Energy for Sustainable Development 21 (2014) 89–99

Contents lists available at ScienceDirect

Energy for Sustainable Development

Preferences for electricity supply attributes in emerging megacities — Policy implications from a discrete choice experiment of private households in Hyderabad, India ☆

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ARTICLE INFO

Article history:
Received 14 November 2013
Revised 9 May 2014
Accepted 5 June 2014
Available online 8 July 2014

Keywords:
Urban electricity supply
Discrete choice experiments
Stated preferences
Scale-adjusted latent class model
India

ABSTRACT

The Indian economy struggles with electricity supply deficits and low quality supply. Although several initiatives including demand side management measures have already been implemented, consumers from different backgrounds suffer from various drawbacks of quality supply. This paper explores the valuation of electricity quality from the perspective of domestic consumers in Hyderabad, India. We conducted a discrete choice experiment with 798 urban households. For analysis, we apply a scale-adjusted latent class model to identify heterogeneity in preferences and in variance-scale. The results confirm the hypothesis of highly heterogeneous household preferences and reveal limited preparedness of domestic users to pay for improved electricity quality and renewable energy. Further, most respondents prefer state owned distribution companies to private enterprises or cooperative societies. We argue that the estimated preferences, implying demand and willingness to pay for single attributes of electricity quality, can help policy makers to adequately incorporate consumers' interests into decision making. The results further indicate that domestic tariff hikes should not be used to finance extension of renewable energies or infrastructure investment to improve reliability in supply.

Introduction

It is often argued that, in countries of the Global South, continuous electricity supply is an important prerequisite for economic development and poverty reduction. In reality, however, country-wide electrification in these emerging economies is often not feasible and even within electrified areas, huge differences in received electricity quality remain. In order to overcome the supply gap, governments and policy makers frequently consider investment strategies for electricity infrastructure improvements based on a given budget. Theoretically, the decision maker should distribute each unit of expenditure in a way that it generates the highest marginal benefit. In the electricity sector, observed prices are not adequate to indicate the benefits as electricity infrastructure is not a purely private good and hence no competitive market exists. While data on electrification and on the quality received by the consumers are widely available there is limited understanding on how this quality is perceived by the consumers. This piece of information can be of critical importance when deliberating policy options and tariff orders.

In highly regulated markets, like several electricity markets all over the world, sustainable infrastructure investments and quality improvements cannot be provided efficiently with market-based instruments. It is impossible to observe precisely the preferences of consumers, as they have no or only very limited ways to reveal them. Hence, policy decisions are often based on surveys, secondary data, estimations and projections and, in worse cases, individual opinion and corruption. Often it remains unclear who is most affected by policy changes and how a new regulation effects consumers. Cost–benefit analyses are only possible if there are reliable data on the benefits. Especially for domestic consumers (private households) the benefits from improved electricity quality are rarely observable and affected by various attributes of electricity as final product such as the occurrence of shortages and the share of renewable energies. In this paper we try to contribute filling this gap by applying a discrete choice experiment (DCE) to elicit domestic consumers' preferences for different attributes of electricity quality. The results can be used to adjust power tariffs in the Indian state Andhra Pradesh (AP) in order to reflect individual willingness to pay (WTP) values and to extract additional WTP values for specific attributes related to electricity supply quality. The survey was conducted in February

☆ Earlier versions of this paper have been presented at the IAEE Conference 2011 in Vilnius, at the IASC Conference 2012 in Hyderabad and at the IAEE Conference 2012 in Stockholm. We would like to thank the audiences for their useful comments.
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http://dx.doi.org/10.1016/j.esd.2014.06.002
0973-0826/

2010 in the capital of AP, Hyderabad covering 798 households. Attributes were chosen pertaining to the relevance for future policy decisions concerning the quality of electricity supply and sensitive to consumers' utility. The rationale is as follows: If there are distinct preferences and hence high WTP values for certain aspects of improved electricity quality consumers retain disposable income which they could spend for these quality improvements i.e. they would be willing to pay a higher electricity tariff for better electricity supply. Assuming that the total costs for these improvements were lower than the aggregated WTP investments in infrastructure and quality improvements could be financed with higher tariffs without reducing the welfare of consumers. Contrary low WTP values indicate that investments may not be financed by increased tariffs because the costs of these improvements would be larger than the benefits generated by it.

For estimation, we apply a scale-adjusted latent class logit (SALC) model which identifies different preference classes within a given sample. This statistical method permits a more exhaustive analysis and takes into account that respondents differ in preferences as well as in the certainty of their decisions. The method seems reasonable as the sample consists of several subgroups including different income groups, religions, educational backgrounds, etc. The results suggest, firstly, that consumers are highly heterogeneous. Secondly, more than 85% of the respondents are not willing to accept further tariff hikes even if power cuts reduce and/or the share of renewable energy increases. Thirdly, many respondents are satisfied with government-owned distribution companies, while about 10% strongly favor private or co-operative distribution companies.

The paper is structured as follows: In Section 2 we introduce the power sector in AP. Section 3 explains the DCE and the SALC model. Section 4 overviews the data and the survey details. In Sections 5 and 6 we illustrate the results, discuss the WTP values and interpret the class characteristics. Section 7 gives a short analysis of the interaction of socio-economic variables with the preference classes and Section 8 concludes with recommendations for improvements of the efficiency of the electricity tariffs in AP.

Overview of the power sector in Andhra Pradesh

Electricity demand in AP as well as in India has been growing continuously faster than generation capacities over the last decades. The Indian economy suffers from permanent power cuts and insufficient energy infrastructure (Tongia, 2007; Lal, 2006). In 2001–2002, the peak deficit in AP was 19.9%. It dropped to 2.3% in 2004–2005 (Central Electricity Authority, 2011), which was achieved by the introduction of demand side management measures, limited supply for agriculture and a stricter control of the distribution companies (Deb et al., 2012). However, due to a strong increase in demand it raised steadily to 20.2% in 2012–2013 (Central Electricity Authority, 2013), leading to increased scheduled and unscheduled power cuts.

The current share of coal fired power plants in AP is about 50% i.e. 8783 MW (Central Electricity Authority, 2014c). In 2012–2013, the total net generation from thermal power plants summed up to 117,231 GWh with a total number of CO_2 emissions of 92.14 million tons, reflecting a weighted average emission factor of 0.785.[2] Overall India, new capacities come mainly from fossil fuels, accounting for comparatively high CO_2 emissions. In 2014 additional thermal power projects with a total capacity of 15,234 MW are planned (Central Electricity Authority, 2013).

In AP, limited financial capabilities and governance failures impede public and private investments in energy efficient technologies and renewable energies. The 12th Five Year Plan of AP (2012–2017) aims to solve the various deficits of the power sector such as growing demand surplus, increasing CO_2 emissions, low share of renewable energy for power generation, power supply interruptions, and low energy efficiency and overuse (CESS, 2013).

In the capital Hyderabad, excess demand is still growing, burdening the local energy infrastructure, and leading to unscheduled power cuts and large voltage fluctuations (Sreekumar et al., 2007). The rapid growth of Hyderabad's population restricts the development of the infrastructure. The number of household connections to the distribution grid increases with an annual rate between 8 and 9% and the rising industrialization of the urban areas again contributes to the rapid growth of the demand surplus in the electricity market.

Domestic end use tariffs, i.e. the price per KWh of electricity consumed by domestic households, are determined by the Andhra Pradesh Electricity Regulatory Commission (APERC), and increase with the total consumption per connection. Consumers using less than 50 KWh per month pay 1.45 INR per KWh, while those who consume more than 500 KWh per month pay 8.38 INR per KWh. This tariff structure should relief financial burden from the low income classes but has been heavily criticized that it does not (Reddy and Raghu, 2012). We argue that the current tariff system does not produce efficient outcomes. If tariffs do not consider all costs and benefits of power generation, transmission and distribution, they fail to set sufficient incentives for efficiency investments of both commercial and domestic consumers. The construction of tariff structures considering these features requires knowledge of consumer preferences for all attributes of electricity utilization. The problem of market observation is that revealed preferences, based on regulated prices, do not reflect the complete set of consumer preferences. An optimal tariff is reached if it reflects all components of the utility functions of consumers. This includes also the source of generation and the organizational form of the distribution company (Sagebiel et al. 2014).

Discrete choice experiments

Background of discrete choice experiments

The DCE method is a survey based instrument to elicit preferences, choice probabilities and WTP values for characteristics or attributes of a good. Respondents are repeatedly asked to choose between alternatives which include these attributes with associated attribute levels. The attribute levels vary over the alternatives. A respondent usually answers six to 16 choice sets and the number of attributes rarely exceeds eight. Fig. 1 depicts an example for a choice set card which has been used in this study.

The selection of the attributes and levels is challenging. If attributes are irrelevant to the respondent or dominated by other attributes or if levels are too close or too far away from each other, the external validity and the estimation are at risk. Usually extensive pretesting and focus group discussions before the experiment are conducted to optimally design the choice sets. DCEs can be carried out online, per post or with inhouse interviews. After collecting the data several econometric models are available for estimation. The underlying economic theory goes back to the contributions of Lancaster (1966) and Rosen (1974) to consumer theory. Thurstone (1927) laid the foundation for the random utility model and Manski (1977) formalized it as the theoretic basis for the econometric modeling. The most frequently applied econometric model is the conditional logit (CL) model (McFadden, 1974) but its use is restricted by several strong assumptions. A more flexible formulation is the random parameters logit (RPL) model (e.g. Revelt and Train, 1998; Hensher and Greene, 2003) which assumes the parameters to vary randomly across individuals. The RPL captures heterogeneity in preferences and allows calculating individual parameters. Semi-parametric variants of the RPL are the latent class logit (LC) models (e.g. McCutcheon, 1987; Greene and Hensher, 2003). Here, heterogeneity is assumed to be discrete and limited to a number of classes. In the current debate in the

[2] The Central Electricity Authority (CEA) in India reports four different types of emission factors (Central Electricity Authority, 2014b). The weighted average emission factor is calculated as kilograms of CO_2 emitted per megawatt-hour produced over all power plants. We used the data provided by CEA (Central Electricity Authority, 2014a) to calculate weighted average emission factor for AP.