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Household energy mix in Uganda ☆

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ABSTRACT

This paper presents evidence that household energy use in Uganda conforms to the energy ladder theory. As household income increases, solid and transitional fuel use evolves in an inverse U manner, while electricity consumption shows a direct relationship with income. Public infrastructure provision, income, and education are the key variables which can be targeted to reduce household dependence on solid-fuels while increasing non-solid fuel use. While education and public infrastructure have varying impacts on rural and urban households' energy mix, these variables generally reduce rudimentary fuel use and increase modern fuel consumption. Timely investment in electricity infrastructure is necessary to cater for burgeoning electricity demand as households become affluent. Strategies for reforestation, dissemination of improved cookstoves, relieving supply side constraints for modern fuels, and staggered payment options to lower the cost of entry for modern fuels can improve Ugandan households' energy security.

1. Introduction

Solid biofuels account for almost 50% of Africa's energy needs (IEA, 2011). Around 94% and 73% of the rural and urban households are dependent on wood fuels (wood and charcoal) for their energy needs, respectively (Bailis et al., 2005). Combustion of biomass (e.g. wood, animal waste, charcoal) typically has low energy conversion due to energy-inefficient stove design. Its use leads to deforestation and soil quality depletion, and health impacts from air pollution (Rajagopal and Zilberman, 2007). A disproportionate amount of time is dedicated to acquiring basic household energy needs, which particularly disadvantages women and children who are responsible for survival tasks. Time saved from survival tasks can translate into greater workforce participation by women and schooling for children (Habermehl, 2007). Modern fuels are of higher quality than traditional fuels, having greater capacity to do useful work, being cleaner to burn, and having greater flexibility of use (Stern, 2010). Moving households towards using cleaner burning modern fuels is an important policy imperative to improve living standards for countries that rely heavily on biomass.

Traditional fuels are over-represented in Uganda's energy mix compared with Africa's energy mix (Figs. 1 and 2). Countrywide, modern fuels (hydrocarbons and electricity) make up around 10% of the country's total primary energy supply, of which less than 1% is from electricity (MEMD, 2007, 2012).[1] Households are almost entirely dependent upon biomass for energy needs. Urban residents obtain close to 90% of cooking energy from wood fuels, while in rural areas this figure raises to 98% (Knopfle, 2004). Deforestation pressures have reduced forest cover from over one-fifth of land area at independence in the 1960s to 7% today (Pearce, 2007).

Energy security is a major stumbling block for economic development and improved living standards in Uganda. Energy consumption per capita is 69.5 kWh, which is a fraction of the African average of 578 kWh and world average of 2572 kWh (MEMD, 2012). Uganda imports all of its oil, which has steadily increased over the past 30 years (EIA, 2012). While oil reserves have been discovered, there has been no local production as of 2012 (CIA, 2012). Fossil fuel imports transit over land from Kenya's Mombassa port and Tanzania's Dar es Salaam port, translating into high transportation costs and domestic market prices. The price of imported fuels such as kerosene is disproportionately expensive relative to per capita income; the cost

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[1] IEA Energy Balance Database does not include data on Uganda.

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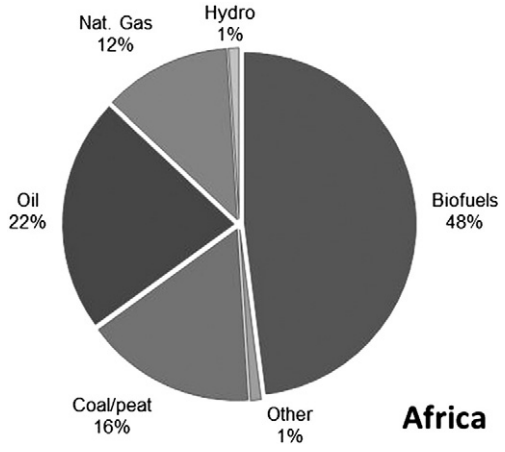

Fig. 1. African total primary energy supply (IEA, 2011).

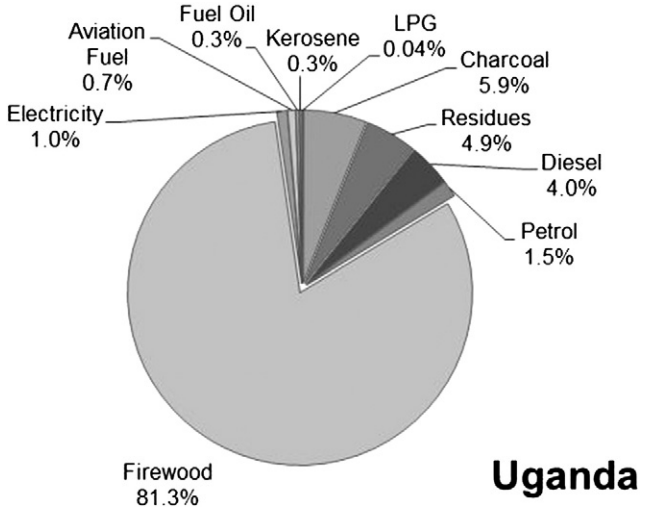

Fig. 2. Ugandan total primary energy supply (MEMD, 2007).

per liter of petrol at the pump in Uganda as of March 2012 was around UGX3300 (USD1.32) compared with JPY150 (USD1.80) in Japan; putting this in perspective, GDP per capita is PPP30,000 in Japan and PPP1100 in Uganda (UNDP, 2011).[2] The electricity sector is dominated by hydroelectricity from Lake Victoria, but severe drought in 2004 and lowered water levels has since led to shortages in electricity generation, which must be supplemented by diesel-fuelled thermal power (Heffner et al., 2010). Only 12% of the Ugandan population uses electricity, although there is a huge disparity in electrification rates between urban (48%) and rural (3.8%) areas (UBOS, 2010). The instability of electricity supply is further exemplified in frequent 'load shedding', with up to 12 hour daily cycles in Kampala.[3] Constraints on electricity generation, and lack of cheap alternatives, may go in part to explain the heavy dependence on solid biomass for household energy needs.

The factors which explain residential energy demand in Uganda have received little attention. As far as I am aware, there has been no econometric evidence on the relationship between household characteristics and household energy mix in Uganda. Understanding these factors will enable public policy to be designed in a direction which improves household energy security and well being, and to address problems associated with solid biomass dependence (pollution, deforestation, etc.). This paper tests the correlation between household characteristics and the use of various fuels, and the variables that increase the likelihood of transitioning away from solid fuels. This is done with two models of household energy use. The first is a parsimonious model of fuel consumption levels; the second is a multinomial logit model of the propensity to switch from solid to non-solid fuels. The relationships were tested using a cross-sectional data of 6775 Ugandan households in 2009–10. The results indicate that Ugandan households regard energy as normal goods. As income increases, households consume more modern fuels and less traditional and transitional fuels, in line with the energy ladder theory. High turning points for kerosene and charcoal consumption with respect to income vindicate the lack of viable energy alternatives for household lighting and cooking needs. A move up the ladder is conditional on the provision of public infrastructure, which is correlated with increased electricity use. Households with greater education and income have a greater propensity to step off the bottom rungs completely, although the vast majority of households continue using a mix of solid and non-solid fuel types even at high income brackets. Addressing supply side constraints, specifically increasing the supply of modern cooking fuels such as LPG, to substitute solid cooking fuel, and expanding electricity infrastructure can reduce dependence on rudimentary fuels and technologies.

The remainder of the paper is organized as follows. Section 2 describes the data used in the ensuing analysis. Section 3 presents the two empirical, cross-sectional models of household energy mix and household characteristics. In Section 4, the results of the two models are presented. Section 5 gives an overall discussion of the results and policy implications. Section 6 concludes.

2. Household expenditure on energy and dependence on fuel types

Energy is a basic household need which often occupies a significant proportion of total household expenditures for low income countries (Heltberg, 2003). Reducing the financial burden of energy costs for these households is important for improving their living conditions. Fuel dependence, hence costs, varies between rural and urban residents, as do access to public infrastructure and services. Fig. 3 presents the proportion of households which use various fuel types and have access to water services. Access to a private water connection or public water source (bore or well) is indicative of the level of public infrastructure provided in the area such as electricity or roads. Households are more likely to be connected to both electricity and water (key public infrastructure services). The majority of households using electricity, charcoal, gas, and a private water connection to the pipeline are in urban areas. Households that use kerosene, firewood, and have access to public water source are mainly in rural areas.

Fig. 4 compares daily expenditure per capita with the budget share of household fuels (charcoal, kerosene, electricity), by urban and rural cohorts. For comparability, the expenditure share of each fuel type up to 7% is shown (there are some observations above the 7% expenditure share but excluding them from these graphs does not detract from the overall trend). There is a cultural sensitivity about disclosing income and wealth in Uganda, particularly by high income households. Per capita daily expenditure is therefore used as a proxy for income, as it reflects the spending power of the household (assuming savings is similar to expenditure as a proportion of income). The survey uses mostly imputed values for firewood 'expenditure' since it is usually freely obtained by the household. Nevertheless, the imputed 'expenditure share' of firewood reflects the household dependence on biomass.

The trends show clear declining budget shares in all fuels as expenditure levels increase, confirming a priori assumptions that

[2] JPY1 = USD0.012 and UGX1 = USD0.0004 in March 2012 (XE.com, 2012). Fuel prices are based on author's personal experience. The WTI spot price for crude oil was USD0.90/l in March 2012 (EIA, 2013).

[3] Author's personal experience and interview.