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Dynamic characteristics of smart grid technology acceptance

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Abstract

Smart grid projects are being actively promoted globally for green growth. There is the consumer acceptance among factors that make smart grid business effective. Many studies have emphasized the importance of smart grid consumer acceptance and examined the factors that influence the acceptance. However, almost studies did not observe how smart grid acceptance changes from a dynamic perspective. This study aims to contribute to smart grid acceptance research by examining dynamic characteristics related to the acceptance. As a result of this study, we found that it is important to manage the risk of smart grids and we should try to minimize the gap between expectation and satisfaction. Also, we should maintain the balance of benefits and reductions of smart grid technologies.

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Keywords: smart grids; causal map; technology acceptance

1. Introduction

Consumer roles in the electricity grid system are expected to be expanded along with the deployment of smart grid technologies. In the existing grid system, consumers are considered as potential stakeholders who occupy a peripheral position. Consumers receive monthly bills for their energy consumption and pay. In the existing grid system, consumer engagement has been limited to making a phone call to power utilities to let them know the information about

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electricity losses when a power supply disruption or blackout occurs. Furthermore, utilities have not provided any information on how consumers' behaviors affect their bills in advance. However, the deployment of smart grids allows electricity consumers to become active stakeholders whose roles are expanding. As smart grid technologies are developed and diffused, consumers are not remaining static and passive agents, but are becoming active prosumers (producer + consumer). Consumers' market participation would increase through demand response, renewable energy production, and vehicle to grid as smart grids are deployed [1, 2].

Accordingly, consumers' active roles are emphasized, and the importance of consumer engagement is increasing [3–5]. Expansion of consumers' participation contributes not only to extending consumers' benefits by smart grids and to accelerating their use, but also to promoting the development of smart grid technologies [6].

To date, some studies dealing with smart grid technology acceptance have explored acceptance factors [7–11] and have demonstrated the significance of causal relations between the factors [12–14]. The existing studies on smart grid technology acceptance can be classified into two groups. One explores the main factors of smart grid technology acceptance and the other reviews the relations between the main factors.

The main factors for smart grid technology acceptance in the literature can be summarized as financial benefit, understanding of the technology, eco-friendliness, and cyber security. Overall, the financial benefit has been considered the most important factor impacting the acceptance of smart grid technologies and educating consumers and improving customers' knowledge on the economic effects of smart grids has been emphasized. This is directly linked to improving the understanding of smart grids.

The studies which are focusing on the relations between the main factors applied in Davis [15]'s Technology Acceptance Model (TAM) in general. Park et al. [12], Park et al. [13], and Chen et al. [14] described the factors of smart grid technology acceptance based on the TAM and analyzed the significance of relations among the factors. TAM is one of the representative theories about the acceptance of new technology1. According to the TAM, consumer technology acceptance is derived from two essential beliefs: Perceived Usefulness and Perceived Ease of Use. Perceived Usefulness indicates the belief that certain technologies help the user to attain better results, while Perceived Ease of Use refers to the belief that certain technologies are easy to use [15]. These two beliefs affect the Attitude toward Using, and the Attitude toward Using and Perceived Ease of Use affect Behavioral Intention to Use. Next, the Behavioral Intention to Use affects Actual System Use. Also, Perceived Ease of Use positively affects Perceived Usefulness.

Like the existing TAM-applied researches, Park et al. [12] set the main parameters of the TAM such as Perceived Usefulness, Perceived Ease of Use, and Behavioral Intention to Use, as endogenous variables, while they suggested Perceived Electricity Saving, Perceived Eco-Environment, Perceived Power Supply Reliability, Perceived Risk of Hacking, and Privacy Invasion as exogenous variables that affected the Perceived Usefulness. Perceived Electricity Saving is the perception that electricity consumers hold in relation to the reduction of the electricity rate through the use of smart grid technologies. The Perceived Eco-Environment is the realization that smart grids will help to preserve the environment. Perceived Power Supply Reliability is the recognition that smart grids may contribute to the stability of a power supply. Perceived Risk of Hacking and Privacy is the awareness about cyber security threats accompanying the building of smart grids [13].

Park et al. [13] expanded the TAM by adding Perceived Risk as an endogenous variable, which had been considered as an exogenous variable in Park et al. [12], and they referred to it as the Risk Integrated TAM (RITAM). Perceived Risk is the awareness of the possible risk in using smart grids. Conventional technology acceptance models emphasize some factors such as Perceived Usefulness and Perceived Ease of Use based on the theory of rational behavior. However, it is not only objective and rational factors that affect new technology acceptance, but also subjective and irrational factors such as emotions and images. In Park et al. [13], consumer smart grid acceptance factors were examined including the Perceived Risk variable, which is a highly irrational element, with a TAM based on the traditional theory of rational behavior. In the model, social/psychological risk, functional/economic risk, and physical risk were included in the exogenous variables affecting the Perceived Risk. The social/psychological risk indicated cyber security threats, the physical risk refers to concerns about the electromagnetic radiation (EMR) of smart meters, and the functional/economic risk is represented by concerns about the accuracy and reliability of the smart meter functions. Also, exogenous variables including Perceived Understanding and Perceived Compatibility were applied to Perceived Ease of Use. The Perceived Understanding is the degree to which the users think that they know about smart grids and can explain them to others. Perceived Compatibility is the degree to which a new technology is not difficult to use because of its similarity with the existing technology [13].