ENERGY CONSUMPTION AND HOUSEHOLD'S WEALTHY: CASE OF HERDER HOUSEHOLD IN MONGOLIA

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ABSTRACT

More than half the world's population lives in rural areas, nearly 90 percent of them - some 2.8 billion - in the developing countries. Most of today's 2 billion people without adequate energy services are in rural areas. Currently, share of herder households in Mongolia with electricity sources accounts 82.7 per cent of total 160.2 thousand herder households (NSO, 2011). This study estimates the herder household's energy consumption based on theory of energy ladder hypothesis, Engle curves and Almost Ideal Demand System (AIDS) model as demand system analysis. The results of the study illustrate that the Energy Ladder hypothesis fits to herder households in Mongolia. They mostly use dung, wood, forest and grass waste and coal in regard to their income and energy source availability. The share of energy expenditure estimation shows that energy is necessity goods for herders. Total household expenditure inversely related to the energy expenditure share. The study results conclude that the herder's energy consumption is on a very low level and some policy interventions are necessary for improving herder´s livelihood.

KEY WORDS: Economic analysis, electricity and heating, energy ladder, Engel curve, herder household in Mongolia

INTRODUCTION

The Mongolian herders have nomadic way of life which is unique worldwide; thus they need special way of supplying adequate and proper resources of energy. According to FAO, the energy is an essential element for both the fulfilment of basic human needs - especially cooking and heating, but also hygiene, health, etc. and for sustainable rural development, including agriculture, food processing and education (FAO, 1999).

Currently in Mongolia there are 305 (about 91 percent) of total of 332 soum centers and settlements which are connected to the electrical transmission systems. Connecting to the central gridlines system is possible for rest of the soums but not for isolated herder households due to their nomadic life tradition. About 69 percent of herder households utilize wind or solar panels only for evening light and for few hours TV program which is compatible with human basic needs. Most nomadic herder households have no access to electricity. The main reasons include (**i**) high costs of household power systems coupled with low incomes of many herder households; (**ii**) sustainable policy support for providing adequate energy sources to herder household level and (**iii**) a nascent market of renewable energy producer which lacks basic quality and service standards. On the other hand, Mongolia is endowed with abundant solar and wind resources, which facilitate the adoption of solar

home systems (SHSs) and small wind turbine systems (WTSs), two mature and highly portable technologies that suit the lifestyle of nomadic herders. With systems donated by the governments of China and Japan, the Mongolian government launched some "100,000 Solar Sets" program in 2001 and provided some 100,000 SHSs to herder households by 2009 (Zorigt. D). After the progress of herders' electricity access has stagnated.

The article refers the study which addresses several objectives: it makes an economic analysis of herder household's energy consumption and insight the interrelationship between energy consumption and household wealthy (animal numbers), find out possible activities to have adequate sustainable energy sources.

MATERIALS AND METHODS

Theoretical framework of Analysis consists of the following steps:

1. The energy mix model which infers that households decide on the types of energy sources to use.
2. The energy consumption behaviour is analyzed. That allows for testing various assumptions about the consumer's behaviour.
3. An empirical study with collection of data on household energy consumption and estimating empirical model according to the theoretically-based models.
4. The demand for various sources of energy has been analyzed theoretically and empirically using different approaches. They include the energy ladder hypothesis (Kebede *et al*., 2002; Arnold *et al*., 2006; Davis, 1998; Masera *et al*., 2000; Barnett, 2000), the Engel curves (Amacher *et al*., 1993, 1996, 1999; Mekonnen, 1999; Helberg *et al*., 2000; Gundimeda and Kohlin, 2003; Balande*t al*., 2005), and energy demand functions (Athukorala *et al.,* 2007; Erdogdu, 2006).

The energy ladder hypothesis

The energy ladder model is one of the most common approaches used in studying the household energy consumption. According to the classic energy ladder a household at lower levels of income and development tend to be at the bottom of the energy ladder, using fuel that is cheap and locally available (Fig. 1). Exclusively, over three billion people worldwide are at these lower rungs, depending on biomass fuels: crop waste, dung, wood, leaves and coal to meet their energy needs. A disproportionate number of these individuals reside in Asia and Africa (Rehfuess and WHO 2006). Coal is seen as a higher quality fuel due to its efficiency and storage, and thus is higher on the energy ladder. As incomes rise, we would expect that households would substitute to higher quality fuel choices. However, this process has been quite slow.

With increasing disposable income and changes in lifestyle, households tend to move from the cheapest and least convenient level (fuels) to more convenient and normally more expensive ones Dziobinski, 1999)

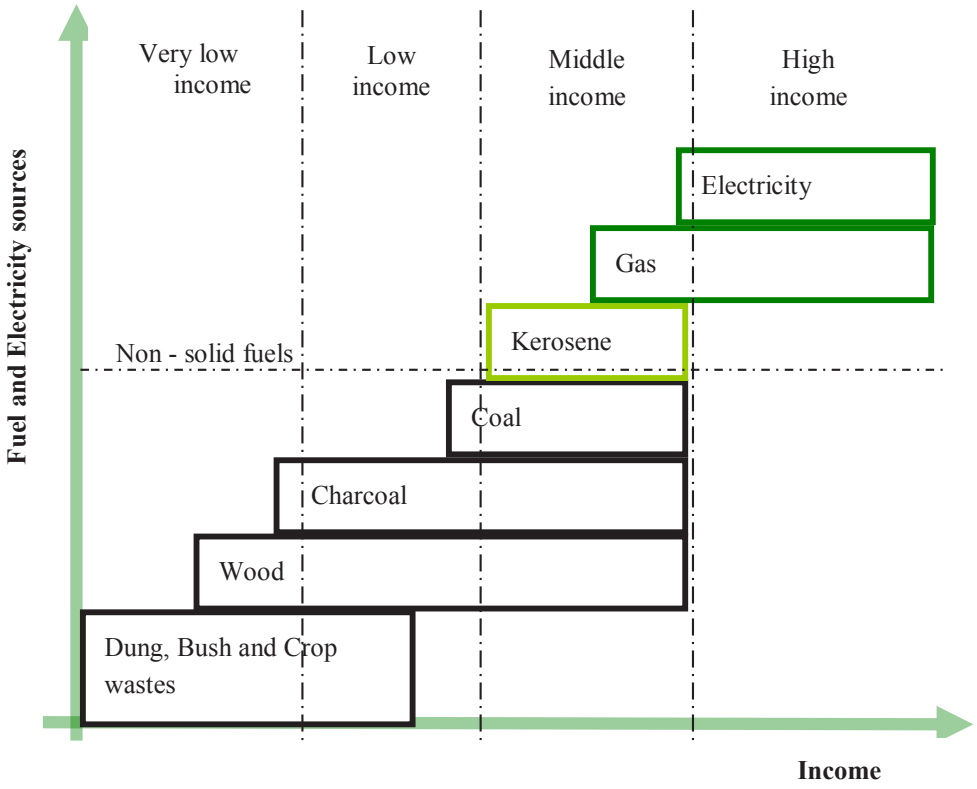

Figure 1. The energy ladder

Household energy expenditure and Engel function

In this study, Engel functions were estimated for the herder households. A hypothesis was assumed that the households first make their decision on the allocation of the total budget on total energy expenditure and then decide how much to allocate on individual fuels within the energy budget. In this study the second stage of the step-wise budgeting was tested empirically by estimating Engel curves using the functional form:

$Wi=\alpha+\beta\ (\ell n\ TEE)$ where,

W*i*= Energy budget share of fuel *i,*

TEE = Total energy expenditure, and

(1)

α and β = Parameters to be estimated

Engel curves were estimated for firewood, dung, wind, solar energy and electricity separately for all and household's averages. The semi-logarithmic model is regarded to be the best suit for empirical estimations of Engel functions (Prais and Houthakker, 1955). Budget elasticity ($\mathbf{з_i}$) for individual fuels, across sectors and over time was calculated by dividing the estimated coefficient "в" by the energy budget share (Sadoulet and Janvry, 1995).

The Almost Ideal Demand System (AIDS)

AIDS is useful tool in the analysis of household energy consumption given the fact that both household expenditure and the prices of alternative sources of energy influence the share of any one source of energy in the energy mix (Deaton and Muellbauer, 1980).

$$\omega_i = \alpha_i + \beta_i \ln TEE + \delta X + \sum \gamma_{ij} \ln p_j + \mu_i R_i + \vartheta \quad \textbf{(2)}$$

Where ω_i are the share of energy expenditure on fuel *i* in total household expenditure

p is price of fuel *i*

X is the vector of household characteristics with corresponding coefficient vector

δ The actual household characteristics that go into the functional form will be determined by a combination of theoretical, pragmatic and econometric considerations

R is corresponding i[th] region of the household (i= 1…5)

α, β, γ *and* μ are parameters to be estimated

ϑ is error term

Here β is to determine whether energy is a luxury, a necessity or of inferior importance (Deaton Muellbauer, 1980). The household factor X enters into the model in linear specification. The coefficients of the variables enable us to assess how the energy share is affected by household factors.

Data collection and household characteristics

Herding households' survey has generated more than 50 variables excluding open ended questions. Variable selection has been made based on statistical significance as well as economics expectations. Seventy six herder households randomly selected from different agro-ecological zones as the objects of this study. Each household differs in several respects, such as: size, educational level and other characteristics that are expected to have different expenditure patterns. Because of these reasons the demand depends not only on prices and family budget but also on household characteristics. Use of coal and firewood or dung depends on region's differences and availability of these sources. The survey was carried out by interviews with groups of key informants. Additional data on population, price of fuels were collected from administrative records.

RESULTS AND DISCUSSION

Herding households' survey has generated more than 50 variables. The most predefined variables were statistically significant with higher rate of significance. The share of firewood in the energy budget increases when the total energy expenditure grows while in the same time the shares of waste and coal decrease. We may interpret these results so that firewood is a quite normal fuel and waste and coal are fuels of an inferior quality. Besides this, also traditional approach to energy sources must be taken into account, i.e. the consumption of firewood is high due to the fact that the firewood is easily available and cleaner than the other two fuels.

The result of the study illustrates that the Energy Ladder hypothesis fits to the case of Mongolia (Fig 2).

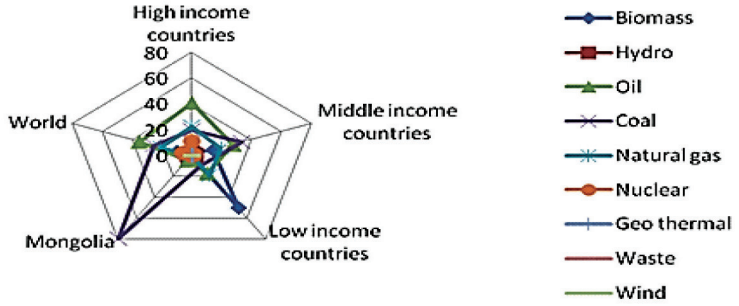

Figure 2. Application of the Energy ladder hypothesis for Mongolia

The herder households mostly use dung, wood, forest and grass wastes and coal with regard to their income and energy source availability. The share of energy expenditure on the total of herder household budget shows that the energy represents necessity for herders. The variables such as number of animals, ger size, family size and khot ail size have positive relationship with the share of energy expenditure - this is in tune with our expectations, i.e. bigger and/or richer family requires more energy to cover their needs. Total household expenditure is inversely related to the energy expenditure share. Total energy budget elasticity of wood, waste and coal are 1.11, 0.20 and 0.99 respectively.

Energy Consumption by an Average Herder Household

The calculations prove that an average herder household's basic electricity consumption estimation (made by National Renewable Energy Centre of Mongolia - NREC), 1.2 kWh (36 kWh per month and 432 kWh per year) of electricity power could be sufficient if the scarce resources reach this level. Today herder households use 16 W colour TV for 5 hours a day, 13 W fluorescent lamp for 6 hours a day, 0.5 W radio for 10 hours a day - which is together 160 Wh (0.16 kWh) per day. In our survey, herder household's electricity consumption estimated about 100-140 Wh per day. This amount of energy consumption is 25 - 30 times lower than that in cities or towns. Mongolian Governmental program entitled "100000 Solar Ger" enables herder households to receive solar panels for a reduced price. The program was started in 2005; 100000 solar panels of potential 55W were delivered to the herders´ households.

The First Stage of Budgeting – Total Energy Expenditure: Household Expenditure

The Tab. 1 presents results of the surveyon the energy expenditure shares of herding households. In

conclusion the model fits to the expectations, i.e. all variables are statistically significant on high probability level of the whole model and are consistent with hypothesis.

Table 1

Total energy expenditure (estimated variables) for selected herder households in Mongolia

Variable	Coefficients	t-statistics
Constant	0.642	4.21
LnTE	-0.280**	1.140**
LnAnimalValue (x_1)	0.310	2.511
FamilyMembers* (x_2)	0.101	2.591
EducHH_Head(x_3)	-0.011	-3.180
GerSize (x_4)	0.001	4.370
KhotailSize(x_5)	0.121	4.671
R^2	0.308	
Durbin-Watson	2.1	
Significance level	0.001	

**Variable "Family Members" has been generated from adding up number of adults and number of kids in the household. This variable represents family size in general;*

***Significant at 10%..*

From this we may assume that energy is a necessity or of inferior significance. The variables such as number of animals, ger size, family size and khot ail size were all have positive relationship with share of energy expenditure which is met our expectation.

Based on the simulation results the Engel function can be represented as following formula. Thus:

$$\omega_{TEE} = 0.642 - 0.280 * \ln TE + 0.310 * X1 + 0.101 * X2 - 0.011 * X3 + 0.001 * X4 + 0.121 * X5 \quad (6)$$

The variables x_1 - x_5 represent household characteristics (see Tab. 1). The function above allows us to draw the Engel curve. Different income levels were applied to estimate corresponding energy budget share.

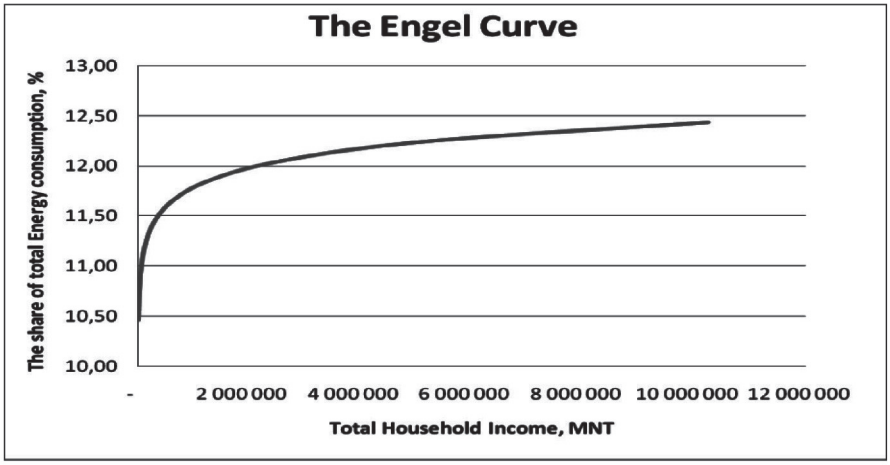

Figure 3. Engel curve of the energy consumption

The shape of the graph on the Fig. 3 clearly indicates that the energy is classed as necessity good in the case of herder household's expenditure in Mongolia.

Second Stage of Budgeting – Allocation of Energy Budget

Allocation of energy budget to individual fuels has been the second stage of our modelling. It is connected to a system of equations, determining the shares of each fuel in the energy mix of certain households total energy expenditure. The system of equations has been estimated by SPSS. Tab. 2 offers estimation results of the energy expenditure shares of different fuels along with the overall statistics, i.e. indication of statistical probability level of the individual variables.

Table 2

Share of individual fuels in herding households energy consumption

Variable	Share Wood		Share Waste		Share Coal	
	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.
Constant	-0.841**	1.70	1.12**	1.52	0.775**	1.64
Ln TEE	0.105	2.20	-0.801	-2.41	-0.012	-2.02
Ln Animal Value	0.70	2.62	-0.009	2.511	-0.440	-2.44
FamilyMembers*	0.44**	1.32	-0.790	-2.590	0.021	2.74
EducHH_Head	0.019	3.10	-0.001	-2.003	-0.020	-3.21
Ger Size	-0.21	-2.11	0.002	2.400	0.005	3.01
Khot ail Size	0.014	2.48	-0.211	-3.52	0.009	2.22
Fuel Wood Price	-0.470	-2.18	0.370	3.421	0.210	2.15
Fuel Waste Price	-0.301	-1.98	-0.185	2.971	0.231	1.45**
Fuel Coal Price	0.281	3.44	0.200	2.490	-0.204	1.97
R^2	0.511		0.311		0.321	
Durbin-Watson	1.620		1.711		2.001	
Significance level	0.000		0.000		0.000	

***Significant at 10%*

The share of firewood in the energy budget increases when the total energy expenditure grows, while at the same time the shares of waste and coal decrease. From economic point of view we may interpret the results that the firewood is a normal fuel and waste and coal are fuels of an inferior significance. Total energy budget elasticity of wood, waste and coal are 1.11, 0.20 and 0.99 respectively. Thus when the total energy expenditure grows the quantitiy of fuel wood increases more while the quantity of wastesgoes up far less than the percentage increase of the total energy expenditure. Surprisingly the change of coal quantity is nearly same as the percentage change in total energy expenditure.

CONCLUSIONS

1. Mongolian herder households' energy equilibrium is in deficiency. Current average consumption is 160 Wh (0.16 kWh) per day. This does not meet basic human needs.
2. The analysis of survey results shows that the herder household's energy supply is considered as necessity. The variables such as number of animals, ger size, family size and khot ail size have positive correlation with the share of energy expenditure.
3. The bigger and/or richer families will require more energy to cover their needs. When the size of herder´s herd surpasses a certain number (500 and more livestock heads) than there is a little correlation between the level of energy consumption and growing number of animals.
4. The poorer herders do not have possibility to secure the electricity provision themselves. They cannot buy any solar systems although their price has recently dropped considerably.
5. There was a working hypothesis that the herders have great willingness rather to maximize numbers of their animals instead of having enough energy resources. This has not been proved by our survey.
6. About 80 % of herders expressed their wishes to have adequate and sustainable energy sources like central grid system. The households which started to use small scale wind electricity generators or solar photovoltaic panels have got a negative opinion on these sources.
7. The herders request more powerful alternative energy sources (equipment) in order to assure their adequate (growing) electricity consumption.
8. The relevant Government (Mongolian Government) intervention policy is directed towards support of improvements of rural livelihood through better management of the energy supplies.

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