



# Energy consumption transition through the use of electricity for lighting and cooking: evidence from Bhutan

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Energy ladder hypothesis states that with an increase in income and awareness households gradually switch from biomass to kerosene and finally to ultra-clean, renewable, green energy sources such as electricity. Electricity lies at the top of the energy ladder hypothesis for household energy use. Empirical results support the fact that income, wealth, gender and the educational status of households often influence the switch from dirty to clean energy; however, in some cases, households even with higher incomes, wealth, and education levels use electricity only for lighting but not for both lighting and cooking. This creates a ladder within the energy ladder. Using a nationally representative dataset collected by the government for the Bhutan Living Standard Measurement Study (2003, 2007 and 2012), covering more than 22,000 households, this study examines the factors influencing the use of electricity for lighting, and lighting and cooking by Bhutanese households. The results of multinomial logit model estimation demonstrate that demographic features, wealth and the education levels of households, in addition to access to infrastructure significantly influence a household's use of electricity for lighting and cooking, which supports a ladder within the energy ladder hypothesis.

## Introduction

According to energy ladder hypothesis, quality, ease of use and price of energy sources increases as one moves up in the energy ladder: solid fuels such as firewood and charcoal are at the bottom of the ladder followed by liquid fuels such as gas, kerosene oil, and electricity at the top [1]. As a result, the use of fuelwood, cow dung, and crop residue is pervasive among the poor households, while households with a higher income are more likely to switch to the use of LPG (liquefied petroleum gas) and electricity [2–4].

This 'energy transition ladder' [1,5] elucidates the relationship between the level of income and the types of energy used by households. It postulates that influenced by higher revenues and other factors, households will shift from dirty fuel such as biomass and other solid fuels to more modern and efficient fuels such as LPG, kerosene, and electricity. Apart from the quantity, the quality of energy used also changes with income [6], with a shift towards modern fuels [7], in particular, electricity [8]. The poor tend to use solid fuels for domestic purposes which damages the environment and health [9–11]. However, with an increase in

income, poor households in general but not always switch to cleaner and greener fuels [12,13].

Among the clean and green fuels, electricity lies at the top of the energy ladder [1,5]. While many of the existing studies mainly focus on household energy use patterns [14–17], studies have seldom focused on an in-depth understanding of the use of clean energy by households for two major domestic purposes: lighting and cooking. Several empirical studies have documented the existence of the energy ladder and/or the determinants of a household's choice to switch from traditional biomass fuel (dirty fuel) to cleaner fuels such as electricity and natural gas with an increase in household income [18]. Household demography (age, gender, family size, and consumption behaviour) also plays a significant role in a household's energy-choice decisions. Hence, determining the relative importance of the above variables which affect a household's use of electricity for all domestic purposes is necessary for a clean energy policy formulation in developing countries.

The contributions of this paper to the existing body of knowledge emanate from the fact that we believe that this is probably the

first attempt to examine the hypothesis of the ladder within a ladder in the use of electricity for lighting and cooking using advanced econometric models. A multinomial logit model has been used to identify the determinants of a household's use of electricity for lighting and cooking simultaneously. Secondly, the availability of a wide range of variables and the quality of data enabled several detailed robustness tests on the significance and role of household education and wealth on a household's choice of electricity as the energy source for lighting and cooking.

Section 2 presents a broad review of the latest relevant literature on determinants of household energy choices; Section 3 outlines the data source and collection; in Section 4, results and discussions on the determinants of electricity use by the households are presented; the paper concludes in Section 5 with policy implications.

### Review of related literature

Several studies have highlighted the benefits of the access to electricity on human development [10,11,19,20]. The provision of the sustainable access to electricity can generate efficiency and free up labour hours which could be used for leisure and other productive activities besides improving health and education. Rural electrification also helps in achieving different economic and social goals [21].

Household wealth is one of the important factors influencing a household's choice of energy sources [6,22]. Wealthier households have higher purchasing power and, consequently, richer households have a greater willingness to pay for better quality energy, particularly for electricity. Hence, with an increase in wealth, a household is more likely to move from dirty energy sources such as biomass and fuelwood, to clean energy sources such as natural gas and electricity. A household's wealth status influences not only the qualitative aspects of energy choice but also affects the quantity of different types of energy consumed. For example, per-capita total household expenditure is positively associated with per capita total energy requirements [23].

Thus, it is well established that the amount of a household's energy consumption increases with the household's wealth [6], which is often measured by farm size and the number of livestock in rural households [20,24]. An increase in farm size and income from agricultural production thus can lead to a decrease in the collection of fuelwood from the forest by raising the opportunity costs of collecting fuelwood and biomass, for the wealthy households that consume more energy and consequently switch to high-quality energy sources.

Education influences the household energy choices in two different ways: first, education increases income and, hence, purchasing power and the value time; second, education increases knowledge and awareness and affects consumer preferences. Households with an educated head are more likely to choose cleaner energy in large quantities because of its convenience of use, health benefits and the higher opportunity cost of their labour. In India, the education of the head of the family led to an increase in the utilization of clean, modern and efficient sources of energy [6]. Furthermore, the number of educated females between 10 and 50 years of age in a household is positively associated with the use of a clean source of energy [25]. Households, where the head and spouse have a higher education, have a greater inclination to use contemporary energy as these offer a

significant savings of time [26]. Education is a strong determinant for switching from dirty to clean fuel [27,28]. Empirical results often demonstrate that higher levels of education increase the likelihood of using modern energy sources, and a lower incidence of the use of solid fuel [29]. In general, the education of the household heads and their spouses lessens the consumption of fuelwood and other conventional fuels because education enhances understanding of the costs and benefits of modern energy sources and, in particular, the health-related benefits [30].

In rural India, female household members are predominantly involved in collecting firewood from the forest while males focus on farming, wage employment and on non-farm self-employment activities [20]. Households with a large number of less-educated women who are not formally employed benefit from a greater availability of labour for the collection of fuelwood and cooking, and are thus less likely to transition to less time-consuming sources of energy [27]. However, women with young children (below six years of age) lack the time necessary for collecting firewood due to child rearing duties, which reduces a household's ability to gather and use this source of energy [31].

The provision of and access to electricity also provides paramount benefits to the female members. Empirical findings indicate extensive benefits of electrification to the female members. For example, it increases the opportunity for evening activities, provides higher flexibility in managing household activities as daylight is no longer a limitation, improves security and provides the opportunity for undertaking income-producing activities such as handicrafts [21].

In households with greater income and headed by a female, women's preferences are more likely to be realized. Female household members are the main collector and user of fuel sources in developing countries, where households are the primary users of energy [32]. The role of female household members varies with income levels, where those living in poverty mainly collect wood, while more affluent females are able to make a decision regarding the fuel the family uses [26]. As the use of clean sources of energy improves, female health also improves and provides women with more time for leisure. When a female household member is the main decision maker, a high priority will be given to goods that are more useful to the female members of the household. In urban areas, females have a stronger preference than men for clean energy, given their higher participation in cooking [30]. Ignoring gender roles and traditions in energy use has reduced the global potential for renewables [32].

Other demographic characteristics such as the age of the household head and the number of adult males and females influence a household's choice of energy source. For example, the size of the family has a negative effect on the likelihood of choosing to use clean cooking energy [25], although the relationship can be non-linear [6]. Similarly, family size has a positive influence on the collection of wood for fuel, due to the higher need for energy, as well as more labour available for wood collection and other activities in rural areas [20,31,33]. The number of members in the household positively affects the fuelwood, and self-collected fuels use because these resources do not have a visible monetary cost. Their collection and use are mainly guided by opportunity costs that directly link to the productivity of family members dedicated to fuelwood collection relative to the opportunity cost

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