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Smart meter adoption and deployment strategy for residential buildings in Indonesia

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HIGHLIGHTS

- Limited consumer awareness of smart meters contributes to skepticism.
- Data obtained from a survey of energy users are analyzed using SEM.
- A CAP index is developed via SEM results to measure consumer propensity for adopting smart meters.
- The findings of this study enhance understanding of consumer perceptions and behaviors.
- Concrete strategies are proposed to help policy makers and utility companies.

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ABSTRACT

For countries pursuing sustainable development and energy efficiency, the use of smart meters is considered a first step in allowing residential consumers to remotely control their energy consumption, and a promising technology for conserving limited energy resources. However, despite the growing interest in smart meters, limited consumer awareness, knowledge, and understanding of these devices contributes to skepticism. This study thus developed an index to measure consumer propensity to adopt smart meters in residential buildings. Data obtained from a survey of energy use by Indonesian households were analyzed using structural equation modeling to determine the interacting factors in consumer acceptance of smart meters. Consumer perceptions, expectations, and intentions regarding the potential use of smart meters in Indonesia were also discussed. The findings of this study enhance understanding of consumer perceptions and behaviors, and can help decision makers and energy utility companies develop policies and strategies for a "one-size-fits-all" program related to smart meter applications in future residential buildings.

1. Introduction

Many countries have recently recognized energy efficiency and sustainable development as important global issues. Simply monitoring consumption is insufficient for improving energy efficiency [1]. Studies show that non-technical losses by power utility companies total 20 billion dollars annually worldwide. Additionally, in the near future, total energy demand is expected to double [2–5]. A promising solution to cope with current energy issues is to possibly save energy by implementing smart grid in addition to developing innovative renewable energies. Notably, one of the critical components in smart grid is a two-way communication-capable metering device.

Various policies have been proposed to facilitate and promote consumer adoption of energy-efficient lifestyles. For example, the European Union has set ambitious targets to be achieved by 2020, including to reduce both energy consumption and CO_2 emissions by 20%, and to increase renewable energy to 20% of total generation. Smart meter thus is considered the most cost effective means of creating a smart grid that can increase end-user involvement and engagement in energy saving [3,6–8]. By 2014, approximately 212 million smart meter units are expected to be deployed globally. In Italy, Enel, the third largest energy provider in Europe has begun deploying smart meters to about 27 million consumers, in what is the world's largest smart meters deployment project.

However, despite growing interest in smart meters, many consumers remain skeptical because they have limited awareness, knowledge, and understanding. The numerous challenges of developing smart meter systems include realigning the interests of government, businesses, and consumers. Several investigations have

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demonstrated that the public remains confused about what smart meter systems can achieve. For example, Krishnamurti et al. [9] and Wolsink [10] found that energy consumers have many misconceptions about smart meters.

Moreover, most studies on smart meters have focused on technical issues whereas social acceptability significantly determines the success or failure of policy maker decisions [11]. Designing an appropriate policy requires clearly understanding consumer concerns and preferences about smart meters. To maximize the effectiveness of marketing spend and minimize losses arising from underutilized service delivery systems, utility companies must measure consumer adoption tendency for smart meters so they can accurately forecast and effectively segment and target markets before investing in high-tech products and services.

Indonesia is facing a shortage of energy to meet the needs of a developing economy. In addition to improving existing energy supply system and researching renewable energy, smart grid is currently considered as a potential solution to cope with power crisis. However, smart meter deployment certainly takes a long time and needs sufficient preparation. Along with studies related to technology development, this is the suitable time to conduct a study on consumer acceptance of smart meter in Indonesia.

In this sense, this study investigated the propensity of consumers to adopt smart meters in residential buildings through an empirical study in Indonesia. This study sheds light on two issues. The first issue is: What are the critical factors that influence the intention to use smart meter in residential buildings? The second one is: What should policy makers pay attention to maximize success in smart meter development according to current status evaluation?

To resolve the first issue, a research model was developed based on the technology acceptance model theory, and data obtained from a survey of energy consumers were analyzed by the structural equation modeling (SEM) technique. To resolve the second issue, a consumer adoption propensity (CAP) index is developed to assess consumers' tendency to accept and adopt residential smart meters based on the analytical results of SEM.

The findings of this investigation enhance the utility company in the service-oriented industry to apprehend the perceptions and behaviors of energy consumers. Practical applications include developing strategies for efficient implementation of smart meters in residential buildings. The remainder of this paper is organized as follows. Section 2 reviews the literature on smart meter technology and acceptance. A structural model is constructed based on the literature support, in which the research hypotheses are assumed. Section 3 then details the research methods used. Next, Section 4 interprets the analytical results. Sections 5 presents implications and practical applications of the study, and section 6 outlines conclusions, limitations, and recommends future research directions.

2. Literature review and research hypotheses

This section synthesizes the literature and its relationship with the current investigation.

2.1. Smart meter as a new technology

Smart meters are an important component of next-generation smart grids because they enable remote metering of energy consumption (including electricity, water, and gas) [12,13] and provide more information than a conventional energy meters. An important feature of smart meters is their use of fast, reliable, and secure data communication networks to effectively and intelligently manage complex power systems [14–16]. Fig. 1 schematically represents how the physical and functional aspects of smart

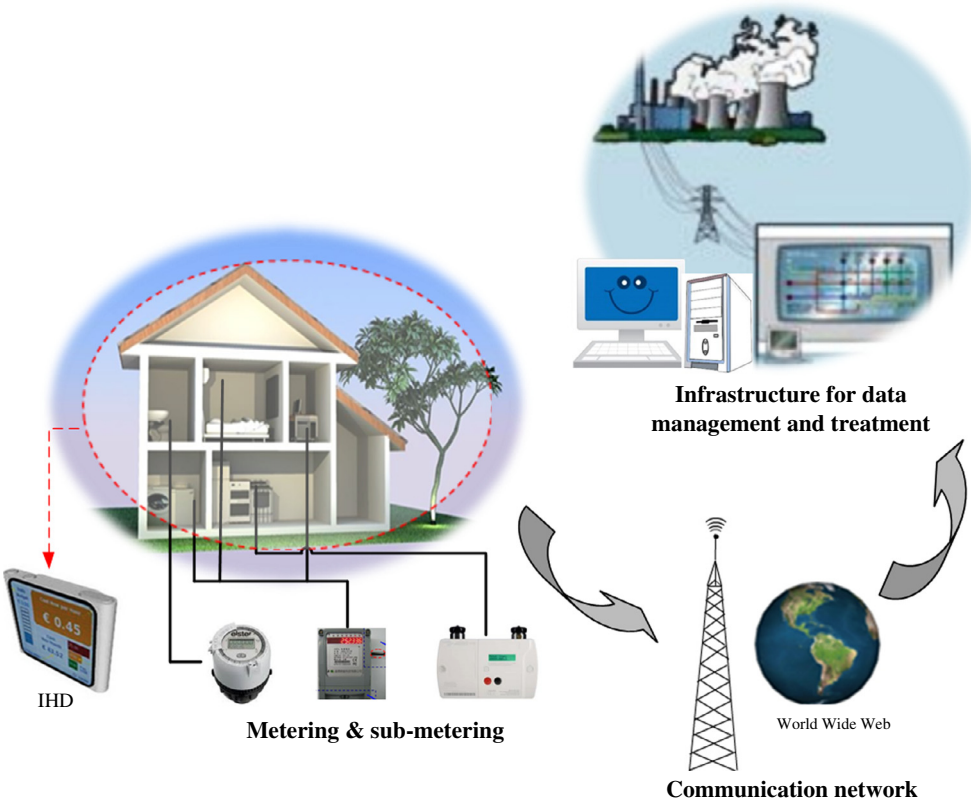

Fig. 1. Smart meter system architecture.