



EMPOWERING SMALL ELECTRICITY CONSUMERS TO HELP EUROPEAN MEMBER STATES TO REACH THE ENERGY EFFICIENCY TARGETS OF THE EUROPEAN UNION

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KEY WORDS

*Energy Efficiency
Smart
Meter
Open
Innovation
Green Button*

ABSTRACT

In Europe, small electricity consumers are not using the full potential offered by smart meters. Although the European Union requires Member States to provide consumers with their energy usage data, small consumers are not using this data for improving their energy efficiency. This paper proposes: first, the standardization of the electrical load curve offered to small energy consumers at European level. Second, the use of open innovation challenges as a policy instrument in the European Union to improve the energy efficiency of the small electricity consumers and to encourage the development of new market niches. Finally, the paper quantifies how ICT energy efficiency solutions for small electricity consumers can contribute to the achievement of the 2020 European Union energy efficiency targets.

1. Introduction

The Third Industrial Revolution by Jeremy Rifkin relates how the great industrial revolutions occurred when new forms of energy converged with new ways of communication. Rifkin predicts that the Third Revolution will come when information and communications technology (ICT) will converge to renewable energy, supported by efficient methods of energy storage and new forms of transport such as electric vehicles. Furthermore, the development of the "smart grid" will allow consumers to become "prosumers", resulting in the development of a collaborative energy (Rifkin, 2011).

Moreover, the large investment in smart metering is not justified if they are only used for generating more accurate invoices. Customer engagement in smart meter data is the key to enabling behavioural demand response, dynamic pricing and other measures to help them to be more efficient (*Hartman and LeBlanc, 2014*).

A study on energy prices in Europe made in 2014 by VaasaETT, indicates that residential electricity prices are at their highest and that they have been on an upward trend since 2010. The study also points out that electricity consumers are missing out savings opportunities on their energy bills by not changing supplier (*Dromacque et Grigoriou, 2014*).

The electricity consumption of households accounted for 29% of total consumption in the EU-28 in 2012 (EEA, 2017). By contrast, residential consumers are often perceived as a customer segment where it is difficult to implement energy efficiency programs because of their large numbers, diversity and low consumption when taken individually, and because they perceive energy as a low-interest product. However, in competitive markets, energy suppliers see programs that provide detailed information on energy consumption and information to reduce consumption to the residential customer, as a way to differentiate their offers, not compete on price and establish a relationship of trust with the consumer (Dromacque et al., 2013)

Additionally a survey conducted by IBM among over 10,000 people from 15 countries

reveals that most consumers do not understand the concepts used by energy providers to adjust rates of energy and over 60% do not know the concepts of "smart grid" and "smart meter ". This study also detected a significant gap between the knowledge of consumers and that they should have to take advantage of the new smart energy initiatives (IBM, 2011). Another survey conducted by Accenture in 2009, indicates that 71% of consumers reported that the reason why new products fail, is because they are unable to find a new value proposition to them (Britt et al., 2011).

Technologies such as Big Data and Cloud Computing enable to analyze cost-effectively the large amounts of data generated by smart meters. For example, Opower¹ (*Laskey et Kavazovic, 2011*) combines Big Data and Cloud technology in order to provide utilities comparisons between millions of customers, breakdowns of consumption by type of load, multichannel offerings based on the customer load curve and which have been accepted by similar customers, use of historical data to calculate what is the best rate for each client and perform standardized client comparisons.

2. Methodology

We have conducted most of our research online. In order to search for articles, we have used scientific databases such as Scopus, Web of Science or IEEE Xplore. We sought ICT tools and pilots between firms reporting the use of the electrical load curve provided by a smart meter as an input of their solutions and open innovation challenges aiming at improving energy efficiency. Monitoring the compliance with the European Directive 2012/27 by member states has been made based on documents published by the European Union. We have also used documents issued by the government of the United States of America.

3. Results and Discussion

The residential sector accounts for 17% of primary energy consumption in the EU and 25% of final energy consumption, estimating a potential energy saving of 27% (*Filippini et al., 2014*).

In order to achieve the 2020 objectives set by the EU, it is necessary to include a reduction of energy consumption in the residential sector. Schaffrin & Reibling after studying energy practices in the residential sector, propose solutions in three areas: energy policies that take into account the lowest incomes, standards of insulation and progressive taxation as consumption increases (*Schaffrin and Reibling, 2014*).

On the other hand, the report prepared by Ricardo-AEA shows how the member states have articulated Article 7 of the European Directive 2012/27. The directive establishes a system of Energy Efficiency Obligations (*Appendix A*) that each state shall establish and the alternative measures to the system of obligations that a member state can implement to achieve final energy savings for end- users. In the Ricardo-AEA report, we observe that so far, no member state has implemented any ICT measures based on the analysis and enhancement of the electrical load curve for improving the energy efficiency of the small energy consumer (*Forster et al., 2016*).

Open Innovation, term promoted by Henry Chesbrough in 2003 (*Chesbrough, 2003*) is a strategy used lately to develop innovative energy solutions. Green Button has been born as an open innovation challenge launched by the White House in 2011 to offer consumers their energy data in a standardized, simple and easily processed format by a computer (*Sayogo et Pardo, 2013*). With over 60 million customers with access to Green Button in the United States of America and with 2.6 million in Canada, we can say that the Green Button standard is a reality with increasing support from utilities and ICT companies. The access to the standardized load curve enables third parties and software developers to receive information collected by smart meters, with the permission of the consumer, and transform it into useful information for consumers (Lewis et al., 2012). Furthermore, in January 2014, the French Ministry of Economy has commissioned to Philippe Lemoine to draft a report for the digital transformation of the French economy entitled "*La transformation numérique de l'économie française*". In this report, published in November 2014, the "Green Button" is identified as one of

the nine measures to be implemented in the short term (*Lemoine, 2014*). Additionally, energy is one of the areas proposed for winning the future of the US through Open Innovation (*Chopra, 2011*). One example of this new policy instrument is the "Apps for Energy" challenge of the United States Department of Energy (*Mergel et Desouza, 2013*).

The challenge is to offer energy services to consumers at the lowest cost rather than selling kWh, which in many cases means lower environmental costs. Thomas Edison, the inventor of the light bulb, already wanted to sell energy services instead of kWh. His vision was that consumers would pay for the number of light bulbs instead of the kWh consumed (*Sioshansi, 2013a*)

Nowadays ICT energy efficiency services for small electricity consumers are already available, but not widely used in Europe. Some examples are:

- **Load Curve Analysis:** extracting value from the load curve and presenting the results in a user- friendly and easy to understand front-end, helps customers to understand their energy behaviours, and hence they are able to change their energy habits and be more efficient. One example is **Compass**, a tool that offers different types of energy reports to homeowners such as: disaggregated energy usage, peer comparison, energy assessment, benchmarking and helpful reports for the contractors that install the energy conservation improvements (*Trehubenko et Schmidt, 2011*). Another example is **UnPlugStuff**, a tool that helps energy end-users to identify how much energy the home is wasting (idle loads) when the house is unused. It helps reduce bills and green house gases (*Chopra, 2014*).
- **Tariffs Recommendation:** dynamic tariffs such as "Inclining Block Rates (IBR)", "Time-of-Use (TOU)", "Critical Peak Pricing (CPP)", "Critical Peak Rebate (CPR)", "Real-Time Pricing (RTP)" (*Stromback et al., 2011*) are tools for modifying consumption patterns in small energy consumers. Processing the load curve allows advising the end customer on which tariff best suits their habits, the calculation of savings obtained accurately and personalized based on the different rates available or even

offering support and assistance in modifying spending habits in order to adapt to a new tariff. These possibilities are aligned with the recommendations made by the adoption of dynamic tariffs (Kowalska-Pyzalska et al., 2014). One example is **PEV4me**, a tool that recommends a utility rate plan based on the Green Button data file with at least one year of usage and questions such as: type of electric car, average miles driven by day, start time of charge and charge level (ACORE, 2014).

- **Disaggregation:** every appliance when turned on or off leaves a fingerprint and when the sampling frequency of the load curve is in the range of 0,01Hz- 1Hz or higher, it allows appliance recognition. The disaggregation of energy use by appliance allows peak analysis (Hartman and LeBlanc, 2014), automated personalized recommendations, segmentation for energy efficiency marketing and better program evaluation (Armel et al., 2013). One example is **Bidgely**, a tool that uses energy disaggregation to show energy end-users the consumption of each appliance (Chakravarty and Gupta., 2013). This allows the offering of personal tips for improving efficiency, comparing the efficiency of appliances with other neighbors and offering effective communication during peak demand reduction events. The data is downloaded in Green Button format from the utility or from the Home Area Network (HAN). Energy end-users exposed to Bidgely consumed 6% less energy, mainly due to behavioural change.
- **Budgeting and Target Savings:** the consumer must be able to set consumption targets and the analysis of load curve should allow to send an alert when energy usage trends are no longer on track to achieve the goal (Hartman and LeBlanc, 2014). One example is **WegoWise** (Yassine et al., 2015), a tool that helps the energy end-user to manage the utility data, track the energy usage, benchmark energy usage for improving efficiency, quantify the savings potential, identify spikes in usage, measure and verify savings, custom analysis and reporting and data sharing with other WegoWise users.
- **Behaviour Energy:** consumption comparisons with standardized patterns, allow the modeling of consumer behaviour and save energy (Cialdini and Schultz, 2004). For example, comparing the energy usage of a consumer to the average consumers of their city having a similar profile and with the average of the 20% most efficient consumers in the city. One example is **Opower Social**, a web-based tool to compare a customer energy use against friends or against a national average of similar homes across the country, share and discover energy saving tips, compete with friends and participate in energy reduction challenges (Grossberg et al., 2015). Another example is **C3 Residential (C3IoT)²** (Yassine et al., 2015), an engagement application that educates residential customers about energy efficiency and helps them to stay motivated while saving energy. It also helps customers to achieve energy savings goals.
- **Gamification:** a new trend in the energy sector to achieve energy savings in a wide range of consumers (Damji et al., 2013). It consists of using games, fun and friendly competition to provide a new customer experience that fosters energy efficient consumption habits, while allowing loyalty and resolving consumer energy problems. Furthermore, games can encourage positive behaviour change and motivate consumers to save energy (Grossberg et al., 2015). One example is **Leaffully**, a tool to track customer energy usage over time in order to reduce its energy footprint. It transforms energy bills and energy usage into something that everyone can understand: environmental impact in terms of trees. It also has other features such as showing alerts, trends, energy peaks, base load and an energy saving calculator (Grossberg et al., 2015)
- **Demand Response (DR):** these programs are encompassed within Demand Side Management (DSM) programs and try to stabilize the electrical grid by balancing supply and demand. In order to achieve these goals, smart appliances or behavioural changes in final consumers are used. One example is **DRIVE System**, a Demand

Response solution that provides incentives (points or air miles) to final energy consumers to reduce consumption during critical peak times. It rewards consumer behaviour for using energy responsibly (Grossberg et al., 2015). Another example is **STEM**, intelligent power storage in the background to automate savings based on customer energy patterns. These patterns are predicted from historical energy use, weather forecasts, energy tariffs and the use of big data analytics (Kearns et al., 2016)

- **Smart Thermostats:** these are thermostats that allow remote control and monitoring via an internet connection and usually incorporate software that optimizes energy efficiency and comfort. Access to the load curve enables these thermostats to provide new features such as the implementation of DR programs. One example is **WiserAir**, a smart thermostat that connects the utility with its customers in order to get end to end energy management and customer engagement. It also allows the deployment of energy efficiency measures such as home energy management, home audits and demand response programs (Schneider Electric, 2015). Another third party service provider is **Wheather Bug Home**, a solution that combines the smart meter data, the real time weather and the home connected thermostat to help homeowners to stay comfortable and at the same time save energy through timely alerts, analysis based on how the home responds to the weather, usage compared to similar residences, personal energy use disaggregation and tips to reduce usage (Rotondo et al., 2016)

The provision of the electrical load curve to the energy end-user, allows the setting up of additional energy efficiency measures based on ICT. These ICT measures, based on the analysis and enhancement of the load curve, improve the energy efficiency of energy end-users and help them achieve a manageable load in the electrical grid (Demand Response); therefore helping the accomplishment of the European Union energy efficiency targets. What is more, if the load curve is in a standardized and easily processable format, such as the Green Button -defined by

some authors (Sayogo and Pardo, 2013) as the "Low Hanging Fruit" because its speed of implementation and the benefits it provides-, member states can help to develop new market niches. These new markets are growing rapidly in what is known as "Home Energy Management" and they expect to reach a global revenue of 7,8 billion dollars in 2025 from 2,3 billion dollars in 2016 (2016, Navigant Research). It is in this spirit, that the use of international standards for encoding the load curve provided by smart meters can be the cornerstone towards the third industrial revolution. In other words, easily access to the electrical load curve in a standard format can boost new value propositions to energy end-users.

Moreover, Open Innovation can be used to stimulate the development of new ICT solutions for energy efficiency. As an example, the following tools mentioned before, were born of the "Apps for Energy" challenge of the United States Department of Energy: UnPlugStuff, PEV4me, Leafully, Drive System and Melon Power³. In addition, Open Innovation challenges can influence the perception of energy consumers, such as the Nesta Big Green Challenge that encouraged the reduction of carbon dioxide emissions in communities. Another example is the NRG COSIA Carbon Xprize, that aims at reducing carbon dioxide by developing and testing new technologies that convert carbon dioxide into valuable products for citizens and at the same time empowering people to be a part of the solution.

4. Conclusions and Policy Implications

Value added services based on the analysis and enhancement of the electrical load curve of energy end-users, offer new opportunities for meeting the energy savings targets set by the European Union for 2020 and beyond.

Although the European Union requires member states to provide consumers with their energy usage data for free and to define a format that facilitates data exchange between final consumers and utility companies (Directive 2009/72/EC, 13 July 2009), small consumers are not using these data for improving their energy efficiency. Additionally, the use of international

standards helps competitive markets to develop by boosting competition among available products and among service providers (Sioshansi, 2013b). Standardized energy data allows the use of existing ICT products and secondly it allows the scalability and a quick internationalization of new products and services being developed in Europe. We have seen before that France proposes the Green Button as one of the nine measures to be implemented in the short term to reactivate its digital economy, and in the results and discussion section we can notice that new market niches are growing quickly. Therefore, the promotion of new ICT solutions providing new value proposition to energy end-users, based on the processing of the standardized load curve can help accomplish the European Union energy efficiency targets and simultaneously helping the development of new market niches in Europe. On the other hand, utilities can use the electrical load curve not only for billing purposes, but also for offering new products and services tailored to each customer (Damji et al., 2013), to engage them.

European Member States are in the process of adopting or have adopted their data models for sharing the load curve as the directive requires. In this sense, the introduction of international standards will come from the hands of those utilities seeking a rapid competitive differentiation (Enel Group, 2015), by offering new value-added services to attract new customers and keep existing provided by smart meters, for example based on the concepts of "Privacy by Design" (Cavoukian, 2012).

5. Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

6. Appendix A: European Directive 2012/27/UE

The Directive (Directive 2012/27/UE, 25 October 2012) establishes a common framework to promote energy efficiency within the European Union in order to achieve 20% savings in primary energy consumption in 2020. Among

other measures, it specifies that each member state must establish a system of **Energy Efficiency Obligations** scheme equivalent to achieving **annual savings of 1.5% of their annual energy sales to energy end-users**, from January 2014 to December 2020 (Article 7). Alternatively, member states may opt to take other policy measures to achieve energy savings among final customers. The measures may include, among others:

- "Standards and norms that aim at improving the energy efficiency of products and services" (Article 7)
- "Training and education, including energy advisory programmes, that lead to the application of energy-efficient technology or techniques and have the effect of reducing end-use energy consumption" (Article 7)

In reference to smart meters the directive establishes (Article 9):

- "They shall ensure that the metering systems provide to final customers information on actual time of use and that the objectives of energy efficiency and benefits for final customers are fully taken into account when establishing the minimum functionalities of the meters and the obligations imposed on market participants."
- "They shall ensure the security of the smart meters and data communication, and the privacy of final customers, in compliance with relevant Union data protection and privacy legislation."
- "They shall ensure that if final customers request it, metering data on their electricity input and off-take is made available to them or to a third party acting on behalf of the final customer in an easily understandable format that they can use to compare deals on a like-for-like basis."

It provides that member states shall take **measures to promote and facilitate the efficient use of energy by small consumers**, including households. Among the measures recommended we highlight: providing information and exemplary projects (Article 12).

It stipulates that member states must provide incentives for grid operators to make available system services to network users permitting them to implement energy efficiency improvement measures within the framework of smart grids (*article 15*). In addition, they ensure that the regulation of the network and network tariffs meet the criteria of Annex XI:

- “Network regulation and tariffs shall not prevent network operators or energy retailers making available system services for demand response measures, demand management and distributed generation on organised electricity markets, in particular:
 - The shifting of the load from peak to off- peak times by final customers taking into account the availability of renewable energy, energy from cogeneration and distributed generation;
 - Energy savings from demand response of distributed

consumers by energy aggregators;

- Demand reduction from energy efficiency measures undertaken by energy service providers, including energy service companies.”
- “Network or retail tariffs may support dynamic pricing for demand response measures by final customers.”

It considers **Demand Response** (including small consumers) as a **tool to improve energy efficiency**, reducing or modifying consumption, decreasing the bill of the final consumer and optimizing the use of the smart grid and the generation of electricity.

Member states may establish a **National Energy Efficiency Fund**, so that energy efficiency obligations are met by annual contributions to this fund. The objective of the Fund will be to support national energy efficiency initiatives (*Article 20*).

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