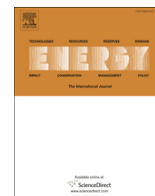




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Determinants of household energy use in Bhutan

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ABSTRACT

Using the Bhutan Living Standard Survey (BLSS) data for the year 2007, this paper attempts to identify and analyze the factors that are likely to influence household decisions when choosing a particular energy source for various uses such as lighting, cooking, and heating. A multinomial logit selection model has been applied for this identification and analysis. The results show that a household's choice of cleaner fuels for lighting, cooking, and heating is driven by level of income, age, education and gender of the household head, access to electricity, and location. Households with a better-educated or female head, those with a higher level of income, and urban households, have a higher probability of switching to the use of clean energy, while poor households, rural households and those with a low level of education are constrained by these factors to continue using dirty energy. The study shows that female-headed households are more likely to choose cleaner fuels, and that above all the availability of a clean and cost-effective source of energy within the proximity is an important factor in the adoption of clean energy. We combined BLSS 2003 and 2007 and conducted similar analyses and confirmed the robustness of the result.

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1. Introduction

With rising concern about the effects of global warming and climate change, the focus of energy policies has generally shifted from so-called “dirty energy,” usually derived from solid fuels and biomass such as fuelwood, towards clean sources of energy such as electricity and liquid petroleum gas (LPG), especially in the context of developing countries.

Households in developing countries rely heavily on fuelwood and other solid fuel-based energy sources for lighting, cooking, heating, and other uses, either due to lack of access to clean and reliable sources of energy, lack of their affordability, or to the abundance of cheap fuelwood in the proximity. Households in developing countries typically face socioeconomic, cultural and environmental barriers in changing their energy-use patterns and moving towards the use of cleaner sources of energy. Households are faced with an array of energy sources with varying levels of convenience, but their choices are constrained by the cost of an energy source and the budget available within the household. In developing countries, especially in rural areas, 2.5 billion people

rely on solid fuels from biomass, such as fuelwood, charcoal, agricultural waste and animal dung, to meet their energy needs for cooking. In many countries, these resources account for over 90% of household energy consumption [1].

Increased quality and convenience of fuel is usually accompanied by a higher cost of energy, leading to a tradeoff between quality and cost. A gradient of quality, convenience and cost can be observed, rising from solid fuels such as firewood and charcoal at the bottom to liquid fuels such as gas and oil, and, finally, electricity at the top. As a result, the use of fuelwood, dung, and crop wastes is prevalent among poor households, while households with a higher income move to the use of electricity and LPG. This so-called energy transition ladder was developed by Leach [2,3] and elucidates the relationship between income and types of energy used. It postulates that in response to higher income and other factors, households will shift from traditional biomass and other solid fuels, to more modern and efficient cooking fuels such as LPG, kerosene, natural gas, or even electricity. This process is also termed ‘fuel switching’ or ‘interfuel substitution’ [3–5]. It is assumed that energy transition occurs from the bottom to the top with increasing socioeconomic status of households, either through a rise in income or a fall in price [6].

Total energy consumption typically increases with income, depicting an inverse “S”-shaped curve [7]. There is also a clear link between household energy consumption and the human

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development index [8], illustrating a strong association between income, education and life expectancy, and energy consumption. Apart from the quantity, the type of energy used also changes with income [9], with a shift towards modern fuels [10], in particular electricity [11]. When households switch from lower- to higher-quality fuels, i.e. movement up the “energy ladder,” this generally leads to substantially lower emissions of health-damaging pollutants [12]. The energy-ladder hypothesis assumes that as their income increases, households not only consume more of the same product, but also shift to more sophisticated, higher-quality goods. It also assumes that cleaner fuels are normal economic goods while traditional fuels are inferior goods.

In Bhutan, the major sources of energy used at the household level are firewood, kerosene, LPG, and electricity. Thus the hypothetical energy ladder at the micro-level for Bhutan constitutes of firewood at the bottom, kerosene in the middle, and LPG and electricity at the top. The poor tend to use solid fuel for lighting, heating, and cooking, which is damaging to the environment and to health [13–15]; when income increases, they generally, but not always, switch to cleaner fuels [16,17]. Thus, we need to understand the factors other than income that play a role in choice of energy by households in developing countries, and design appropriate policies for promoting the transition from dirty to clean fuel.

This study was therefore conducted to investigate patterns of energy use by rural and urban households, and to identify and analyze the factors that influence the choice of energy used by these households for lighting, cooking and heating. In particular, in this paper we test the hypothesis that with an improvement in the economic status of households, they would shift towards modern fuels.

The contribution of this paper to the existing literature is threefold. First, no such energy study has been done using quantitative techniques in the case of Bhutan, which is an interesting case because, despite the commissioning of mega hydropower projects, rapid economic growth, rise in per capita income, and an ambitious rural electrification project, a significant proportion of Bhutanese households still uses dirty fuels such as firewood, straw, manure, and kerosene as sources of energy for lighting, cooking and heating. A recent study [18] was the first to examine domestic energy consumption in Bhutan, comprising residential energy end uses such as space heating, water heating, cooking, lighting and running other household electrical appliances, but this study was limited to a descriptive analysis without analyzing the factors that influenced the choice patterns observed. In addition, the study only covered urban areas in a few districts and the sample was not representative of the whole of Bhutan.

Secondly, this paper contributes to existing literature by applying a multinomial model to analyze fuel choices [6,8,9,19–21], and differs from other papers by examining the choice of energy for different purposes, in particular lighting, cooking, and heating. For example, a household maybe using electricity for lighting but not for cooking and heating. In a study in India, using a multinomial logit model found that the decision about choice of energy was influenced by per capita income, household size, educational status of the head, occupation, and locational characteristics [9]. In urban Burkina Faso, the persistent preference of households for cooking with wood was shown to be due to poverty factors such as low income [8]. Another study in eight different countries illustrated a strong link between electrification and the uptake of modern cooking fuels [21].

The two major factors affecting the quantity of energy consumed are income and education. There is a large body of evidence documenting the energy ladder, or the switch towards cleaner fuel with an increase in household income. There are several other factors that seem to play a role in energy-choice

decisions by households: gender, education, cost of alternatives, availability of/access to clean fuel, habits, etc.; these merit due consideration when formulating a national policy on clean energy. Thus, an examination of the importance of other critical factors such as gender of the head of household, education, urbanization, and the availability of a clean and approved source of energy, is the third contribution of this paper.

The paper is organized as follows. Section 2 presents the methods used, including the conceptual framework, specification of econometric model, data source and data collection. In Section 3, Bhutans’ electricity network is presented, followed by a description of infrastructure and policy, household characteristics, an explanation of energy use and consumption in Bhutan, and factors that affect the choice of energy for lighting, cooking, and heating. Throughout the analysis, focus is on whether households operate on an ‘energy ladder’ and if they do, whether certain policies can elicit desired movements or substitutions. The final section presents the conclusions.

2. Methods

2.1. Conceptual framework

Microeconomic theory postulates a range of factors that affect the quantity of a given commodity that would be demanded at a given price: average levels of income; the size of the population; prices of and availability of the substitutes (in this case, kerosene, cooking gas, and coal); individual and social tastes; special influences (e.g. distance of household to market place); and season [22–24].

According to this theory, the following factors influence fuel use and choice of fuel by a household: price; income; household size and composition; education; and cultural preferences. With increased income, the opportunity cost of time also increases along with purchasing power, and consequently the household’s willingness to pay for a better quality of fuel and greater convenience of use. Hence with an increase in income, a household is more likely to move up the energy ladder from using dirty fuel to using clean fuel.

Household income is one of the important parameters influencing the choice of fuel [9,25]. The relationship between income-poor and energy-poor remains uncertain [25]. A study in India found that per capita total household expenditure has the largest positive effect on per capita total energy requirements [26]. Several studies show that there is an energy transition process whereby households move from low-quality traditional fuels, to more convenient and cleaner modern fuels [21,27,28]. However, a number of studies have pointed out flaws in this energy-ladder hypothesis, and find that some higher income households and households in urban areas do not make the transition [16,17]. Interestingly, another study using data from India, found that energy-poor households are not necessarily income-poor, and suggests a comprehensive energy policy that may encourage such households to change to using more convenient and cleaner modern fuels [25].

The education level of the household members affects movement up the energy ladder in two different ways: (1) education improves income and hence affordability and the opportunity cost of time; (2) income increases knowledge and affects cultural and consumer preferences.

Households with an educated head and spouse tend to choose cleaner energy because of convenience of use, health benefits and the opportunity cost of their labor. In India, the education level of the household head has been found to increase a household’s interest in choosing a clean and efficient source of energy [9]. Furthermore, the number of educated females between 10 and 50

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