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Household willingness to pay for green electricity in urban and peri-urban Tigray, northern Ethiopia: Determinants and welfare effects

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ABSTRACT

This paper set out to estimate household willingness to pay for green electric services and welfare gains attributed to such schemes. For this purpose, contingent valuation survey was conducted on 300 urban and peri-urban households in northern Ethiopia. A bivariate probit model was used to elicit willingness to pay and analyze determinants of household willingness to pay. On the other hand, welfare gains were analyzed using consumer and producer surpluses. The mean willingness to pay was estimated to be Birr 12.5 (0.66 USD) per month per household for five years on top of monthly electricity bill. Among others, income played positive role on willingness to pay while difference in willingness to pay behavior was observed between male and female-headed households. In addition, distance to wood and charcoal (alternative energy) markets played encouraging role for willingness to pay. Results from the welfare analysis show that there is significant societal gain to be made both in terms of surplus for households and producers (government) if the previously 'untapped' green electricity service was implemented. The revenue (producer surplus) for the state would be instrumental in contributing to the state's endeavor to generate a much-needed capital for investment in and expansion of renewable energy.

1. Introduction

Urban areas constitute settlements where growing population resides and host many economic activities that significantly contribute to climate change. These settlements as a result stand to suffer from by-products of people and economic activities (IPCC, 2011; Johnson and Breil, 2012). Given this reality, urban and peri-urban areas are key players both in the generation of greenhouse gases (GHGs) and reduction of the impacts of climate change. The plethora of research (such as Dodman, 2009; McKain et al., 2012; Phillips et al., 2013; Valentini et al., 2014; Lucas et al., 2015; Guo et al., 2016; Patarasuk et al., 2016) in this regard shows that it is the fossil fuels energy use by entities (energy utilities, commercial entities plus households) located in these urban and peri-urban areas that emit the largest volume of GHGs.

The most common strategies used to deal with the impacts of climate change are mitigation and adaptation. While mitigation reduces or prevents the unmanageable impacts of climate change (such as investment on renewable energy resources), adaptation manages the unavoidable (Laukkonen et al., 2009). In this regard, adaptation is not the ultimate solution but a reaction measure, where the sustainable approach lies in GHGs emission reduction to optimum level particularly from the energy sector- such as mitigating schemes by promoting green electric energy sources. Mitigation widely invests in renewable energy implementation to reduce climate change and improve energy security as well as energy efficiency (Winkler, 2005; Goldemberg, 2007; Laukkonen et al., 2009; Driscoll and Naess, 2010). One aspect of this is investment in large scale green electricity supply system based on renewable energy sources (Glenn, 2010).

From the total energy consumption in Ethiopia, electricity generated from renewable resources as of 2012 was 13% (Kifle, 2015). The majority of the energy in Ethiopia comes from traditional sources. In fact, the extent of dependence on traditional fuels (such as biomass) is very high in Ethiopia. While biomass energy sources are relatively more accessible in developing countries, on the flip side Grieshop et al. (2011) argue that biomass use has serious environmental impacts, particularly deforestation and GHGs emission though other studies (such as Soliño et al. (2009)) acknowledge the positive externalities of forest biomass through sustainable forests management. This and the growing unmet demand for energy have forced the Ethiopian government to invest on the energy source that the country has not only a huge comparative advantage but also sustainable resource- hydro-

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power. In this regard, the emphasis on the rapid development of renewable energy is often mentioned as an important response option for addressing not only the power problems faced by Ethiopia but also combating climate change through mitigating initiatives (Karekezi, 2002; Winkler, 2005).

The Ethiopian government has taken pioneer initiatives for building climate resilience green economy. This strategy is based on four main pillars: agriculture, forestry, sustainable and green energy, and transport and industry sectors. In this grand strategy, expanding electricity generation from renewable energy sources is one pillar among many. However, there are challenges, which may act as stumbling blocks for the realization of this pillar. As FDRE (2011) pinpoints, there is significant financial gap to finance investment on green energy. One strategy the government adopted to partly fill this capital void is cost sharing by urban and peri-urban entities for the development and expansion of green and better electricity services.

The potential from this cost sharing scheme and the resultant welfare gains/losses however have not been sufficiently studied. To our knowledge, we are unaware of studies that especially attempted to investigate welfare issues vis-à-vis expansion of renewable energy from hydropower in their willingness to pay analysis. It is from this perspective that this study set out to estimate the willingness to pay (WTP) for improved electricity services from green hydropower sources, analyze how this willingness to support green energy services is related to different factors, and further scrutinize welfare gains from the willingness to pay. There are some studies (such as Mekonnen and Köhlin (2008); Gebreegziabher et al. (2010); Takama et al. (2012); Alem et al. (2013)) that attempted to examine household fuel choices for various fuel types in urban households of Ethiopia particularly in the capital, Addis Ababa. However, this study differently scrutinizes urban and peri-urban households' contribution for climate change mitigation programs through WTP for the expansion of electricity generated from green energy sources. Generally in the literature, there are also studies (most recently Abdullah and Jeanty (2011); Adaman et al. (2011); Guo et al. (2014); Twerefou (2014)) that were conducted in relation to the willingness to pay for improved green electricity services. Many of these studies however did not tackle what should be the 'icing on the cake' of investigating the welfare gains of the proposed improved green electricity service. Unlike most other studies, therefore, we illustrate how welfare of households and society changes as a result of the WTP for improved green electricity expansion.

The rest of the paper is organized as follows. Section 2 presents a concise description of the valuation scenario for the proposed green electricity service. Section 3 deals with the estimation strategy used to compute the mean WTP and identify factors that determine willingness to pay behavior. Section 4 describes the study areas and briefly presents data used for estimation. Section 5 reports and discusses results related to WTP behavior and welfare aggregation. Finally, Section 6 presents concluding remarks.

2. Valuation scenario

For the purpose of this valuation scenario, a renewable energy source refers to energy from hydropower, from which renewable and sustainable electric energy can be generated with minimal environmental externality (Winkler, 2005). Electricity generated from such energy sources is largely clean, efficient and long-lasting. The new initiative introduced by the Ethiopian government is generation of electricity from large and small-scale hydropower energy sources so as to address electricity supply for all. For the best part of the last two decades, the government has been investing huge amount money for the expansion of renewable and sustainable energy, which needed financial support from the Ethiopian community. Such expansions of the generation of electricity from renewable energy sources is aimed at addressing residential energy demand as well as meeting commercial needs, and in the process minimize emissions of GHGs from household and commercial energy consumption.

Despite the huge resources allocated to the expansion of renewable electricity and supply thereof, there is huge unmet demand for electricity. A large section of the Ethiopian population is not connected to the national electricity grid (especially the rural part). In Ethiopia, total demand for electricity grows at an average rate of 15–20% percent annually (Kifle, 2015). Even for the urban and peri-urban households connected to the national grid, service is not satisfactory. Ration, blackout (power outage) for long hours and intermittent supply (power goes off only to come back instantly or in a few minutes) are all too common as far as electricity service is concerned in Ethiopia. While the ration arises from insufficient generation of electricity, intermittent electricity and outage result from technical or mechanical and management problems.

Using the current electricity service that urban and peri-urban households get as a backdrop, an attempt was made to study how strong the willingness of these households would be to pay for improved renewable electric supply in terms of continuity and longevity. The hypothetical electricity supply presented to the households was that the government is planning to provide customers with continued supply of renewable electricity from hydropower without rationing. Electricity will be supplied without interruption (or power outage will be kept at a minimal given perfection is impossible). For this however, the government needs to engage in the expansion of both electricity generating structures (such as hydro dams) and dependable as well as high-capacity electricity transmission lines. The government will also build its technical and management capabilities for effective provision of electricity services. All of these schemes require cost sharing by the end user, such as households. Given this scenario for the proposed electricity supply, as a vehicle for the cost sharing, households would be expected to contribute an additional fixed monthly payment calculated based on the mean willingness to pay. In effect, households would pay this fixed rate (each month) on top of the monthly electric bill.

To elicit the willingness to pay for renewable and sustainable electricity by households, the payment vehicle was presented by initial bids and follow-up bids in a dichotomous set up. In this set up, households were first presented with the initial bid. The initial bid was determined based on the electric bill data of the average household over three consecutive years (obtained from Ethiopian Electric Power Corporation, EEPCo). Moreover, additional feedback was obtained from pilot-survey to have an idea about where households' ability to pay lies and refine the amount of the initial bid. In the end, the data from the pilot-survey and the average over the three-year period helped us design the initial bid to vary between 10–15% of the average monthly household expense for electricity. Based on this, we selected three initial bid amounts with their corresponding follow up bids and randomly assign to sample households in order to reduce starting point bias, which is the most serious problem in contingent valuation studies (Boyle et al., 1985; Kanninen, 1995; Herriges and Shogren, 1996). In the end, the process (for each initial bid) yielded three bid designs (*base*, which is the initial bid, and *upper* and *lower* bids, which represent the follow-up bids). Finally, based on the responses to follow up bids, households were asked about the maximum and minimum amount they would be willing to pay for the renewable electric energy. Willingness to pay data using bids were finally obtained via face-to-face interview by making use of well-trained enumerators that help obtain as much accurate as possible bid payments, thereby reducing interviewer bias (Yoo and Yang, 2001).

With this proposed electricity scheme, not only do current users benefit from effective electricity supply but the government will also generate revenue to expand electricity generation to meet current or future (unmet) demand. The proposed scheme for the expansion of electricity supply in addition would help substitute traditional fuels by less-polluting and sustainable source of energy (for lighting, cooking and heating, etc.), which also plays positive role on the climate through