Why perfect stoves are not always chosen: A new approach for understanding stove and fuel choice at the household level

Authors
Stanzin Tsephel[1], Takeshi Takama[2], Fiona Lambe[3] and Francis X. Johnson[4]

[1] Email: ladakhleh@gmail.com
[2] Email: takeshi.takama@sei.se
[3] Email: fiona.lambe@sei.se
[4] Email: francis.johnson@sei.se

Figure 1: Woman cooking doro wat or chickpeas on the CleanCook stove

Despite the numerous benefits associated with cleaner alternatives, the transition to improved fuels and stoves has not progressed hugely in Sub-Saharan Africa. Why is it that so often, well designed, efficient and clean stoves fail to penetrate the market in developing countries? In order to design effective policies and programmes to scale up the use of cleaner cooking alternatives, the barriers to improved cooking technologies must be understood at the household level. To date, research on the determinants of stove choice at the household level has focused mainly on socio-economic factors, such as income, age, gender and education, while the role of product-specific factors such as safety, indoor smoke, usage cost and stove price have been largely disregarded.

This article presents research conducted by the Stockholm Environment Institute (SEI) in July 2008 in Addis Ababa, Ethiopia to investigate the role of socio-economic factors and product-specific factors as determinants of cooking stove choice in cooperation with Gaia Association, a local Ethiopian NGO involved in the promotion of ethanol and ethanol fuelled cooking stoves. The research team applied an alternative methodology, Discrete Choice Analysis (DCA), which is commonly used in transportation studies, in order to assess the trade-off between factors affecting household cooking choice. The study argues that product-specific factors are as important as socio-economic factors to create a market for clean cooking stoves and that future research should strike a balance between both types of factors. In a short-term perspective, product-specific factors are more important since socio-economic factors tend to change slowly, in line with longer-term patterns of economic growth and human development.

Background

The switch from traditional biomass use to modern energy sources and efficient stoves for cooking is one of the major sustainability challenges currently facing developing countries. Switching from traditional biomass fuels to modern, energy efficient sources and associated technologies is expected to alleviate numerous health, socio-economic and environmental problems; however, despite the numerous apparent benefits of fuel

	Product-specific factors	Socio-economic factors
Specific to:	Product	Person
Characteristics	General in nature	Specific to context
Variation in choice:	Within individuals	Between individuals or groups
Change in short-term:	Relatively easy	Difficult
Useful for:	Product design, demand forecast, policy formulation	Market segmentation/ profiling and policy formulation

Table 1 Categories of Fuel/Stove choice determinants

switching, the transition to modern fuels has been slower than expected. Indeed, the number of households relying on traditional biomass is expected to rise to 2.6 billion by 2015 (IEA 2006). It is within this context that this study seeks to understand cooking stove choice and fuel-switching patterns at the household level.

Gaps in the literature

Since the 1970s, much scholarship has been devoted to understand the switch from traditional biomass stoves to modern energy efficient cooking stoves, and a large number of factors affecting stove choice have been identified. However, recent literature argues that a proper understanding of the determinants of fuel choice at household level is still elusive (Heltberg, 2005; Kohlin & Gupta, 2005; Horst and Hovorka, 2008). A literature review indicates that the research on determinants of cooking stove choice has focused on socio-economic factors such as income, age, gender and education, while the product-specific factors such as safety, indoor smoke, usage cost and stove price have largely been ignored.

Types of choice determinant factors: Socio-economic and Product-specific

In theory, all determinant factors of cooking stove choice such as income, education, stove price, smoke level, etc. fall into either the socio-economic or the product-specific category. Some factors reported in the literature such as level of deforestation, government policy and level of urbanization do not immediately seem specific to a product or individual However, when the impact of such factors on stove choice is deconstructed, they essentially fall into either of the above two categories. For example, deforestation's effect on fuel choice is influenced by changing price or cost of fuelwood collection, which is a product-specific factor. It is important to cluster all determinants into the two categories, as the usefulness of the factors is different in each.

The socio-economic determinants of fuel or stove choice could be any factor defining and describing 'people' that has some correlation with variation in stove choice. A socio-economic focused analysis seeks to identify individual or household characteristics and assess if stove choices differ across the specified socio-economic variables. The most commonly reported socio-economic factors are age, income, education, household size, and gender (Heltberg, 2004, 2005; Ouedraogo, 2005; Kohlin & Gupta, 2005). These factors do not vary within individuals in a limited time period; rather the variation occurs 'between' individuals. Socio-economic factors are useful for identifying the target market for a stove and for understanding the characteristics of that market and its consumers.

In contrast, product-specific factors are the associated characteristics of the available cooking stove options and the fuels that are used. Since an individual can test and use different products within a short period of time, these factors change 'within' the individual's experience. The product-specific factors include stove price, usage cost, convenience and level of smoke. Previous research on the determinants of fuel choice lacks a focus on product-specific factors, which significantly limits the scope for promoting clean cooking stoves: only product-specific factors can be easily modified to a more appropriate stove design with a high probability of acceptance in a given target market. Thus, an innovative approach and method is required to categorise and study both types of factors and these factors must be quantified in order to provide guidance for project implementation.

An alternative approach

In an effort to address this knowledge gap, SEI applied DCA in order to evaluate the tradeoffs inherent in household choice of cooking stoves and fuels. The model is based on the work of McFadden (1974) and has been used extensively for cooking fuel choice studies (Ouedraogo 2005; Heltberg 2004; Pundo and Fraser 2006). The socio-economic factors included in this study were age, gender, education and income. A sample of 200 households compared three stoves such as a wood stove, a kerosene stove, an ethanol stove and a different level of product-specific attributes namely price, usage cost per month, smoke and safety were used in each experiment. DCA was used as it allows for the quantitative assessment of both types of factors and also because the research team was interested in how important each attribute is in relation to other attributes.

Results and discussion

The study found that when compared to a low-income group, a high-income group was willing to pay ten times more for a unit reduction in indoor smoke, two times more for increased efficiency and ten times more for increased safety. Moreover, results demonstrated that for all respondents, the first preference was for ethanol, followed by wood and lowest for kerosene. This indicates that, other things being equal, people prefer ethanol over wood and kerosene; furthermore it also shows that everyone except the lower income respondents prefer wood over kerosene.

The results show that the effect of product-specific factors on household choices remains reasonably consistent across all other tested socio-economic factors. Crucially, the difference is in the magnitude and trade-offs across factors. By examining the trade offs between product-specific factors, one can select a stove design to fit the specified market segments. This is not possible by considering socio-economic factors alone.

The study indicated that the usage cost is more significant than stove price for the middle and high-income groups. It was shown that a lower usage cost will reduce the overall cost of a cooking stove in the long term. Thus, poorer households consider an initial investment such as stove price to be more significant in the short term but less so in the long term. This trade off phenomenon between attributes amongst different socio-economic classes is even more important when non-monetary factors such as smoke and safety are compared. Results showed

Figure 2: Cook in low income home in Addis Ababa, showing the CleanCook stove

Figure 3: Coffee ceremony using the ethanol stove

that for the low-income group, indoor smoke is not an important factor in their choice of fuel or stove. Hence, it can be inferred that the low-income group does not want to pay for a unit of reduction in smoke. As a whole, similar to the usage cost, with an increase in the level of income, willingness to pay for a unit of reduced smoke level increases significantly.

When the various trade-offs are understood, it becomes possible to make predictions about the market for specific products given certain conditions, for example, under different fuel price scenarios. This type of information is of particular interest to countries such as Ethiopia where policy makers are in the process of allocating biofuels resources (ethanol, in the case of Ethiopia) to different sectors (e.g. export, transport, household) and require firm guarantees about the existence and size of a household market for the fuel at a given price in order to allocate sufficient quantities to support the development of this sector.

Conclusions: Advantages of this type of approach

This research distinguished the socio-economic and product-specific factors as separate categories of factors determining stove and fuel choice, with the former responsible for variation in choice between individuals and the latter for variation within an individual. The results of the study illustrated the importance of making this distinction. The study clearly demonstrated that compared to middle and higher income households, lower income households are more concerned about the initial cost of the stove than about the usage cost (fuel). Here, socio-economic factors, in this case, income level, were useful for market segmentation – for identifying a target market for a designed stove or designing a stove for a particular segmented market.

By including product-specific factors in the model, it is also possible to characterise how much more important the initial stove cost is for lower income families (compared to higher income households) when it comes to selecting a stove. This information can be used to guide policy makers and stove programme designers on the best approach for market penetration. For example, in the case of Ethiopia, it would seem that a policy of subsidies on ethanol stoves for the lower income households would be an appropriate strategy if this market is to be penetrated. It is often the case that improved stoves are designed to fit a perceived market as defined by socio-economic profiling. Although the improved technology may be technically superior to the traditional stoves in terms of efficiency, cleanliness and aesthetic appearance, there is still no guarantee that the stoves will be adopted by the target market.

The above discussion about the role of socio-economic and product-specific factors is summarised in Table 1. Previous research has only focused on Quadrant 1 and 3 (Q-1 and Q-3) helping to identify a target group or market segmentation. This study has focused on Q-2 and Q-4 by estimating the trade-off among such factors, which helps when designing cooking stove projects with a high probability of acceptance.

The study has generated great interest, particularly among stove practitioners that need to more accurately predict the market share for their stoves in relation to other variables, such as the price fluctuation of fuels. The project is expanded in other LDCs including Dar es Salaam, Tanzania and in Maputo, Mozambique. The research will be used to strengthen local information related to the household market for improved cooking fuels and stoves and to inform policy makers engaged in biofuel strategy development in both countries. It can thereby contribute to better programme and product design, supporting more efficient, modern and clean cooking stove projects.

The full study report is available at the Household Energy Economic Analysis page on the SEI website.

References

AFREPREN/FWD, 2002. *African Energy Data Hand book. Occasional Paper no. 13*. AFREPREN/FWD, Nairobi.

Heltberg, R., (2005) Factors determining household fuel choice in Guatemala. *Environment and development economics,* 10:337.

Heltberg, R., (2004) Fuel switching: evidence from eight developing countries. *Energy Economics,* 26:5:869-887.

Horst, H., Hovorkader, G., (2008) Reassessing the "energy ladder": Household energy use in Maun, Botswana. *Energy Policy,* doi:10.1016/j.enpol.2008.05.006.

Odihi, J., 2003 Deforestation in afforestation priority zone in Sudano-Sahelian Nigeria. *Applied Geography,* 23: 227–259.

Pundo, M.O, Fraser, G.C.G, 2006, *Multinomial logit analysis of household cooking fuel choice in rural Kenya: The case of Kisumu district,* Agrekon, 45: 1: 24-37.

IEA, 2006. *World Energy Outlook. International Energy Agency,* Paris[9] Kohlin, G and Gupta, G., (2006) Preferences for domestic fuel: Analysis with socio-economic factors and rankings in Kolkata, India, *Ecological Economics*. 57:1: 107-121.

MCFADDEN, D., (1974) Conditional logit analysis of qualitative choice behavior, in *"Frontiers in Econometrics"* (P. Zarembka, Ed.)

OUEDRAOGO, B., (2006) Household energy preferences for cooking in urban Ouagadougou, Burkina Faso. *Energy Policy.* 34:18:3787-3795.

Zhang, J., Smith, K.R., MA, Y., YE, S., Jiang, F., QI, W., LIU, P., Khalil, M.A.K., Rasmussen, R.A. and Thorneloe, S.A., (2000) Greenhouse gases and other airborne pollutants from household stoves in China: a database for emission factors. *Atmospheric Environment.* 34:26:4537-4549.