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Electronic feedback as a tool for changing households energy consumption

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Summary. Reducing energy consumption and its impact on the environment is one of the priority objectives of the European Union. Activities aimed at increasing energy efficiency in the household sector are of particular importance in achieving this goal. The aim of the article is to present tools used to inform consumers about household energy consumption and a review of literature in this field. A review of research conducted in recent years indicates that providing information on energy consumption may lead to changes in behaviour. Nonetheless, other activities aimed at engaging consumers and educating them on the subject of possible ways to reduce energy consumption are necessary.

Introduction

In recent years, both international institutions and national governments have been paying more and more attention to the need of reducing energy consumption and associated harmful emissions. Sustainable energy is part of the concept of sustainable development, defined by WCED (1987) as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs”. The concept of sustainable development draws attention to the need to take economic, social and environmental issues into account equally. In the case of sustainable energy, attempts are being made to determine the essence of this concept, which is important because very often the issues of sustainable energy are mainly addressed from the per-

spective of the use of renewable energy sources. What can result in narrowing the consideration only to the issue of obtaining energy from renewable sources and omitting or reducing the importance of including consumption for achieving energy balance. For example, the Energy Efficiency Act (Dz. U., 2016) indicates a series of activities and obligations forcing various entities to increase energy efficiency, bypassing measures aimed at increasing the awareness of end-users. What is so surprising that, especially that „in 2015, the households or residential sector represented 25.3% of final energy consumption or 16.8% of gross inland energy consumption in the EU” (Eurostat, 2017). Taking the raised issues into account, the definition of sustainable energy adopted by Prandecki (2014, pp. 240) as “a conversion of primary energy into electricity and heat and its delivery to the end user in a way that enables meeting the needs of present and future generations taking into account economic, social and environmental aspects human development” seems appropriate. The above-mentioned definition considers both social, economic and environmental aspects and draws attention to the importance of satisfying the needs, an important but often neglected part of demand side of the energy market. Considering the high importance of energy consumption in the household sector and the need to raise consumer awareness in this area, the author decided to focus on this aspect of energy sustainability.

The aim of the article is to present tools for informing consumers about household energy consumption (with focus on smart meter feedback) and review of works considering their impact on changing energy behaviours. The basic tool used for the study was the analysis of available domestic and foreign literature. The paper will outline the issues related to energy efficiency in the household sector and information-based tools designed to promote actions to increase it.

1. End-user energy efficiency measures in European Union

The efforts to reduce energy consumption and its impact on the environment are one of the overriding, measurable objectives adopted by the European Union in both the short and long term. The priorities set in the outlooks for 2020, 2030 and 2050 relate to reducing greenhouse gas emissions, obtaining energy from renewable sources and increasing energy efficiency (EC, 2018). Article 12 of the Energy Efficiency Directive includes measures in the field of consumer information and empowering programmes. These activities were left to individual Member States with an indication of possible actions in two highlighted areas (EU, 2012):

- a) promoting behavioural change, e.g. through:
 - tax incentives,
 - access to financing,
 - providing information,
 - exemplary projects,
 - activities at the workplace;

- b) engaging consumers and consumer organizations in the promotion and proliferation of smart meters by informing about:
 - cost-effective and easy-to-achieve changes in energy use,
 - possible measures in the field of energy efficiency.

In the report summarizing and assessing the implementation of the Energy Efficiency Directive, attention was drawn to the importance of proper information in increasing energy efficiency in the household sector. The particular significance of the information was emphasized especially in the case of such phenomena as:

1. The energy efficiency gap – this phenomenon is defined as the slow adoption of solutions allowing for greater energy efficiency. There may be many reasons for this behaviour of residents, including risk aversion, lack or incomplete information about potential benefits, problem with assessment both of necessary costs and possible benefits, etc.
2. The rebound effect – the phenomenon of increasing the total energy consumption due to replacing the old appliances with a new, more effective ones. Unfortunately, this is a phenomenon that is difficult to measure and of which consumers are often unaware, indicating the need for information and promotion activities in this area.
3. Free riding – when a given tool (usually financial or fiscal) is used by an entity that would still take action related to increasing energy efficiency (e.g. renovation or thermalisation of the house) without additional incentive, which reduces the chances of activating entities that require additional incentives.
4. Free drivers – a phenomenon similar to the previous one, but with a definitely more positive overtone – entities that do not take advantage of incentives by themselves, start to act on their own as a result of increased awareness resulting from information about available programs.
5. Discounting uncertainty – uncertainty about future energy prices and potential benefits related to investment costs needed to obtain future savings may be a significant problem and one of the reasons for overestimating or underestimating future benefits, which may translate into deepening the energy efficiency gap.

Considering the differences and asymmetry in access to information and the potential impact on consumer decision-making, it is necessary to emphasize the great importance of undertaking information, education and promotion activities. Way in which and when the information is passed on to consumers should also be considered. Too much information on a given topic, instead of making decisions easier and encouraging behaviour change, can have the opposite effect (Kos-Labędowicz, 2015). The moment of consumer exposure to information is just as important. Taking the above reservations into account, the information-based instruments for promoting energy efficiency will be presented next.

2. Information-based instruments for promoting energy efficiency in household sector

There are several types of information-based instruments that can be used to foster energy efficiency in the residential sector. Those include (Ramos, Gago, Labandeira, Linares, 2015):

1. Energy certificates and labels – this type of instruments is most often used to highlight the energy efficiency of buildings, vehicles and household appliances. It takes the form of a sign/label placed on products from various categories, depending on the country and the certifying authority it may be compulsory or voluntary. Certificates and labels have been designed to help consumers make decisions aimed at sustainable and efficient use of energy by providing the information they need in a simple and understandable way. A good example of this type of instruments is the Energy Star program launched in 1992 by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The purpose of this international program (e.g. in 2000 the agreement on the applicability of signs has been signed by the EU) is to provide consumers (individual and business) with information allowing to reduce expenses and harmful emissions (EC, 2017).
2. Energy feedback – that is, informing consumers about the energy consumption in the household and incurred costs. Very often, consumers are not aware of how activities that they perform on a daily basis using various home appliances translate into electricity consumption and associated costs. Energy consumption is secondary to the activities performed. Providing consumers with information on how daily, routine activities translate into energy consumption (and bill) can become an impulse to convert behaviours into more effective ones. Feedback usually takes two forms:
 - a) energy bills with comparative information – that is, bills where the consumer receives information not only about their energy consumption, but also about how it compares to other users consumption (introducing the effect of social pressure);
 - b) smart meters – devices installed in houses/flats that improve the operational efficiency of the power grid and enable using available options, such as in-home displays (IHD), access to the information on energy consumption in different time intervals (Krishnamurti et al., 2012).
3. Energy audits – that is, providing the consumer with personalized information aimed at reducing energy consumption by an external expert. By adapting to specific conditions and taking other factors than just energy consumption into account (e.g. condition of electrical installation, building insulation, type and age of household appliances used) this tool potentially has the greatest impact on increasing energy efficiency. However, it involves several problems, e.g.

higher costs, imposing solutions by an outsider, the need to support the initiative and supervise experts by the energy supplier or the state administration (Murphy, 2014).

Selected research on information transfer and consumer energy consumption, with particular focus on the use of real-time information from smart meters and IHDs will be discussed next.

3. Real-time feedback as a tool for improving energy efficiency in household sector

Providing information on real and current consumption of energy to consumers is seen as a promising tool for reducing energy consumption. Modern smart metres with in-home displays (IHDs) or Smart Energy Monitors (SEMs) provide customers with real-time, detailed information about energy use and cost. These differ from monthly bills, which, although they can also be delivered in electronic form, only inform about aggregate consumption and costs (Lynham, Nitta, Saijo, Tarui, 2016).

The use of energy in the household sector changes cyclically and depends on such external conditions as the climate or the season. In addition, there is the daily cycle, with greater consumption in the morning, before going to work, and in the evening, after returning from work (when large part of housework, such as cooking, dishwashing, laundry and using household appliances for recreational purposes takes place). The progressing implementation of smart meters in EU countries in recent years allows conducting research based on real data on electricity consumption. Selected research on the subject of changes in energy behaviours potentially resulting from consumer feedback is presented in Table 1.

The reviewed researches show the effectiveness of particular tools indicating that usually the mere transfer of information is enough to achieve certain effects (Dulleck, Kaufmann, 2004; Schleich, Klobasa, Götz, Brunner, 2013). Nonetheless, for achieving specific goals combining several types of instruments is more effective. For example, both Weber, Puddu & Pacheco (2017), as well as Bradley, Coke & Leach (2016) showed that information combined with additional incentives (e.g. participation in a contest, monetary incentives, access to electricity monitoring equipment) is more effective both in the case of reduced consumption and displacement of consumption to the off-peak time.

Table 1. Review of researches dealing with electronic feedback on household Energy consumption

Authors	Method	Aim	Results
Hargreaves, Nye & Burgess (2013)	field experiment & interviews	checking if the impacts of feedback from SEMs durable over time	the initial knowledge helps to change the behaviour, but the newly achieved "baseline" for the now considered normal level of consumption is harder to change
Oltra, Boso, Espluga & Prades (2013)	Field experiment, focus groups, interviews & diaries	identifying the reasons for a variation in the influence of feedback from IHDs on energy consumption	the observed variation depends on factors as user's involvement with the IHDs, user's motivation to save energy and prior attitudes and level of involvement generated by the intervention
Carroll, Lyons & Denny (2014)	field try	investigating the role of feedback in changing household energy usage	it is possible that feedback and other information serve as a remainder and motivator for changing (reducing) energy demand
Gölz & Hahnel (2016)	field trial & interviews	examining the underlying goals behind the use web-based feedback about electricity consumption	end-users follow multiple goals toward using feedback; cluster analysis and profiling of the end-users basing on their goals was possible
Lynham, Nitta, Saijo & Tarui (2016)	field experiment	why IHDs change energy-use behaviour, checking for learning effect and saliency effect	the change was observed, but it was not statistically significant; learning effects proves to be more important than saliency effect
Chen, Delmas, Locke & Singh (2017)	field experiment	testing effectiveness of information strategy based on environment and health impacts or monetary savings for reducing electricity consumption	the environmental/health strategy proved to be more effective in terms of electricity usage reduction and higher frequency of accessing data about electricity usage
Foulds, Robison & Macrorie (2017)	netnographic analysis of online discussion & in-depth interviews	investigating how households interact with monitoring energy consumption and how (if) it changes their behaviours	it turned out that decisions about energy-related changes usually preceded monitoring, which was then used as a tool to than achieve that change
Schleich, Faure & Kobasa (2017)	field trial	estimating the effect of providing feedback in addition to smart metering devices	feedback effected an electricity consumption reduction that was persistent for a longer period of time (11 month) that suggests that feedback changes the users' behaviour

Source: own work on the basis of literature review.

Conclusions

The analysis of instruments aimed at ensuring energy efficiency should take the behaviours and reactions of end-users to the implemented activities into account. Consumers' willingness to take more energy-efficient actions and to accept technological solutions such as smart meters is of great importance for achieving the assumed goals of energy efficiency policy (Broberg, Persson, 2016). It should also be noted that the mere transmission of information on energy consumption may not be enough to change behaviours in the long run (Buchanan, Russo, Anderson, 2015). The context in which information is conveyed and the type of provided feedback (qualitative or quantitative) is of great importance (Kendel, Lazaric, Maréchal, 2017). It is equally important to provide information on potential ways of action that may reduce current energy consumption and to create and sustain consumer engagement in these activities (Burchell, Rettie, Roberts, 2016).

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ELEKTRONICZNE INFORMACJE ZWROTNE JAKO NARZĘDZIE ZMIANY ZUŻYCIA ENERGII W GOSPODARSTWACH DOMOWYCH

Słowa kluczowe: zużycie energii, zachowania energetyczne, sektor gospodarstw domowych, elektroniczne informacje zwrotne, inteligentne liczniki, UE

Streszczenie. Zmniejszenie zużycia energii i jej wpływ na środowisko są jednym z priorytetowych celów Unii Europejskiej. Szczególne znaczenie dla osiągnięcia tego celu mają działania skierowane na zwiększenie efektywności energetycznej w sektorze mieszkaniowym. W artykule przedstawiono narzędzia służące informowaniu konsumentów o zużyciu energii w domach oraz przegląd literatury z tego zakresu. Przegląd prowadzonych w ostatnich latach badań wskazuje na to, że przekazywanie informacji o zużyciu energii wpływa na zmianę zachowań. Nie mniej konieczne są inne działania ukierunkowane na angażowanie konsumentów oraz ich edukowanie w temacie możliwych sposobów redukcji zużycia energii.

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Cytowanie

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