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Estimating the economic value of residential electricity use in the Republic of Korea using contingent valuation

Kyoung-Min Lim [1], Seul-Ye Lim [1], Seung-Hoon Yoo*

Department of Energy Policy, Graduate School of Energy and Environment, Seoul National University of Science & Technology, 232 Gongreung-Ro, Nowon-Gu, Seoul 139-743, Republic of Korea

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ABSTRACT

This study attempts to estimate the economic value of residential electricity use in the Republic of Korea. According to micro-economic theory, the economic benefit of residential electricity consumed is the sum of the actual residential electricity price and the additional WTP (willingness to pay) for the consumption. We apply the dichotomous choice contingent valuation method to assess the additional WTP. Moreover, the spike model is applied to dealing with the zero WTP responses. The results show that the mean additional WTP for the residential electricity is estimated to be KRW 15.38 (USD 0.01) per kWh. Given that the average price of residential electricity is KRW 103.40 (USD 0.10) per kWh at the time of the survey, the economic benefit that ensues from the residential electricity consumption is computed as KRW 118.78 (USD 0.11) per kWh. This information can be beneficially utilized in conducting an economic feasibility study for a new project related to residential electricity supply service.

1. Introduction

Electricity is the most convenient source of energy since it is relatively easy to transport it over large distances, and then convert to other types of energy at the home – for example, kinetic energy to move some electric motor in a kitchen appliance, microwaves in a microwave oven, converted to heat in a shower, etc. Thus, in today's culture, it is a vital part of functioning as a society. Moreover, electricity has a positive correlation with economic growth because it can enhance the productivity of capital, labor, and other factors of production [1]. A number of studies reveal that electricity consumption leads to economic growth [2]. In particular, it has played an important role in the economic development of ROK (Republic of Korea) and has become a critical factor in sustaining the well-being of the Korean people [3].

The residential electricity consumption and real GDP (gross domestic product) of ROK have grown at average annual rates of 11.7% and 6.5%, respectively, over the period 1970–2010 [4]. The former has expanded more rapidly than the latter. However, in 2011, the country underwent an electricity crisis that led to a national blackout due to the sudden increase in the demand of electricity causing an overload on electricity supply. In particular, accidents caused by shortage of electricity have given enormous damage to the households. In order to cope with the rapidly increasing residential demand for electricity, efforts should be made to enhance the supply reliability of electricity and overcome the constraints on electricity consumption.

A possible solution is to increase investments in electricity supply infrastructure such as power plants and transmission lines. This task has become one of the most important ones for the nation in the near future as well as in the present. Thus, policy-makers are currently addressing the likely effectiveness of constructing a number of new power plants and transmission lines. However, in certain regions, the construction of new power plants and/or transmission lines is being delayed due to strong objections raised by the residents. In short, new building of electricity supply infrastructure obviously requires more social costs than the past.

Employing economic efficiency as the sole criterion, whether to construct a new power plant should be evaluated in a conventional cost-benefit analysis context. In other words, the decision on whether to construct a new power plant could, in principle, be made from an examination of social costs and benefits associated with the construction. Moreover, an important first step in fostering a productive debate over whether to construct a new power plant is a better understanding of its benefits and costs. Information on the social costs can be more easily obtained than that on the economic benefit of electricity. However, to the best of the authors' knowledge, the estimation of the economic benefit of residential electricity has been rarely done in ROK.

* Corresponding author. Tel.: +82 2 970 6802; fax: +82 2 970 6800.
E-mail addresses: lkymin@seoultech.ac.kr (K.-M. Lim), im@seoultech.ac.kr (S.-Y. Lim), shyoo@seoultech.ac.kr, shyoo111@nate.com (S.-H. Yoo).
[1] Tel.: +82 2 970 6960; fax: +82 2 970 6800.

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Such situations require researchers to provide policy-makers with accessible and responsible information on the economic benefit or value of residential electricity use. Therefore, this study attempts to estimate the economic benefit or value of residential electricity use in ROK. To this end, we here report the findings from the application of a CV (contingent valuation) to quantify the economic value of residential electricity use to households. The message of this paper is all the more useful because there are few studies that assess the economic value of residential electricity using CV.

The remainder of this paper is organized as follows. Section 2 clarifies the concept of the economic value of electricity use, provides the framework for the valuation of residential electricity, and explains the measurement method used in this study and the methodological issues. Section 3 describes a model of WTP (willingness to pay). Section 4 presents the empirical results, compares them with previous studies, and discusses the potential uses of them. Some concluding remarks are made in the final section.

2. Methodology

2.1. The concept of the economic value of electricity use

Following the tenets of modern microeconomic theory, in the case where a market exists for a good or service, given the price, a consumer determines the quantity that is demanded such that total utility is maximized subject to a budget constraint. Generally, *ceteris paribus*, changing prices of the good in question will alter the quantity that is demanded. We assume the existence of a smooth, well-defined, continuous function that represents the relationship between the quantity of electricity demanded by a consumer and the price of electricity. Given the possibility of estimating this relationship, a derived demand function can be used as a basis for measuring the value of electricity.

A demand curve illustrates the maximum price a consumer would be willing to pay for obtaining any quantity in question. This concept of value has been often described as willingness to pay (WTP) [5]. For all the units demanded, the total WTP is the total value of the area under the demand curve. The consumer surplus is usually defined as the area under the demand curve that lies above the market price or the amount paid by the consumer. In other words, the economic value of electricity consumed is the sum of the consumer surplus and the actual consumer expenditure.

Therefore, when one unit of electricity is consumed at a price, the economic value or benefit of electricity consumed is calculated by summing up the actual electricity price and the additional willingness to pay (WTP) for the consumption. Therefore, it would be meaningful to measure the additional WTP for residential electricity consumption since the price electricity provided by a public utility is well-known information in ROK. To derive how much people would be willing to additionally pay for a stable supply of residential electricity, this study attempts to apply the CV method. The CV method is a widely used technique for valuing the non-market environmental benefits of any policy decision taken for the improvement of environmental resources. The CV method has been widely applied in energy management issues (e.g., [6,7]).

2.2. CV method

The blue-ribbon NOAA (National Oceanic and Atmospheric Administration) Panel's report concluded that the CV method can produce estimates reliable enough to be the starting point for administrative and judicial determinations and presented several recommendations [8]. In addition, the CV method would seem to fit very comfortably within the traditional concept of micro-economics, anchored squarely in individual preferences [9]. From an extensive review of a number of empirical CV studies, Vehkatachalam [10] concluded that CV method could be used to derive useful information. The validity and accuracy of a CV study will be enhanced if people are familiar with the issues, if the issue and method of provisions and payment are meaningful to people, professional interviewers are used, and other conventions suggested by the NOAA Panel are followed. Our study meets these conditions, which will be discussed in detail in the following sub-sections.

2.3. Sampling and survey methods

The data on the household's additional WTP for residential electricity supply service and characteristics used in this study are derived from a 2012 survey of households all over the nation. The total number of households in the country was 17,339,422 in 2010. To draw a random sample of this population, sampling was carried out by a professional polling company. The survey was conducted with the heads of household or housewives whose ages ranged from 20 to 65. The survey yielded 2500 reliable interviews.

Such a survey can be conducted either by face-to-face interviewing, telephone interviewing, or by mail. Of these methods, we chose to use face-to-face interviews for the CV survey for cultural and practical reasons [11,19]. First, we felt that randomly chosen Korean households would be even less likely than Americans or Europeans to be familiar with the idea of supplying unprompted values for proposed public goods if they were confronted with a telephone interview or mail survey questions. However, face-to-face interviews with well-trained interviewers can offer the most scope for detailed questions and answers. In this regard, we selected the most experienced and best-educated of the polling firm's interview experts to conduct the interviews and gave them a thorough briefing. Second, a telephone interview was the least preferred method because conveying information about the product or service being considered may be difficult over the telephone. Finally, mail surveys are rarely used because they suffer from non-response bias and extremely low response rates; thus it seemed especially risky to use this method in the context of ROK.

2.4. Survey instrument

The survey instrument (questionnaire) was pre-tested with 100 persons. In designing a CV survey, the scenario should offer the respondents information on the characteristics of a specific product or service and the context that will meet the requirements of understandability, plausibility, and meaningfulness to enhance the credibility of the survey and the likelihood of producing reliable results. The survey questionnaire consisted of i) introductory questions, such as the respondents' perception after providing general background information on the residential electricity; ii) the WTP question about the stable supply of residential electricity service; and iii) household information.

2.5. Elicitation method

The elicitation format employed in this study is a referendum or DC (dichotomous choice) question according to the 'blue-ribbon CV panel' of Arrow et al. [8], which strongly endorses a referendum question rather than an open-ended question. The DC model has been favored since it was popularized by Hanemann [12]. Typically, a random sample of the population is asked a question with a 'yes' or 'no' possible response regarding their willingness to contribute a specific amount toward the preservation of some environmental resource or the provision of a service for the public good. The question format employed in this study is usually called the SB