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Gamification-based framework for engagement of residential customers in energy applications

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ABSTRACT

According to the European Union Third Energy Market package, the roll-out of smart meters in the residential sector can presumably play a key role in reaching the goals of sustainability strategies. However, the deployment of smart meters alone does not necessarily drive residential customers to use energy in a more sustainable manner. Therefore, more attention should be paid to customers energy behavior in order to reach the objectives of the roll-out policy. In this study, we propose an interdisciplinary framework that establishes a behavioral model to identify the main energy-related behavior change requirements necessary to engage residential customers in energy applications. To fulfill the requirements, we first present the technical system architecture that enables energy applications for residential customers. Then, we assess how gamification, which is the employment of game design elements in non-game contexts, can be used to enhance energy applications by driving customer engagement and energy-related behavior change. To do that, the most relevant game design elements are discussed and classified. After that, the expected value streams from using a gamification-based solution for different stakeholders in the energy market are identified. Finally, the study discusses the potential of the proposed framework in different energy applications for residential customers.

1. Introduction

The European Union (EU) has set an ambitious energy policy objective to achieve by 2030 represented by three main targets: a 40% cut in greenhouse gas emissions compared to 1990 levels, a 27% share of Renewable Energy Sources (RESs), and 27% energy savings compared with the business-as-usual scenario. Empowering consumers, as key players in the energy market, is declared as an explicit strategic goal in order to reach these targets [1–3]. This includes improving the provision of information on energy consumption and increasing the awareness of consumers in the metering and billing of energy.

Essential to the achievement of these targets is the transformation of Europe's conventional electricity grids into so-called *Smart Grids* that are characterized by bidirectional flows of electricity and information between power plants and appliances, and all points in between. Smart metering systems roll-out is at the core of this transformation since smart meters are fundamental in monitoring the performance and energy use characteristics of the grid load, and provide the required infrastructure to support energy management services [4–6].

The EU Recommendation 2012/148/EU [7] deeply focuses on the roll-out of smart metering infrastructure stating that at least 80% of residential customers in the EU member states should be equipped with smart electricity meters by 2020, unless a different decision is taken by a member state based on the results of a cost-benefit analysis (CBA) [8]. It is expected that the use of smart meters will create a value proposition for different stakeholders and lead to more participation of residential customers in the electricity supply market. The recommendation explicitly states that active participation of residential customers in the efficient planning and use of electricity is one of the EU main smart meters roll-out policy objectives.

Nevertheless, it is still uncertain whether the deployment of smart meters alone will have a direct impact on residential customers energy-related behavior. It has been discussed in the literature that engaging customers is a critical factor for the success of smart grids [9–11]. Therefore, it is complementary to the roll-out policy to identify what is required for customers energy-related behavior change in order to achieve an active participation and engagement in the energy system. Motivation techniques from the uprising research area of *gamification* can play a key role in achieving this goal. Gamification addresses the features of an interactive system that aims to motivate and engage users through the use of game design elements [12,13]. It has been emerging as a compelling and effective engagement tool in almost every field including education, business, human-computer interaction, technology adoption, sustainability, health care, and transport. One example is the

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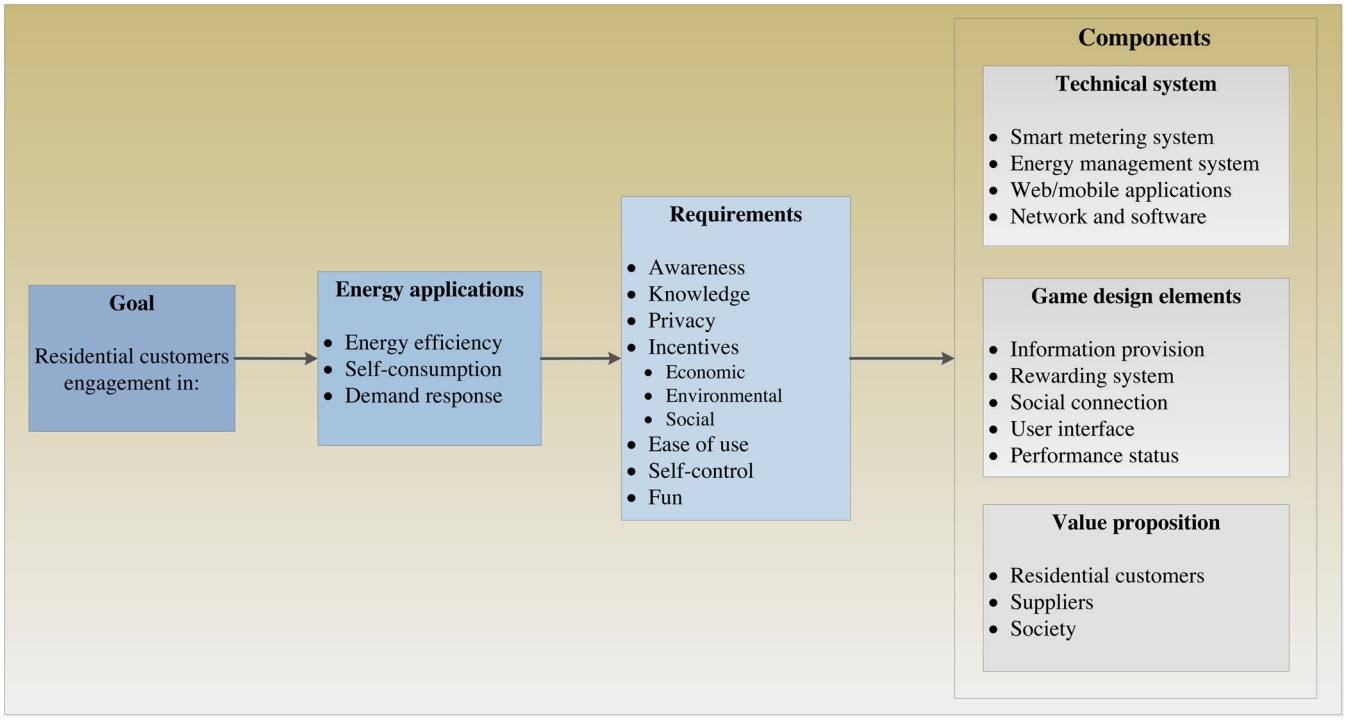

Fig. 1. Conceptual diagram of the proposed framework for gamified energy applications.

social rewarding system used in transport strategies to promote eco-driving [14]. Some major car manufacturers have developed interfaces in this direction. For instance, in Ford's "Ecoguide", green leaves appear on the screen and increase in number as driving behavior becomes more pro-environmental. In Nissan's "Leaf", there is a system of a network of drivers that compares driving styles and offers high-scores for the most energy efficient drivers.

Recently, gamification has also emerged as a tool for increasing residential customers engagement in energy systems through targeting a wide set of motives that a customer may have, including economic and environmental motives, as well as social motives, such as learning and contributing to the community [13,15–19]. For instance, the effect of passive versus interactive, gamified information [18], and the potential of serious games [19] on the antecedents of behavior change have been assessed using the context of solar energy adoption among residential customers. While interesting, some of these gamification-based solutions are designed to run for a limited period of time (e.g., weeks or months) [15–17], or to achieve a certain target (e.g., adopting solar energy production in hosueholds) [18,19]. We argue that when gamified interaction with participants is run for a limited period of time, it is not clear whether the change in participants behavior would be sustained following the completion of the game. For example, in the Energy Battle game [16], only few participants continued to lower their electricity consumption, while others used more electricity than before the game. Other solutions have been developed before the roll-out of smart meters and, thus, the interaction process is not fully automated and/or isolated from the energy system [15–17]. For instance, in [16], residential customers were required to upload their energy consumption data manually to an on-line platform for analyzing their energy consumption behavior.

Based on the above-mentioned observations, this paper introduces a framework that establishes a behavioral model to identify the energy-related behavior change requirements necessary to engage residential customers in the energy applications enabled by smart meters. The proposed framework considers a distinction between the technical, economic and behavioral components that are necessary to fulfill those requirements. It is generic and applicable for any location or country where smart meters are deployed. The main energy applications where residential customers can be engaged and play an active role are: (i) *Energy Efficiency*, (ii) *Self-consumption* and (iii) *Demand Response (DR)*. These applications are all part of the wider term *Demand Side Management (DSM)*. DSM is defined as "the planning, implementation, and monitoring of distribution network utility activities designed to influence customer use of electricity in ways that will produce desired changes in the load shape" [20,21]. In practice, these applications can be offered by energy suppliers to retail customers in the energy market in the form of (optional) programs with voluntary subscription. However, residential customers have limited awareness and knowledge about those programs, and thus their understanding and level of engagement in energy applications is relatively low. The proposed framework presents the technical system architecture that enables these applications, classifies the most suitable game design elements to engage residential customers in each application, and identifies the value streams to different stakeholders in the energy market when using a gamification-based solution, including residential customers, energy suppliers and society in general. It aims to offer different actors, such as suppliers, academic institutions, solution providers and public bodies, a unified view about a gamification-based solution for achieving an active participation and engagement of residential customers in the electricity supply market.

The paper is structured as follows. The methodology of the study is provided in Section 2. In Section 3, the key requirements for energy-related behavior change are identified. The system components needed to fulfill these requirements are presented in Section 4. Section 5 discusses the potential of the proposed framework in each energy application. Finally, conclusions are provided in Section 6.

2. Methodology

The methodology of the proposed framework is divided into three steps. The first step is to identify the main energy-related behavior change requirements that are needed to engage residential customers in energy applications. The second step is to define the components needed to fulfill these requirements, which includes technical,