Chapter 04

Literature Review

4. Introduction

A number of previous studies on energy consumption and household welfare will be reviewed in this chapter. In this review primary emphasis is laid on the interrelation between energy consumption and economic development. I shall try to demonstrate how energy consumption impacts on economic development. I shall also make compression between developed countries, developing countries, new industrials countries and oil producing countries.

Secondly I shall devote my attention to studies pertaining to the supply of energy. In this regard I shall consider the energy intensity index and try to define what is meant by energy flexibility. Also I shall take in to consideration the factors which influence the household demand for energy and also how demand for energy influences the overall economy of a country.

Thirdly I have paid attention to literature on energy consumption in its relation to household welfare. I have also discussed consumer surplus, the desirable price, available price, compensation effects, variables etc. along with standards of welfare and how variation in household welfare has been calculated.

4.1. Energy consumption and economics developments

Munasinghe and Gunter, in their "Energy Economics, Demand Management and Consumption" (1983) have pointed out that energy consumption is one of the primary factors in determining the welfare level of a country. Their argument is that if a country desires to achieve a 10% annual growth rate that country should maintain a 15% energy consumption rate. This works out in to a ratio of 3/2 (1.5) ratio between energy consumption and annual growth rate. The countries which fall below this ratio are considered underdeveloped countries and countries which have ratio between 1 and 1.5 are considered developing countries and those countries which reached higher ratio are considered developed countries.

4.01: Energy Consumption and Nature of Economy

Country	A	B	C	D	E	F
Japan	507560	13367	107.6	124.2	22879	4.9
India	212100	6462	7.7	836.3	320	5.0
Bangladesh	5895	202	1.82	110.4	179	5.8
Nepal	538	12	0.62	19.1	170	2.0
Pakistan	32973	814	7.15	113.8	365	5.2
Sri Lanka	2647	61	3.56	17.1	416	4.9

Source: Energy Economics, Demand Management and Conservation Policy.
Van Nostrand Com. Inc. (1985)

A = Energy Production (GWh)
B = Energy Consumption
C = Per Capita Energy Consumption (10^6- kilo Joules)
D = population (Millions)

According to the above mentioned study Japan is defined as a country which reached a rapid economic development in the decade 1971 – 1980. It also includes a comparison of facts regarding energy consumption and economic development pertaining to underdeveloped countries as well. Japan is accepted as a developed country. One characteristic high lighted by the study is the high per capita consumption of energy in relation to per capita income. This study also shows that other countries in the region including Sri Lanka have a low growth rate due to the fact that the per capita energy consumption is relatively low.

4.02: **The relationship between energy and economics characteristics.**

Country	A	A_1	B	B_2	C	C_3	D	D_4	E	E_5
Year	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995
Sri Lanka	14.5	17.9	4.1	5.0	360	710	8	9	3	4
India	659.2	836.3	3.6	4.8	280	420	5904	6114	8	10
Bangladesh	88.9	110.4	1.5	5.8	100	200	141	152	2	3
Pakistan	79.7	113.8	4.5	5.2	310	465	538	556	6	7
China	964.5	1135.0	6.9	9.3	380	800	25930	25980	22	27
Japan	115.7	124.2	6.1	4.9	9810	29879	1440	1480	105	110
Singapore	2.4	2.7	9.9	7.5	5830	9001	0	0	139	144
UK	55.9	59.9	2.1	1.8	6820	10503	9632	9800	155	156
America	223.6	249.2	2.5	2.4	15630	21601	58110	58442	284	286
Australia	14.3	16.7	4.4	2.6	9820	12150	5671	5680	201	202
Saudi Arabia	8.6	14.1	14.0	0.1	8280	10890	9692	9702	184	185
Kuwait	1.3	2.1	3.6	1.6	17100	18602	2919	2926	268	269
Iraq	12.6	18.9	4.1	3.4	2710	2925	4422	4430	22	22

Source; Kumar; (1997), Energy Pricing Policies in Developing Countries,
UNDP and ILO.

A and A_1 = Population (Million)
B and B_1 = Economics Development Rate (%)
C and C_1 = Per Capita Income (US$)
D and D_1 = Per Capita Energy Production (10^{12} Kilo Jules)
E and E_1 = Per Capita Energy Consumption (10^{12} Kilo Jules)

M.S. Kumar who wrote "energy pricing policy in the developing countries" (1997) takes in to consideration countries out side the region represented in table 4.01. He takes in to consideration economic data and makes a comparative study of this period 1985-1995. He examined the inter relationship between the economic development in our country and the per capita income and per capita consumption of energy. According to his study the inter relationship coefficient of the countries under study was 0.92 (Table 4.02). In the year 1995 the coefficient had changed to 0.91. This goes to prove that there is a strong connection between per capita income and per capita consumption of energy (Kumar, 1997). This confirms the conclusion of the research conducted by Mohan Munasinghe and Gunter 1983.

A study conducted by G. Dematoes "Energy demand in developing countries"1992. has pointed out that under developed countries share a number of common problem such as poverty, malnutrition, disparity of income, unemployment which slows down industrialization of those countries. Many underdeveloped countries adopt various economic strategies and reforms with the aim of turning themselves into new industrial countries. Yet no industrialization has taken place up to the desired level. Thy have identified the cause of this failure as the low consumption of energy. This idea is confirmed by a comparison of economic development and per capita consumption of energy as well. Table number 4.03 makes a comparison. Relatively speaking the ratio of energy consumption between newly industrialized counties and Sri Lanka is proximately 1 is to 12. It means that one person in newly developing countries consumes 12 times the energy consumed by a single person in Sri Lanka. If we compare the ratio with the developed countries it is even greater.

4.03: Consumption of energy: a comparison between new industrialized countries and Sri Lanka 1990

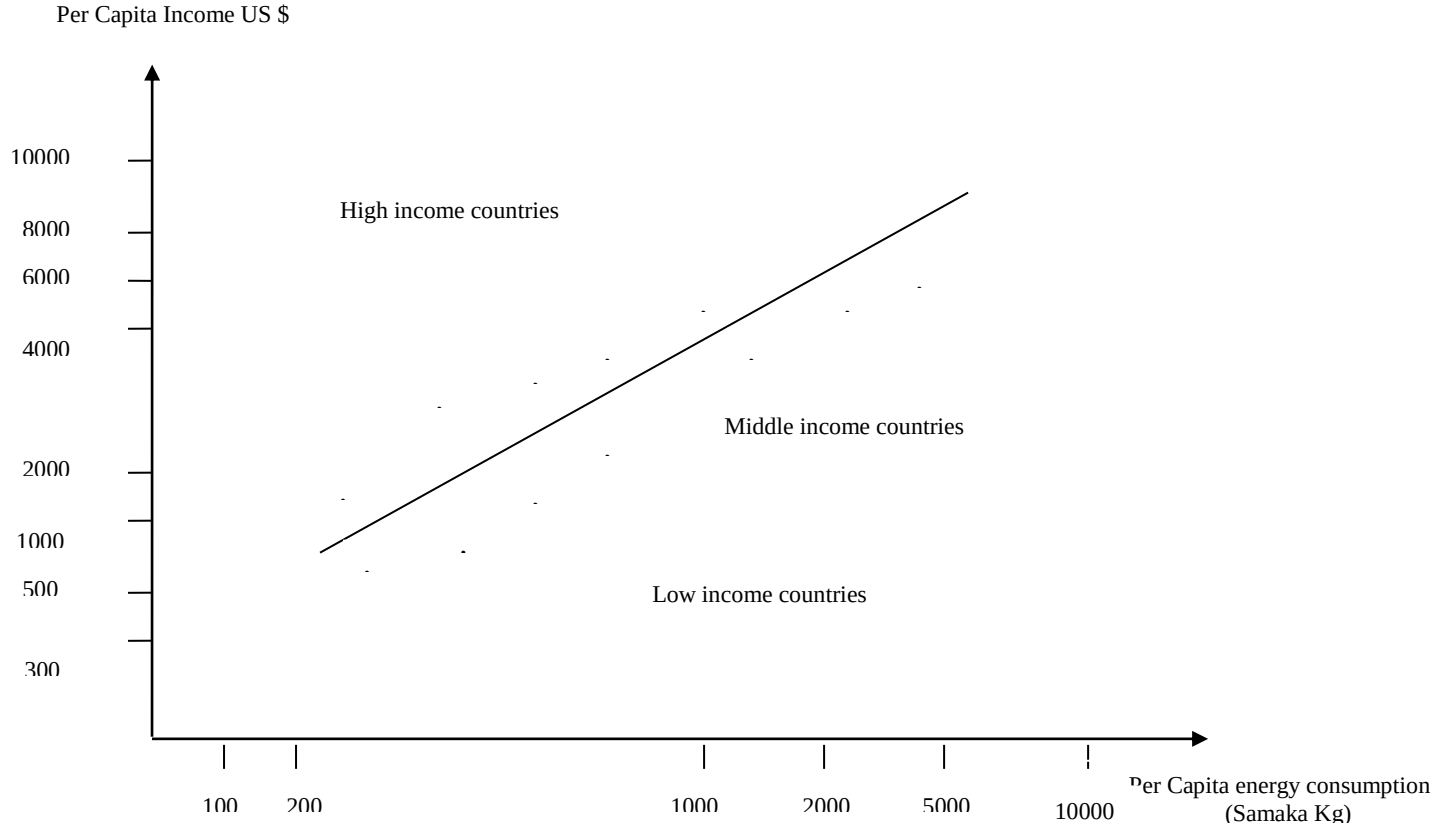
Country	Population	Energy Consumption	Per capita energy consumption
South Korea	43.5	63000	1600
Taiwan	19.6	59000	3100
Hong cong	5.6	26000	3800
Singapore	2.7	11000	4400
Sri Lanka	17.9	4000	260

Source: Domatos, D, (1992) "Energy Demand in the Developing Countries". Energy Economics, Vol.11.p.147.

If under developed countries are to achieve faster development per capita consumption of energy has to be raised. This is confirmed by the industrialized countries which reached high level of economic development in the two decades from 1980to 1989 and 1990 to 1999. This is true of the newly industrial countries as well. The principle reason why the new industrialized countries were able to reach their development target was that the per capita consumption of energy of those countries rose rapidly.

M.C. Stern in his study "Energy consumption and economic growth in Developing countries" in 1993 has pointed out very clearly the intimate relationship that exists between per capita consumption of energy and per capita income. When this relationship is quantified it takes the co efficient 0.91. In the study Stern has classified countries in to three categories; mainly industrial countries where the per capita is high, countries where per capita income is moderate and lastly countries where the per capita is low.(Stern 1993) This is illustrated in graph 4.01.

4.01 The relationship between per capita consumption of energy and per capita Income.



Source: Stern M.C.(1993), Energy Consumption and Economic Growth in Developing Countries, Journal of Energy Economics, Washington DC.

In 1993 Hwang in his study (The causal relationship between energy and GNP) bases himself on the co relations between per capita income and per capita consumption and extends the argument by working out a relationship between consumption and energy and income ratio. His argument is that the co efficient between a consumption of energy and per capita income could be made the instrument for comparison of development process of different countries. He takes data from ten countries and classifies them in to three categories. Table number 4.04 makes a comparison of the data related to those countries.

What this study has shown is that countries with low income show a lower energy consumption co-efficiency. What it means is that industrialized countries (0.84) have a higher co-efficient than countries which export oil (2.27). The energy co efficient of medium income countries is higher than industrialized countries. In the same way the energy co-efficient of low income countries (2.01) is higher than middle income countries. So the final conclusion of Hwang (1992) is that the coefficient in under developed countries will be more than one while developed countries will have a co-efficient of less than one.

4.04 The co efficiency of energy consumption in relation to per capita income (1990)

Classified countries	Per capita income (US$)	Per capita energy consumption	Intensity of energy income
Low Income Countries****	280	562.8	2.01
China	520	1669.2	3.21
Sri Lanka	417	250.2	0.63
Nepal	210	23.1	0.11
Middle Income Countries***	1520	1307.2	0.86
Singapore	5830	5363.6	0.92
Yemen Arab	1008	171.3	0.17
Industrial Countries**	9480	7963.2	0.84
Canada	10046	9443.2	0.94
Italy	6250	4062.5	0.65
Petroleum exports countries *	5870	1584.9	0.27
Quiet	18100	5249	0.29
Iraq	2610	2505.6	0.96

Source: Hwang D.B.K. (1992) “The causal relationship between energy and GNP” Journal of energy development, Washington DC.

According to this table the lower income countries where the average middle income is 280$ US the energy consumption will be 562.8kg. In 1990 China was considered a low income country and China recorded the highest per capita income as well as the highest per capita consumption of energy. In the decade 1996 to 2005 China became the country with the fastest growth rate (the economic growth recorded a value of more than 10%). In the year 1995 the per capita income in China was

761$US while in 2005 (That is ten year later) it s rose to 1760 $US which is an increase of 999 $US. Parallel with this in 1995 the per capita income of energy was 2001.6 toe kg and by 2005 it had increased to 3807.2 toe kg. This is an increase in 18.056 toe kg which is almost double the previous rate. An increase in per capita consumption of energy has obviously enabled china to reach a higher economic development in the given period. This makes abundantly clear the inter relationship between consumption of energy and economic development.

At this point we could get on to a comparison between China and Sri Lanka in relation to per capita energy consumption and economic development. According to the table 4.04 we see that in the year 1990 the per capita income in Sri Lanka was 470$US while the per capita consumption of energy stood at 250.2 toe kg. In the year 1995 the per capita income in Sir Lanka rose to 710 $ USD which is 8.25% growth. At the same time the per capita consumption of energy increased to 289.6 toe kg which is an annual growth of 2.72%. In the year 2005 the per capita income increased to 1188 $USD this was an annual growth of 4.02%. The reason for the decline in the per capita income for this decade is that the per capita consumption of energy has remained at a lower rate (Dissanayaka .2006). While in China in the decade from 1996 to 2005 the per capita consumption of energy increased from 2001.6 to 3807.2, that is an increasing in 180.56 ie. 47.42% in Sri Lanka the per capita consumption of energy has increased form 289.6 toe kg to 331.4. This is an increase of 41.8 toe kg which is an increase 12.6. What this makes clear is that an accelerated economic growth must be accompanied by an accelerated rate of energy consumption.

Singapore which has been considered as middle income country, Canada which is an industrial country and Iraq which is an oil producing country all show the close co relationship that exists between per capita income and per capita consumption of energy as amply demonstrated by the figure is in 4.04 .

4.2. Energy Demand

The growth in demand for energy and the environmental problems connected with it was addressed by the environmental foundation limited in their publication energy conservation and development project report 1992. What they emphasis that the energy intensity index as well as energy elasticity should be considered when assessing the significance of energy sources.

Energy intensity index is the gross equivalent of the national income……..??
In the year 1972 overall energy intensity index was at 66 and in the year 1977 it was reduced to 57. In the year 1990 it came down till further to 44. Partially considered the energy intensity index the per year 1972 was 03 in the year 1977 it was 03.6 and in the year 1990 it showed a development of 04.8. The energy intensity of petroleum also showed a systematic decline over the period 1977 to 1999. The energy intensity index for non commercial sources of energy also showed decline over the same period. A comparison of energy intensity indexes is given in (Table 4.05).

4.05: Energy Intensity Index

Item	1972	1977	1982	1987	1990
Electricity	3.3	3.6	4.3	4.7	4.8
Petroleum	16.1	11.5	11.4	9.6	8.8
Non Commercial	46.2	42.1	33.5	32.0	30.1
Total	65.6	57.2	49.2	46.3	43.7

Sources: Environmental Foundation Ltd. Energy Conservation and Development Project Report, Colombo, 1992

The other factor emphasis by the environmental foundation in their research the flexibility of energy. In many countries we could see a close a connection between the growth in gross domestic product and growth in the demand for energy. This is known as Energy Elasticity (EE) is calculated by dividing the annual energy growth ratio by ratio of gross demotic product (EE= GRE/ GRY)

4.06: Energy Flexibility of Sri Lanka

Item	1978	1980	1982	1984	1986	1988	1990
GRE	5.9	1.2	3.2	6.0	3.5	1.7	3.6
GRY	8.2	5.8	5.1	5.1	4.3	2.7	6.2
EE	0.7	0.2	0.6	1.2	0.8	0.6	0.6

Source: Environmental Foundation Ltd. Energy Conservation and Department Project Report, Colombo, 1992

As pointed out by the energy conservation and development project Colombo 1992 the energy flexibility of Sir Lanka stand at 0.6 in the period from 1978 to 1999 (flexibility of less than one) if we are to compare to this with other developing countries Sri Lanka shows favorable picture because these developing countries also show a value of less than one. This shows common feature all developing countries. This report emphasis that Sri Lanka has been able to reach expected level of development precisely for this reason.

At the same time value should remain at least close to 1.0 in order to overcome the challenges of the future. And thereafter the energy flexibility should be kept at level of 0.5 in order to maintain that level of economic development continuously. Munasinghe 1983 opines that in economically under developed country should maintain and energy flexibility value 1.5 if these countries are to reach their development goals. All these leads the simple conclusion that if the energy flexibly index is at a point less than 1.5 there is no rapid economic development to speak off.

Peterson 2001 in his study off house hold energy demand in Denmark has highlighted most important factor which pertain to house hold energy such as..

The nature of job
The nature of house and its location
The number of people in the household
The number of hours they spend at home
The nature of utensils used
The climatic condition
The facility for storage electricity

The variability of these factors have a decisive impact of the demand for house hold energy.

Under Nature of the job what is considered is whether employment is carried out within the house hold or outside the house hold. Under nature of the house he considers whether its constructed or not and also the number of rooms and squire root of each room. This is because energy is necessary in order to preserve the internal temperature of the house. Obviously amount of time house holders spend at home is also crucial. Needless to say the house hold implement use also makes a demand on energy. Also distinction has to be make counting the heads of each house hold because if they are children the demand for energy rises correspondingly. Seasonal changes have an impact on energy because it’s necessary to keep the houses warm. Although electricity is made available from the national grid to keep houses warm within municipal sector. House holds out side city limits may

have to depend on other sources of energy such as fire wood. Peterson says that in order to keep to maintain a level of temperature of the houses five squire meter of fire wood is necessary for a person per year. Emphasizes the need for storage for this purpose that is why storage has been considered as one of the factor in his study.

According to R. Goswamy 2002 there is a natural growth in the demand for energy along with the growth of its population. Here Goswamy refers to the per capita consumption of energy. This is to state obvious.

There are other reason for the growth in demand for energy such as following:
When the income of the population grows as result of the gross growth rate of national product, leading to increase in savings which leads to greater investment and the creation of new industries.

Another would be the mutual dependency of the demand for energy. This means although there are a number of possibilities by which the domestic needs for energy can be satisfied, people tend to select the more advantages or cheaper source of energy. For example kerosene oil can be used for purposes of lightening electricity to could do the same. So if electricity is cheaper than kerosene more investment will be made.

As Goswamy points out when the level of education of a country the demand for energy also shows a corresponding rise. For example the use of computer, use of electrical gadgets are example of this trends this encourage by the introduction of modern efficient and multiple appliances to consumer market. There are many example in this regard, air conditioner washing machine, driers threshing machine, floor cleaning machine are few example.

Ali be Nagib 1993 in his study of situation the energy situation of Morocco shows how geographical and environmental factors influence the demand for domestic energy. In his field study 40% of the expenditure of energy was for firewood 32% for gas. 15% for charcoal 10% for electricity and 3% for other source of energy. The monthly average of consumption per house hold was 55kg of firewood, 12 kg for coal, 10 kg for gas. Thus Nagib argues higher consumption firewood is due to the geographical environmental factor of availability of that resources in the immediate environment . 18% of house hold in his study use firewood so only for cooking purpose. Although generally gas as well as called are also used for cooking. However the primer resource of energy for lightening is electricity. The average monthly house hold consumption of energy for 45 kWh . Averages of 9.2 of the overall house hold expenditure is devoted to the consumption energy.

4.3. Domestic Consumption of Energy and Welfare

According to Gunnar Kohling 1998 Geographical and environmental resources directly influence energy consumption (In this study firewood has been considered as the primary source of house hold energy.) In Orissa a large extend of land (32%) has been allocated to natural forest shrub jungle as well as reforestation.

In the state of Orissa the average house hold consumption of firewood per month comes close to 120 kg and the time devoted to gathering of this extended firewood has been estimated 45Lh. The time deepens on from distance from home to the location of the materials (Df) . The Number of trips made to collect the firewood (Nt), and the amount firewood necessary for house hold consumption (Qw), This works out in to a formula which goes as follows (Lh= f (Df,Nt,Qw). According to this formula the time necessary for collecting one kg of firewood is 22.5 minutes (45÷120=0.375×60= 22.5) The average daily wage of a laborer is 100 rupees and therefore the labor cost for 45 hours of works comes up to 562. 50 (100÷8 = 12.5×45=562.5) This is equal to 18.75 ($ 1=30R) the average

price of 1kg firewood is 2.50 R. (50kg of firewood will come up to 125 R.). Assuming the market prices to be such the average house hold expenditure on fire wood would be (120×2.50) 300.00R. Accordingly if a person does not buy the necessary firewood from market and resource to collect the firewood from the surrounding environment the monthly per less house hold could be valued at 262.50 Rs. (562.50-300=262.50). This loss directly implies a drop in consumer satisfaction which means a drop in house hold welfare. So the conclusion this study drives at is that when a house holder does not buy the firewood from the market place and resorts to obtaining from the immediate environment he inquires a drop in house hold welfare.

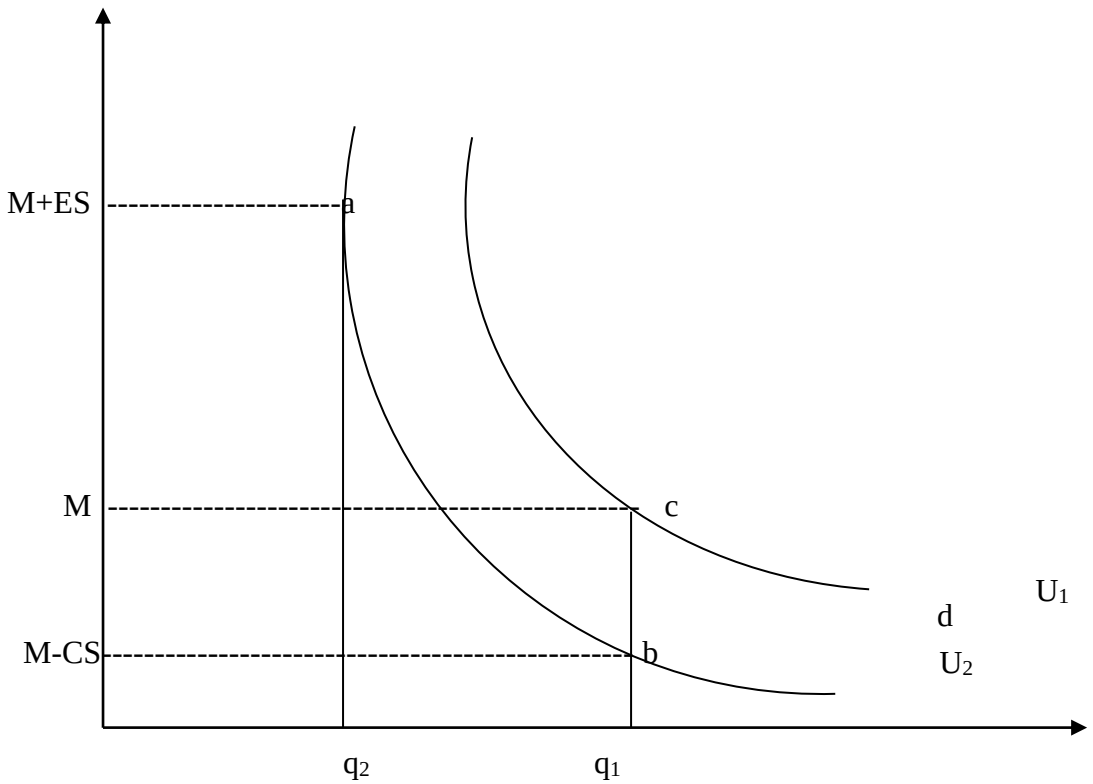
At the same time the study pays attention to the relationship between leisure and welfare. People have to for fit there leisure in trying to gather firewood the time consumed for this purpose is approximately 45 hours converted it to money value its equal to Rs. 562. Its argued that this is a drawing away from their welfare. This because they have sacrifice their leisure for purpose of gathering firewood the opportunity cost is Rs. 562. 50.

The next question that this study address is: Although each house holder has to spend 45 working hours for purpose of gathering firewood the question to be considered is how fair is this to be taken as a drain on their welfare the fact is that the time of most of these house holders has no market value. Their not engage any other alternative economic activity which means they have all the time in the world in order to gather firewood for their house hold welfare to look alternative scenario if they did not use their free time to gather firewood they will be compelled to buy the firewood from the little financial recourses at their disposal which means they will be 562.50 Rs. out of pocket. Because they were able to obtained firewood without any cost to their pocket they have ultimately save and equivalent some of Rs.562.50Which they can now use to purchase other commodity of services. Thereby the real income of these house holds has gone up. Kohlin 1998 in his study of the state of Orissa in India examined how the forest rehabilitation programme in that Indian state had unable to improve the level of welfare of house holds.

Alemu Mekonnen 1998 also has undertaken a similar study of the impact of energy consumption on house hold welfare in rural Ethiopia. He has confirmed that the use of firewood use of firewood as a alternative to oil electricity or gas has unable these householders to increase the surplus and thereby uplift the welfare of their house holds. The study approves that the cultivation of forest reserves has let to the up liftmen of welfare condition. 304 birr are needed to satisfy household needs of oil electricity or gas. These about 60% percent of their monthly income (One $= 6.34 birr). If firewood is use as an alternative energy source 60% of their expenditure namely 182. 4 birr can be reduced. So the money save in this manner can be utilized to purchase essential commodity thus the real increase in the real income house hold leads to higher consumer satisfaction and combined with up liftmen of the levels of house hold welfare. That is the conclusion arrive that in Mekonnen study. Apart from firewood foresters also provide great deal of timber for future use.

According to this study the household coming this research would prefer (WTP) to spend and average of 2.63 beer. In this manner the forestation project would earn a total of 756.62 beer per month (it works out in to 2.63 beer per month × 2875 households (Mekonnen 1998 p.86.Table 4.4)

Karl- Goran Meler in his study of consumer surplus and welfare published in 1974 'Environmental Economics: a theoretical study' goes practically in to a study of ascertaining the question of variation in the levels of consumer welfare in the study he makes a quantitative comparison between WTP and WTAS. In this calculation he has made use of concept like Compensation Variation and Equal Variation drown from welfare economic.



Source: Maler K.G. (1976), Environmental Economics: A theoretical Enquiry, Duke University.

In this study of natural resources (sunlight, natural forest, the sea shore, garden, lakes, water falls etc) as common consumption goods economists have paid attention to the possibility of calculating× consumer surplus.[8] The notes 4.01 explains the theoretical base upon which this calculation can be make In calculating consumer satisfaction we have also made use of concept relevant to the analysis of Indifference Curve.

Calculating compensating surplus

$$CS = e\,(P,q_0,u_0) – e\,(P,q_1,u_0) = M – e\,(P,q_1,u_0) \qquad (4.3)$$

Calculating Equivalent Surplus

$$ES = e\,(P,q_0,u_1) – e\,(P,q_1,u_1) = e\,(P,q_0,u_1) - M \qquad (4.4)$$

Eg.
e = Consumer Expenditure
P = Shadow Price
u = Utility
M = Consumer Income
Q = Quantity

Diagram 4.02 explains the detail working of the relevant facts.

This study has confirmed $\Delta u>0$ (if utility take surplus)
CS = WTS and ES = WTA.

Mical Hanemanne (1991) as improved upon Karl Goran Meler in his work "social choice welfare and individual values"

$$CV = e\,(p^0,u^0) - e\,(p^0,u^0) + \Delta m \qquad (4,5)$$

$$EV = e\,(p^1,u^1) - e\,(p^1,u^1) + \Delta m \qquad (4.6)$$

According to above variation Consumer gap $\Delta m = m^1 - m^0$

Table 4.03

Hicksion Consumer Surplus

$$CV = \sum_{i=1}^{N} \int_{p^0}^{p1} \times (p,u^0)\, dp + \Delta m \qquad (4.7)$$

As compensation variation

$$EV = \sum_{i=1}^{N} \int_{p^0}^{p1} \times (p,u^1)\, dp + \Delta m \qquad (4.8)$$

As Normal Variation

According to 4.03 compensation variation represented as p^0a d p^1 normal variation represented as p^0 c d p^1 This makes clear that the EV larger than CV. Accordingly Marshalian consumer surplus is demarcated by the (CV<EV) That is the compensation variation the Hicksian Consumer Surplus is marked by p^0a d p^1.This is the Equal Variation. This makes clear the different between the Marshalian Consumer Surplus and Hicksian Consumer Surplus p^0c d p^1 which were concepts introduce by Robin W. Boadway and Neil Bruce in their book welfare economics published in 1984. This study proves the contention that Hicksian Consumer Surplus is much larger than the Marshalian Consumer Surplus.

4.4 Conclusion

The energy consumption has direct impact on the economic welfare of a country as well as economic development. This confirm by the inter relationship between per capita income and per capita consumption of energy. When income rises as positive function of that of that fact the level of consumption also increased. When the level of consumption increases The level consumer satisfaction goes up with it. Consumer welfare naturally goes up alone with this. Accordingly the growth domestic consumption energy leads to domestic welfare.

The study on the consumption energy and welfare have lead the foundation for deciding upon the factors which influence the consumption energy and the demand for energy. In addition to domestic income, the nature of household, the number of members in household, the appliances which need energy, the educational level of the members, would be necessary to be taken into consideration. The fact that house hold energy consumption has and impact on house hold welfare levels (this is due to the behavior of variables which influence the consumption of energy.) compelling us to take this factor into consideration in studying the nature and levels of house hold welfare. The fundamental of

welfare economics can be readily applied in a practical study of house hold energy consumption and its intimate relationship with issues of house hold welfare.