are characterized by lower densities than are found in cities but with many urbanized features including good infrastructure and easy access to markets, services and other inputs. The suburbs are dynamic in space and time, as they shift from rural to urban characteristics. Areas within the zone are heterogeneous in their degree of urbanization, but often have improved facilities (e.g., electricity, piped water, schools) which may speed up development (Howorth et al., 1997; DETR, 2001). It is assumed that, over time, as the consequence of continuing economic development, these intermediate "suburban" communities will evolve to become more like the communities on the urban end of the continuum, while those located at the rural end of the continuum, will gradually shift to resemble the suburban ones as they are today. The continuum concept recognizes that there may not be clear boundaries between rural and urban communities. Instead, communities at different points along the continuum are expected to display different mixtures of rural and urban characteristics. The concept of suburban is more complex since it is neither a distinctive type of production system nor a fixed geographical area around a city but is instead an ill-defined interface between city and country and displays a mixture of rural and urban elements (Drechsel, et al., 1999).

The concepts of urban, suburban, and rural are, therefore, multidimensional. The defining criteria can be population size/density, administrative boundaries, proximity to urban settings, and economic activities. Population size and population

density are two important criteria proposed for classifying rural, suburban, and urban communities (Richardson, 1965; DETR, 2001; ODPM, 2001; Chan and Hu, 2003). The administrative boundaries reflected the actual degree of urbanization and urban activities (mainly industrialization in that area) (Chan and Hu, 2003; DETR, 2001). These criteria will be used in this study.

3. Studies on community utilization of energy

Several studies have been conducted in different parts of the world on energy consumption and utilization in urban and rural communities and the factors affecting their energy use.

For urban areas, a number of studies pointed to the high percentage of biomass energy consumption in developing countries, but much less in the more developed countries. For example, in Tanzania it was found that more than 80% of urban people used charcoal as a source of energy (Mwampamba, 2007), while 52.3% of the urban poor in Zimbabwe used kerosene and biomass as their main sources of energy for cooking (Dube, 2003). In Ouagadougou, the capital of Burkina Faso, Ouedraogo (2006) found that wood-energy remained the preferred fuel of most urban households although the firewood utilization rate decreased with increasing household income and was replaced by LPG for cooking. In some more developed countries, charcoal is much less important, being used by only about 10% of urban households in Thailand (Nansaior et al., 2006) and about 5 % of urban households in Buenos Aires (Bravo et al., 2008). For suburban areas, Howorth et al. (1997) found in their review of literature that firewood and charcoal still dominated household energy use in several places though there was an increase in usage of multiple fuel technology types. For rural areas, particularly in Africa and India, biomass constitutes a major share of energy consumed by rural households. For example, in Kenya, Senelwa and Sim, (1999) found that firewood accounted for 69% of total household energy consumption. In rural India as a whole, Mahapatra and Mitchell (1999) reported that 65% of the energy in the domestic sector was provided from wood, while in Haryana state Devi et al. (2009) found that about 30% of rural household energy was from biomass energy sources. In another study, Pohekar et al. (2005) reported that 90% of

rural households still relied on biomass fuels such as wood fuel, cow dung, and agricultural residues. These studies appear to indicate that biomass energy still plays an important role in communities across the range of urbanization.

Household use of biomass is mainly for cooking, but other uses are also reported. In Greater Buenos Aires, Argentina, urban poor households mainly use charcoal for cooking (Bravo et al., 2008). In Khon Kaen municipality in Thailand, however, food restaurants used a large amount of charcoal for cooking whereas individual households consumed much less (Nansaior et al., 2006). In India, high dependency on biomass fuels for cooking, rice boiling and livestock feed preparation was found for rural households (Mahapatra and Mitchell, 1999), while urban and suburban households, although still mostly depending on wood fuel for cooking, increasingly use multiple sources of energy, i.e., wood fuel mixed with charcoal, kerosene and LPG (Howorth et al., 1997; Pohekar, 2005; Dhingra et al., 2008). Chinese living in urban areas used more energy for TVs and other electric appliances, while rural people used more energy, mainly from biomass, for cooking and space heating (Cai and Jiang, 2008, Xiaohua and Zhenmin, 2005). In Switzerland, Madlener and Vögtli (2008) reported that wood can substitute for fossil fuels for heating.

Several factors have been found to affect household energy utilization. Urban or suburban communities in developed and developing countries have infrastructures and technologies that make access to other fuels easy or offer more energy choices, and consequently affect household energy use. There is a tendency for urban households to use more energy and also more diversified sources of energy, and to switch from wood and charcoal to modern fuels. In suburban areas, although wood fuel continues to dominate household energy use, there is an increased use of multiple fuel types, i.e., wood mixed with charcoal, kerosene and some LPG (Howorth et al., 1997). Dhingra et al., (2008) and Cai and Jiang (2008) reported that, as a community became more urbanized, the people tended to use energy sources that are more convenient, cleaner, and more efficient. Lenzen et al. (2006) found that differences between areas in average energy requirements were largely due to geographical conditions and population density, but were also affected by differences in energy conservation measures and technology. Scarcity and seasonal availability of wood

could also lead to changes in the source of energy use (Nansaior et al., 2006; Lenzen et al., 2006).

Several reasons for preferring wood fuel have also been reported. These include its being free or low cost and having easy access of wood fuel (Howorth et al., 1997; Senelwa and Sims, 1999; Pohekar et al., 2005; Dhingra et al., 2008), less cooking time and more flexibility in using wood-burning stoves than kerosene or LPG stoves, and better taste of food cooked with wood (Nansaior et al., 2006; Howorh et al., 1997).

Characteristics of households are also found to influence both the amount and the source of energy use. Level of education, type of life style, occupation, location of residence and type of foods cooked were found to affect household use of charcoal (Nansaior et al., 2006). As living conditions and life styles become more modernized, the sources of energy are also changed from traditional to modern energy sources (Senelwa and Sims, 1999; Nansaior et al., 2006; Bravo et al., 2008).

The amount of energy used also depends on the size of the household. Mwampamba (2007) found that, while large households consumed more charcoal than small households, household size was negatively correlated with the amount of charcoal consumed per capita, indicating lower per capita consumption for large households.

Household income is another important factor affecting the form of energy consumed (Mahapatra and Mitchell, 1999; Senelwa and Sims; 1999; Dube, 2003; Ouedraogo, 2006). Poor slum households use charcoal and kerosene for cooking, although these fuels are dirty and less efficient (Bravo et al., 2008). Devi et al. (2009) found that people in Haryana, India, who had good economic conditions liked electricity most, followed by LPG, biogas, coal, firewood and agricultural residues. The increased use of electricity and LPG was due to more awareness, higher education and better financial conditions. Similar findings were also reported by Pohekar et al. (2005) in their study of cooking energy use by Indian rural and urban households.

4. Approaches used in studying community energy utilization and methods of data collection

The methodology and means of data collection employed to study community energy utilization depend on the objectives of the studies and the units of analysis. Data collection can be classified into two types: 1) literature review and collection of secondary data, and 2) primary data collection.

Examples of studies that used secondary data or literature reviews are Howorth et al. (1997), Pohekar et al. (2005), Xiaohua and Zhenmin (2005), Ouedraogo (2006) Dhingra et al. (2008) and Madlener and Vögtli (2008). Howorth et al. (1997) used a literature review to explore the range of energy demand issues in the suburban interface. This included an examination of household livelihood strategies, energy conservation, fuel-switching, gender issues, suburban energy markets and participatory planning for energy interventions. In their study on factors affecting rural household energy consumption in China, Xiaohua and Zhenmin (2005) used statistical figures from the Yearbook of China's Rural Household Energy. The data were processed and analyzed with the software package of social science (SPSS). A similar procedure was used by Ouedraogo (2006) in studying household energy preferences for cooking in urban Ouagadougou. He used data from extensive surveys that were carried out in 1996 by the National Institute of Statistics of the country. Pohekar et al. (2005) used historical information on household energy consumption for 50 years from 1950–2000 to examine the trends in household energy consumption and the uses of cooking energy alternatives in India. Also, Dhingra et al. (2008) used a review of existing literatures and policies in their study on household energy consumption of urban and suburban poor in Delhi, India. Madlener and Vögtli (2008) analyzed information from city reports and made recommendation to national policy.

Studies that used primary data collected by surveys also differed in several methodological aspects:

4.1 Study sites

The study sites were selected differently depending on the objective of the research and the effecting factor to be examined. In studying energy access in urban and suburban areas, Bravo et al. (2008) selected two villages in southern Greater Buenos Aires to collect qualitative primary information among the poor. Mahapatra and Mitchell (1999) studied biofuel consumption in rural India by collecting data from 24 village communities around two districts, one on the coast with relatively little forest cover and another with good forest cover. Senelwa and Sim (1999) chose two districts in Western Kenya for a survey of rural households. Mwampamba (2007) studied charcoal consumption in urban areas in Tanzania by selecting six cities that varied in terms of their nearness to forest areas and their urban areas well represented other urban areas of the country to be the study sites. Dube (2003) conducted his study on urban poor households in three major cities in Zimbabwe. In their study on the change of energy consumption patterns from rural households to urban households in China, Cai and Jiang (2008) used the administrative hierarchical system, i.e., central government, provinces, cities, counties, towns, and villages, to determine the population, area and degree of urbanization.

4.2 Sample households

Households samples were also selected differently and the number varied from 100-500 households. Mwampamba (2007) surveyed 244 households that were classified into two income levels, i.e., rich and poor, based on the location of the house within the city and the style of residence. Devi et al. (2009) surveyed 500 households door-to-door to collect data for their study, while Bravo et al. (2008) surveyed only 100 households but interviewed key informants for additional qualitative information, and Dube (2003) surveyed 128 urban poor households in three major cities in Zimbabwe. Senelwa and Sim (1999), however, selected only 42 households from a survey of 200 rural households for their study. In studying biofuel consumption in rural India, Mahapatra and Mitchell (1999) assessed the domestic use of biofuels by a PRA questionnaire. Twelve villages were selected randomly from each of the two districts, and 20 % of the households in each district were randomly

selected for their study, totaling 428 households. Cai and Jiang (2008) used 100 % of the households in small village, 50% random households in township and only 0.0001-0.0015% random households in town, county and city in their study on energy consumption in rural to urban households of China.

4.3 Data collected and method of collection

It also varied in the different studies. In the study of Mwampamba (2007) on charcoal consumption in Tanzanian urban areas, the sample households were initially classified into rich and poor by consultation with the natural resource and planning staff from the municipal offices. These households were interviewed with a questionnaire that was designed to collect information on household size, amount of charcoal used per day, week or month and the price paid per unit of charcoal bought. The charcoal measurement was converted to standard units. The report of Bravo et al. (2008) presented energy access in urban and suburban areas in Argentina. It provided an overview of the phenomena and local context and policies applied. The methodological approach for determining energy needs was also presented, followed by a description of the case-study and information related to energy consumption by the urban poor. In their study on energy consumption pattern of a decentralized community in northern Haryana, Devi et al. (2009) collected information on number of people, number of houses, energy consumption patterns and energy supply and demand on the basis of their existing facilities, such as availability of various energy sources, educational facilities and social hierarchy. Amounts of energy consumed from the different sources, e.g., biomass (firewood, cow-dung, biogas) and non-biomass (diesel, petrol, coal, kerosene, electricity and LPG), were converted to mega joules using the pre-defined conversion factors. Energy consumption in different sectors, i.e., domestic, agriculture and transportation, were also calculated. In the domestic sector, contributions of different energy sources (firewood, cow-dung, coal, biogas, kerosene, LPG and electricity) to different domestic activities like lighting, cooking, warming in winter, animal food preparation, water heating and miscellaneous were determined. The same was done for other sectors.

Dube (2003) selected three major cities in Zimbabwe for his study of the urban poor based on represented of the natural and economic zones in order to incorporate the variation of incomes and the availability and costs of energy from different sources. The survey total 128 households also took into consideration the gender aspect of energy use. In their study on energy consumption in a densely populated rural area in Kenya, Senelwa and Sim (1999) interviewed 42 households using a structured questionnaire to define socio-economic classification of the households and evaluate their energy utilization in various activities. The quantity of fuelwood was assessed by the number of headloads used. Samples of fuelwood bundles and the quantity of charcoal (either by stove fuels or bags) used daily or weekly were measured.

Mahapatra and Mitchell (1999) used a questionnaire that was designed in discussions with farmer groups and key informants to study biofuel consumption in rural India. The study covered households of four socio-economic groups, classified on the basis of land ownership. Sample households were visited during two seasons in October 1994 and April 1995 and the head of each household was interviewed. The type of biomass fuel and kerosene used for domestic purposes, the source of fuelwood collected, the distance travelled to gather it, and the amount purchased were investigated for each district. Since it was difficult for villagers to give the weight of wood consumed, they were asked how many bundles of wood they used each week. The weight of fuelwood used was estimated separately for each village because the species used for fuelwood varied from village to village. The monthly consumption of other biomass fuels (crop residues, dung, leaf litter) was calculated and the annual demand estimated and converted to tons using a standard weight that was determined for each type of fuel. The questionnaire was pre-tested and the format improved to incorporate the appropriate local dialect to elicit the correct information. The estimation of quantity used was a one-time measurement. The respondents were asked to recall the number of fuelwood bundles and the number of charcoal bags used daily or weekly, and these quantities were converted to a standard unit using the respective conversion factors.

Cai and Jiang (2008) collected information on family size, economic status, types and quantities of energy consumed by each of the sample households from July 2003 to October 2004 in their study on energy consumption in rural to urban households of China. Three methods of data collection were used in this study. Participant observation was conducted in the village where they stayed with the sample families to record the daily fuelwood consumption for seven days in each season. PRA was conducted in the township and town, and a pre-designed questionnaire was used to survey the county town and city.