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A study of factors enhancing smart grid consumer engagement

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HIGHLIGHTS

- We examine what factors influence electricity consumers' smart grid acceptance.
- We test the smart grid technology acceptance model including the perceived risk as a main factor.
- The importance of consumer education and public relations of the smart grid has been confirmed.
- Another shortcut to ensure the acceptance of the smart grid is to mitigate the anxiety about the risk in the use of the smart grid.

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ABSTRACT

It is important to ensure consumer acceptance in a smart grid since the ultimate deployment of the smart grid depends on the end users' acceptance of smart grid products and services such as smart meters and advanced metering services. We examine how residential consumers perceive the smart grid and what factors influence their acceptance of the smart grid through a survey for electricity consumers in Korea. In this study, consumers' smart grid acceptance factors, including the perceived risk, were examined with the existing technology acceptance model suggested by Davis. This study has an implication that it has provided theoretical and empirical ground, based on which the policies to promote consumer participation in the deployment of the smart grid can be developed. Since there are few studies on the policies from the perspective of the smart grid users, this study will contribute directly to the development of the strategy to ensure the acceptance of the smart grid.

1. Introduction

A smart grid is a next-generation power grid to optimize energy efficiency with exchange of real-time information between suppliers and consumers by integrating information and communication technologies with the existing power grid. Through a market's various price signals, energy consumption can be managed in a time-based way and the supply and demand of power can be optimized. Since 2009, many countries around the world have actively promoted various projects aimed at building a smart grid as the primary means for green growth. The countries have been installing advanced metering infrastructure including smart meters, which are considered as primary infrastructure for a smart grid, at residential buildings as well as commercial and industrial ones. As for residential consumers, however, the smart grid is something unfamiliar, possessing acceptance restraints such as cyber security threats, the possibility of electricity rate increase, and reluctance among targets in using a new kind of technology (Baltimoresun, 2009; Venturebeat, 2009; Earth2tech, 2010; Chicagotribune, 2011).

In order to successfully build a smart grid, it is necessary to set key policy objectives to ensure consumer acceptance and to make a scientific analysis of the factors affecting consumer acceptance, since the ultimate deployment of the smart grid depends on the end users' acceptance of smart grid products and services (Harris Interactive, 2010; Pike Research, 2010; IEA, 2011; SGCC (2010); IBM, 2011; EPRI, 2012; GridWise Alliance, 2013). Likewise, the degree of consumers' participation in smart grid projects causes a high scale of smart grid benefits. In Korea, the importance of consumer acceptance has been stressed in smart grid policies, but it has not been treated as a key policy objective, being emphasized mainly in the aspect of public relations.

In this study, we examine how residential consumers perceive the smart grid and what factors influence their acceptance of the smart grid through a survey to electricity consumers in Korea.

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We assume that the advanced metering infrastructure including smart meters is considered as the main smart grid technology to residential electricity consumers. The research result would contribute to lay the foundation for setting policies and strategies that will ensure smart grid acceptance.

2. Theoretical discussion

2.1. Technology acceptance model

The technology acceptance model (TAM) proposed by Davis (1989) has been widely applied in research related to information and communication technology acceptance and has been regarded as a suitable model to predict and explain the acceptance of a new technology by many researchers.

In TAM, the users' technology acceptance is said to be made up of two important beliefs: perceived usefulness and perceived ease of use of a new technology. Perceived usefulness is defined as the degree of belief that to use a specific technology will improve one's work performance. Perceived ease of use is defined as the degree of belief that to use a particular technology will be easy (Davis, 1989). These two beliefs influence the attitude toward using, with the attitude toward using and the perceived usefulness interacting to alter users' behavioral intention to use. Actual use is affected by a user's behavioral intention in the same way perceived usefulness is influenced by perceived ease of use. TAM by Davis (1989) is employed in Fig. 1.

Later, researchers have simplified TAM by removing the attitude toward using, which is similar to the behavioral intention to use. In other words, the user's intention to use a technology is affected directly by belief variables such as perceived usefulness and perceived ease of use (Davis, 1989; Venkatesh and Davis, 2000).

After the publication of TAM by Davis (1989), many studies have been conducted to modify and extend TAM. A representative extended TAM is TAM II proposed in 2000 by Davis and Venkatesh who had presented TAM for the first time. TAM II emphasized perceived usefulness over TAM I. The reason TAM II specified perceived usefulness of the two variables is because perceived usefulness consistently had higher explanatory power on the intention to accept information technology than the perceived ease of use as a result of most studies of TAM. TAM II was supposed to explain perceived usefulness through variables such as subjective norm, image, job relevance, output quality, and result demonstrability. Meanwhile, Venkatesh and Bala (2008) presented TAM III by providing the basic TAM with exogenous variables such as individual differences, system characteristics, social influence, and facilitating conditions.

Other studies were actively done to learn if there was a third determinant variable other than perceived usefulness and perceived ease of use. Those studies started from the criticism that Davis' TAM (Davis, 1989) did not reflect users' various viewpoints because it limited the determinant variables affecting the intention by using only perceived usefulness and perceived ease of use. Koufaris and Hampton-Sosa (2002), in the study on the acceptance of the Web, maintained that users' acceptance was determined by five factors: perceived control, pleasure of action, concentration, along with perceived usefulness and perceived ease of use of the existing TAM. In the study applied to e-commerce, by adding the variable of trust to the existing TAM based on previous studies, Gefen et al. (2003) stressed the importance of trust as a factor affecting intention to use.

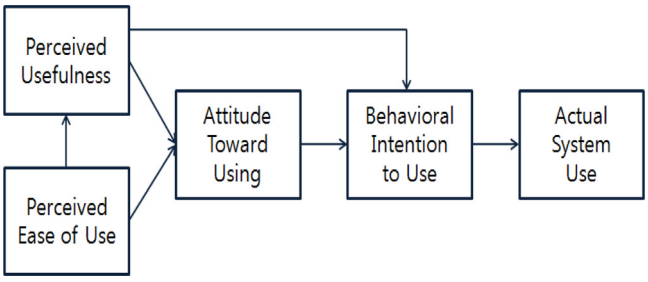

Fig. 1. Davis' TAM.

2.2. Needs to consider perceived risk in TAM

The existing technology acceptance theory focuses on perceived usefulness and perceived ease of use as factors influencing one's intention to accept based on the theory of reasoned action. It has been proven by many documental researches that a wide range of explanation in relation to the intention to accept a technology is possible with this rational decision-making factor. However, the acceptance of a new technology is affected by subjective and irrational factors such as emotion and image as well as objective and rational factors (Kim, 2009). A representative subjective factor with respect to technology acceptance is perceived risk. There are important issues that hinder the acceptance of smart grid technologies such as cyber security threats in a smart grid, performance reliability of smart meters, and concerns about electromagnetic radiation. The analysis of the smart grid acceptance factors should include the consideration of those risk factors.

The consideration of the perceived risk in relation to the analysis of consumer behavior was started by Bauer (1960). Bauer's perceived risk of consumers referred to subjective risk which was distinct from the risk of objective probability. The perceived risk involved psychological risk which was perceived in the process of choice such as brand choice, store choice, and way of purchasing a particular product (Yang and Jung, 1999:120–121). Bauer regarded consumers' perceived risk as a function of two factors: uncertainty and performance (gain or loss) (Jun et al., 2003:22).

Cox (1967) developed the idea of Bauer (1960) to define perceived risk as a function of two factors: uncertainty and loss. Cox defined perceived risk as the existence of one or more cases in a consumer's mentality among three: not knowing the purpose to buy a specific product, not knowing which choice to meet the purchase purpose, and not knowing that negative consequences resulted from dissatisfaction with the purchase result. Jacoby and Kaplan (1972) and Vincent and Zikmund (1976) also analyzed perceived risk with two factors of uncertainty and loss (Jun et al., 2003:22–24).

Though the definition of the perceived risk was more or less different from one another among researchers, it generally included both the subjective uncertainty which a consumer perceived about the results from a purchasing behavior and subjective expectations about any loss caused by the purchase results (Kassarjian and Robertson, 1991; Stone and Gronhaug, 1993, Jun et al., 2003:24).

The type of perceived risk was categorized in various ways by researchers. Roselius (1971) used time loss, risk loss, ego loss, and pecuniary loss for the types of the perceived risks in the study on how to reduce perceived risk. Brooker (1984), in the research on the relationship between the characteristics of each risk type and the overall risk about spaghettis and peaches, also classified the risk types into psychological risk, financial risk, functional risk, physical risk, and social risk, clarifying that these five types of perceived risk could explain more than 60% of the overall perceived risk. Taylor and Todd (1995) took the concept of loss for the perceived risk and divided social/psychological loss and functional/economic loss in the study on the consumers' behavior

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