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# Household valuation of smart-home functionalities in Slovenia

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The paper analyses consumer willingness to invest in a smart home and attempts to establish willingness to pay for various smart-home functionalities among Slovenian households in 2013. The estimated results suggest that consumers positively perceive energy and security related smart-home functionalities, though willingness to pay (WTP) for any particular functionality is not found to be very high. In comparison to stated WTP, current market prices are mostly too high to expect higher penetration rates of smart home devices in the very near future. Household income, technology progressiveness, and energy conservation habits are found to positively influence purchases of smart-home functionalities.



## 1. Introduction

Liberalisation, deregulation, and EU energy strategy have dramatically changed the electricity sector and caused the field of electricity services to evolve rapidly in the past two decades. The legal framework for opening up electricity markets of the EU member states was provided by two Electricity Directives (96/92/EC and 2003/54/EC). The main goal of electricity market deregulation was to separate the competitive functions of generation and retail services from the natural monopoly functions of transmission and distribution. This has changed the traditional supply chain by forcing both electricity generation and purchasing to become legally independent from system network operation (Thomas, 2006). Liberalisation of electricity market has increased competition (Nazarko et al., 2005), by allowing end-consumers to freely choose their electricity supplier. The residential electricity market was wholly introduced in the EU in the middle of 2007, causing a dramatic change in the relationship between former utilities and customers. Boundaries between markets that were once discreet are slowly blurring.

Another important driving force of change in the EU electricity market in recent years has been the promotion of energy efficiency. In 2010, the EU adopted a new energy strategy (EC, 2010), where efficiency is listed among top priorities. According to the strategy, improving energy efficiency is viewed to be one of the most cost-effective ways of achieving sustainability, increasing the security of energy supply, and enhancing industry competitiveness. Member states, according to projected trends, are expected to deliver 20% savings in energy consumption by 2020 (Directive, 2012/27/EU).

In the attempt to achieve these objectives, a greater integration of information and telecommunication systems into electricity grids is essential (Gerpott and Paukert, 2013). This commonly refers to the concept of a Smart Grid, which aims to improve the reliability, quality, and efficiency of electricity services. On the residential side of the distribution grid, the Smart Grid concept includes smart metering, smart thermostats, smart appliances, demand-response programs, and home automation (Harper-Slaboszewicz et al., 2012; Lakota Jeriček et al., 2010; Strbac, 2008).

Smart homes are seen as a key component of smart grids, as without them, the functionalities and capabilities offered at the network level will not be fully realised by residential consumers (Balta-Ozkan et al., 2013a). Realising the potential that the residential sector holds for energy savings may be compromised if aspects of consumer value and acceptance are disregarded (Kaufmann et al., 2013).

While many consumers understand the concept of energy efficiency, their use of energy tends to be driven more by their desire for comfort and convenience, or by financial savings, than by concern for effects on system costs or emissions reductions (Hauser and Crandall, 2012). The ecological benefit is commonly perceived as a positive side effect of efficiency; this makes consumers feel good and indicates their green conscience, but for most people it is not sufficient as the sole reason to make a purchase (Mert et al.,

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2008). Chamberlin and Herman (1996) noticed this tendency almost two decades ago and suggested that demand-side management programs, which include demand-response programs as well as efficiency and conservation programs (Gellings, 1996; Prindle and Koszalka, 2012), should be accompanied by value-added services that increase comfort and enhance convenience in order to motivate consumer participation. Nair and Zhang (2009) saw the chance for new services based on Smart Grids in the fields of remote metering, remote control of appliances, and real-time monitoring of homes to enable better care for the elderly and other vulnerable groups. Harper-Slaboszewicz et al. (2012) further implied that home-automation and demand-response vendors could couple their services with other services (such as home security systems, internet connections, and cable television) to become more attractive for consumers and vendors offering a suite of services.

Several studies forecast a rapid growth of the smart home market by 2020; some predict up to three times market expansion (European Smart Homes and Assisted Living Market, 2011; Global Smart Thermostats Market, 2014–2018, 2014; Smart Homes and Home Automation, 2013). Even though some see integration of communication technologies from every nook of the home to the smart grid as something inevitable, there may be a wide gap between what consumers actually want and what the smart-home industry and utilities expect consumers to do (Harper-Slaboszewicz et al., 2012). The latter are expected to install a home automation system and gradually transition to a smart home by investing in smart electrical devices, including appliances, or retrofitting existing ones with add-on functionality. Besides investment costs, paying attention to dynamic electricity prices and/or setting rules for how and when their smart appliances and devices will respond in different situations require consumers to devote more time to energy consumption. On the other hand consumers (presumably) seek for products and services that will increase their comfort, enhance convenience and/or to lower their energy bills in exchange for the former. Since there is still a lack of knowledge of consumers wants, the objective of this paper is to determine preferences for smart-home functionalities in terms of energy efficiency and security among Slovenian residential consumers and to establish their willingness to pay for each of these functionalities.

The hypothesis tested is that WTP is positively related to functionalities and respective services provided by smart meters, while consumers may prefer certain functionalities over others. In addition, WTP is also hypothesized to vary across consumers with different socio-economic characteristics.

The paper is structured as follows. Section 2 explains the smart home concept and briefly reviews related literature. Section 3 outlines the methodology in three steps, namely the survey design, data description, and models used. Sections 4 and 5 present results and draw conclusions, respectively.

## 2. Background and related studies

A smart home can be defined as a residence equipped with high-tech household devices, appliances and sensors that can be remotely accessed, monitored, and controlled and that provide services that increase comfort, energy efficiency, and security (Balta-Ozkan et al., 2013b; Chan et al., 2009; Frances, 2003). Smart-home technologies are therefore able to monitor equipment performance, optimize comfort and efficiency, and convey environmental performance as well (Hauser and Crandall, 2012).

Balta-Ozkan et al. (2013a) categorise types of smart-home services based on the user needs they target or types of technical application. Accordingly, they identify the following subsets of services: energy efficiency, security, communication, assisted living, health, convenience and comfort, and entertainment. As shown in Fig. 1 these services can be further grouped into three broad and complete yet interconnected categories, namely energy consumption and management, lifestyle support, and safety. Among the above-mentioned services, it is argued that energy consumption and management services will form the core services supporting the development of smart grids. Thus in our research we focus primarily on this group of services, including also security as well as convenience and comfort services. Furthermore, electricity suppliers can offer these services to residential consumers as complementary products and services to electricity supply and/or to motivate consumers to participate in demand-response programs.

Smart meters play a key role in making homes smarter and more efficient (Smart Homes and Home Automation, 2013). They serve as a main component of smart-grid infrastructure at the consumers' end, linking the grid system with the home (see Fig. 2). This provides a gateway for various smart home services by communicating data across different devices and technologies within homes, including energy displays, thermostats, lighting controls, smart appliances (e.g., refrigerators and washing machines), energy generation (e.g., photovoltaic and wind) and storage (e.g., battery appliances and heat pumps) on consumer premises, plug-in electric vehicles, and energy-management systems (Balta-Ozkan et al., 2013a).

Regarding to the main objectives of this paper, we focus on functions and services that smart metering and smart home provide to end consumers, irrespective of technical implementation, which may require them to be provided by one or more devices/gadgets; we thus refer to them as "**smart functionalities**." For more details on technical features see, for example, Mohsenian-Rad and Leon-Garcia (2010) or Rashed Mohassel et al., 2014.

Until now, the smart-home concept as a whole was mostly discussed from an engineering or technological perspective (Kühnel et al., 2011; Li and Yu, 2011; Reinisch et al., 2011). On the other hand, an extensive corpus of literature focuses on energy efficiency and conservation gains from the introduction of smart metering and the various energy-management options that it enables, such as demand-response programs and consumption-feedback services. Numerous pilot projects have shown that real-time energy consumption feedback via In-Home Displays (IHD) can contribute on average from 2% to 18% energy savings (Faruqui et al., 2010; Gans et al., 2011; Raw and Ross, 2011). By combining IHDs with historic feedback, simple energy efficiency advice, or

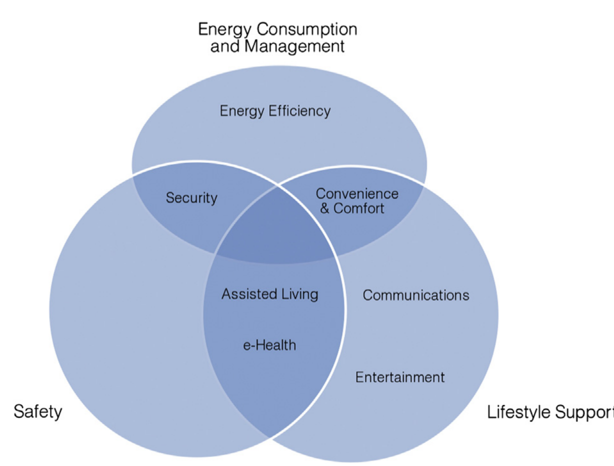


**Fig. 1.** Types of smart home services; Source: (Balta-Ozkan et al., 2013a).