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Is the Korean public willing to pay for a decentralized generation source? The case of natural gas-based combined heat and power

Hyo-Jin Kim, Seul-Ye Lim, Seung-Hoon Yoo*

Department of Energy Policy, Graduate School of Energy & Environment, Seoul National University of Science & Technology, 232 Gongreung-Ro, Nowon-Gu, Seoul, 01811, Republic of Korea

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A B S T R A C T

Natural gas (NG)-based combined heat and power (CHP) plants can be installed near electricity-consuming areas and do not require large-scale and long-distance power transmission facilities. This paper attempts to assess the public's additional willingness to pay (WTP) for substituting consumption of a unit of electricity generated from nuclear power plant, currently a dominant power generation source in Korea, with that produced from NG-based CHP plant in terms of decentralized generation using the contingent valuation (CV) method. To this end, a CV survey of 1,000 households was implemented. The results show that the mean additional WTP for substituting nuclear power plant by NG-based CHP plant is estimated to be KRW 55.3 (USD 0.047) per kWh of electricity, which is statistically significant at the 1% level. This value amounts to 44.7% of the average price for electricity, KRW 123.69 (USD 0.106) in 2015, which implies that the public are ready to shoulder a significant financial burden to achieve the substitution. Moreover, the value can be interpreted as an external cost of nuclear power generation relative to NG-based CHP generation, or as an external benefit of NG-based CHP generation relative to nuclear power generation with a view to decentralized generation.

1. Introduction

Nuclear power has been widely accepted to have lower costs than other generation sources such as coal and natural gas (NG) in Korea and thus the government has expanded and will expand the construction of nuclear power plant. According to 'The 7th Basic Plan for Long-term Electricity Supply and Demand (2015–2029)' published by the Korean government in 2015, an additional thirteen nuclear power plants are planned to be constructed. Nuclear power is presently a base-loaded and dominant power generation source in Korea. All the nuclear power plants in Korea are located around coastal areas in order to acquire sea water for cooling and are quite remote from the Metropolitan area for safety. Consequently, the nuclear power plants inevitably require large-scale and long-distance power transmission facilities (PTFs) since they are located far from the consumers.

Some believe that there may be health hazards emitted from these facilities for those living close to them. Moreover, PTFs are a blot on the landscape. The rights-of-way for high voltage lines often run through high-value land and reduce the property values there (Weimers, 1998). In summary, the significant externalities of PTFs include electric and magnetic fields (EMFs), visual disamenity, and land use (Ju and Yoo, 2014). Whether or not the possible damage from PTFs is backed by scientific evidence, the construction of new high-voltage transmission lines is occasionally confronted by public opposition or political resistance. This usually causes a substantial amount of social costs.

The social costs caused by large-scale and long-distance PTFs are as follows. First, there is a construction cost; second, there are transmission losses due to the long-distance power transmission (Fitiwi et al., 2016); third, a transmission congestion cost from the transmission bottleneck effect is incurred as a result of the largest amount of electricity being consumed in the Metropolitan area (Göransson et al., 2014). Lastly, there is damage in the form of visual disamenity, depreciation of land prices and prohibition on land usage, and damage to the health of local citizens caused by large-scale and long-distance PTFs (Ju and Yoo, 2014). For example, Ju and Yoo derived quantitative information on the cost of damage caused by overhead power transmission lines in Korea by applying a choice experiment technique that investigated public preferences for the above-mentioned damage. In addition, Navrud et al. (2008), Giaccaria et al. (2010), and McNair et al. (2011) examined the external costs of PTFs by implementing various non-market valuation methods. Some related studies are also found in the literature (e.g., Furby et al., 1988; Ottinger et al., 1991; Rowe et al., 1995; Weimers, 1998; Pasqualetti, 2000; Zhu et al., 2005).

Recently, a number of social conflicts related to PTFs construction,

* Corresponding author.
E-mail addresses: hyojinkim@seoultech.ac.kr (H.-J. Kim), sylim@seoultech.ac.kr (S.-Y. Lim), shyoo@seoultech.ac.kr (S.-H. Yoo).

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which rarely arose in the past, have taken place in Korea. A representative conflict arose in Milyang which is located between the Metropolitan area and Singori nuclear power plants. 765 kV power transmission lines and 69 transmission towers are scheduled to be constructed in Milyang to transmit electricity generated at the Singori nuclear power plants to the Metropolitan area. The opposition has continued since the government first officially announced and approved the construction in 2008. One resident burned himself to death and another resident poisoned herself to death with the intention of objecting to the construction. Some Milyang residents took over the construction sites in protest. Unfortunately, these conflicts were not peacefully resolved. The government exercised its power to stop the opposition in 2014 through police action. Thus, at least the conflict seems to be resolved externally.

However, the anxiety of the Milyang residents is not yet healed and similar opposition is likely to arise in other areas. In the past, we suffered from an insufficient supply of power, as a result of insufficient power plants. The ceaseless public and private investment in power plant construction has successfully removed the problem of insufficient power supply. We are now confronted with the new and serious problem of social conflict related to the construction of large-scale and long-distance PTFs. As the social cost regarding PTFs has become a more significant issue, there has recently been more interested than previously in expanding decentralized generation which does not incur any social cost.

In order to deal with the problem, the Korean government planned to increase the proportion of decentralized generation from 9.6% in 2013 to 13.9% in 2029. In particular, decentralized generation sources such as NG-based combined heat and power (CHP) plant can be installed near to electricity-consuming areas and do not require large-scale and long-distance PTFs. Thus, the opposition can be eliminated by operating decentralized generation such as NG-based CHP generation. The government will increase the ratio of CHP generation from 3.1% in 2013 to 4.6% in 2029. This means augmenting the amount of electricity produced by CHP from 16,751 GWh in 2013 to 34,175 GWh in 2029 (Ministry of Trade, Industry, and Energy, 2015).

Obviously, the public preference for decentralized generation to avoid the damage caused by PTFs can be utilized as a proper and important reference for further discussion of the expansion of decentralized generation and decisions on the establishment of PTFs and power generation. The public preference can be investigated through their additional willingness to pay (WTP) for NG-based CHP over nuclear power. Moreover, the WTP can be taken as indicative of an external cost of nuclear power generation relative to NG-based CHP generation or an external benefit of NG-based CHP generation relative to nuclear power generation with a view to decentralized generation.

Therefore, this paper attempts to analyze the public preference for NG-based CHP plant over nuclear power in a perspective of decentralized generation using the CV approach. The message of this paper is all the more useful because, to the best of the authors' knowledge, this study is the first trial to address the issue quantitatively. The remainder of the paper comprises four sections. The methodology adopted in this study is explained in Section 2. A model of WTP is described in Section 3. The results are reported and discussed in Section 4. The paper is concluded by the final section.

2. Methodology

2.1. Method for assessing the public preference for a power generation source switch

In the context of economics, the economic benefits of a commodity are defined as the area below the demand curve for the commodity. This area is precisely the consumer's WTP for the commodity. Thus, we can usually value the benefits by first estimating the demand function and then computing the area. However, if the commodity is not traded in the market, in other words, if it is a non-market goods, it is quite difficult to estimate the demand function. A power generation source switch from nuclear power to NG-based CHP in the perspective of decentralized generation is such a case, for which directly calculating the area under the demand function is a good strategy; this can be done using a stated preference technique such as the CV method.

The CV technique has been very widely applied in the literature to obtain the WTP for non-market goods (Ladenburg, 2014; Lim et al., 2014). There are no restrictions on the objects that can be valued using the CV method. In particular, it is more useful than other methods because it can capture the non-use or existence value of goods, which cannot be measured through a market mechanism. Non-market goods include environmental goods or public goods such as a power generation source switch from nuclear power to NG-based CHP in the perspective of decentralized generation. Thus, as explained earlier, this study seeks to utilize the CV approach to assess the economic benefits that would follow from the switch. It asks a potential consumer a question concerning the WTP for conducting the switch using a well-structured survey of randomly chosen consumers (Saz-Salazar et al., 2009).

Some people may doubt the practicality and usefulness of the CV method because it gathers information from a survey of respondents. In this regard, the blue-ribbon National Oceanic and Atmospheric Administration (NOAA) Panel came to the influential conclusion that the CV method can produce reliable quantitative information that can be utilized in decision-making both for public administrations and judicially, provided that several guidelines proposed by the NOAA Panel are observed (Arrow et al., 1993). Moreover, following the guidelines can secure the validity and accuracy of the CV method.

For example, the goods of concern should be familiar to the public, the CV survey should be administered through face-to-face interviews by professionally trained interviewers rather than through telephone or mail interviews, the number of respondents should be at least 1,000, a suitable payment vehicle should be adopted and presented to the respondents, and the substitutes for the goods should be explained to the respondents in the survey. The conditions are met in our study, as will be discussed in detail below.

2.2. The goods to be valued

The Korean government has a very clear long-term plan for decentralized generation. At present, there are national energy master plans for the expansion of NG-based CHP. The government declared its plans to expand the NG-based CHP plants as a representative decentralized generation source from 2013 to 2035. Accordingly, "The 8th Basic Plan for Long-term Electricity Supply and Demand", an official national plan expected to be published in 2017, seems to include the construction of additional NG-based CHPs.

The goods to be valued in this study is the power generation source switch from nuclear power to NG-based CHP in the perspective of decentralized generation in order to avoid damage caused by PTFs. NG-based CHP plant does not require PTFs, which are inevitably required in consuming the electricity generated from nuclear power. Therefore, any damage arising from PTFs can be eliminated by NG-based CHP plants since they are constructed near to electricity-consuming areas on a small scale. These points have been explicitly conveyed to the respondents in the CV survey.

In designing a CV survey, the current state (Q_0) and target state (Q_1) should be clearly defined. In our study, Q_0 and Q_1 mean the consumption of electricity generated from nuclear power and that from NG-based CHP, respectively. The CV survey elicits a response of WTP to achieve the change from Q_0 to Q_1, the power generation source switch, from a respondent. In this regard, the WTP can be interpreted as a premium of NG-based CHP over nuclear power with a view to decentralized generation.

The respondents may not regard large-scale and long-distance PTFs