Energy Policy 115 (2018) 514–522

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Recent experiences with tariffs for saving electricity in households

Ashreeta Prasanna[a,*,1], Martin K. Patel[b], Jasmin Mahmoodi[c], Tobias Brosch[c]

[a] Empa, Urban Energy Systems Laboratory, Uberlandstrasse 129, 8600 Dubendorf, Switzerland

[b] Chair for Energy Efficiency, University of Geneva, Institute for Environmental Sciences (ISE) and Department F.-A. Forel for environmental and aquatic sciences (DEFSE), Faculty of Science, Uni Carl-Vogt 1211, Geneva 4 Switzerland

[c] Consumer Decision and Sustainable Behavior Lab, Department of Psychology, University of Geneva, 40 Boulevard du Pont d'Arve, 1205 Geneva, Switzerland

ARTICLE INFO

Keywords:
Residential energy efficiency
Price elasticity of electricity
Electricity saving feed-in tariffs
Progressive tariffs
Prospect theory
Loss aversion
Energy efficiency tariffs

ABSTRACT

Financial incentives or disincentives in the form of electricity tariffs can be used to encourage energy efficiency. In this paper, two simple tariffs aimed at residential consumers are reviewed: progressive tariffs (PTs), which penalise high consumption of electricity, and electricity saving feed-in tariffs (ESFITs), which provide incentives to reduce consumption of electricity. The effectiveness of these tariffs is quantified and compared using the price elasticity (for PT) and an incentive elasticity (for ESFIT). The results indicate that PTs are more effective in mobilising electricity saving than ESFITs and confirm biases in human decision-making (here loss aversion). While further research is necessary, we propose a tariff which would motivate consumers to reduce their consumption by offering both an incentive for reaching an energy saving goal and a disincentive for failing to reach this goal. The flexibility of such a tariff makes it a promising solution suitable for application in countries with a comparatively high household income and liberalised retail electricity market.

1. Introduction

Reducing electricity consumption provides multiple benefits, including reduction of carbon emissions, pollution and energy cost. Several countries have committed to reduce their absolute energy consumption and double their rate energy efficiency improvement, which is also one of the UN's Sustainable Development Goals/SDGs (United Nations Department of Economic and Social Affairs, 2017). The EU countries have agreed on an energy saving target of 20% by 2020 and 27% or greater by 2030 (European Commission, 2012). In the US, more than half of the states have adopted long-term mandatory energy saving targets for utilities and efficiency program administrators (Downs and Cui, 2014).

According to an overview of recently proposed policy measures and their contribution to energy saving in the EU, the residential sector is expected to generate almost half of the projected saving by 2020 (Rosenow et al., 2015). The residential sector accounts for approximately 18% of total final energy demand in OECD Americas, around 24% in OECD Europe and nearly 23% world-wide (International Energy Agency, 2016) and thus offers a substantial potential for saving energy.

Between 1990 and 2013, final energy efficiency in households in the EU-28 countries increased at an annual average rate of 1.6% per year (European Environment Agency, 2015). The saving was mainly due to energy efficiency improvements for space heating and more efficient large electrical appliances. However, various drivers such as an increase in number of households, larger homes, greater comfort and growth in the number of electrical appliances have compensated half of the efficiency gains achieved through technological innovations (European Environment Agency, 2015; Gynther et al., 2015). Energy saving in the US residential sector increased by about 17% per year from 2006 to 2011 (Frankel et al., 2013). However, growth in the number of housing units and the size of homes has resulted in a net increase of electricity consumption in the US residential sector (U.S. Energy Information Administration, 2015). Thus, even though improvements in the efficiency of equipment results in energy saving, additional measures which include behaviour change are required. Policy measures which address behaviour in addition to technical measures are also likely to be more cost-effective than those which fail to include behaviour (Lutzenhiser, 2014).

Behavioural economics and psychology offer a large variety of approaches to impact consumer decision-making in relation to energy consumption (Frederiks et al., 2015). Measures which address behaviour have only started to be introduced - for example, detailed billing information (e.g. comparison of own consumption with that of

Abbreviations: PT, Progressive tariff; ESFIT, Electricity saving feed-in tariff

* Corresponding author.
E-mail addresses: ashreeta.prasanna@empa.ch (A. Prasanna), martin.patel@unige.ch (M.K. Patel), Jasmin.Mahmoodi@unige.ch (J. Mahmoodi), Tobias.Brosch@unige.ch (T. Brosch).
[1] Formerly with University of Geneva, Chair for Energy Efficiency.

https://doi.org/10.1016/j.enpol.2018.01.044
Received 29 March 2016; Received in revised form 7 January 2018; Accepted 21 January 2018

neighbours), implementation of incentives (various types of dynamic electricity tariffs), and platforms which provide information and feedback to consumers about their electricity consumption (smart meters, online websites to monitor energy use, etc.).

Recent research shows tariffs which reflect the amount and time of energy consumption (in addition to provision of detailed information) can have an impact on energy use. Dynamic tariffs are one possibility to identify and capture demand response potential of residential consumers. However, it is unclear whether it is realistic to apply dynamic tariffs on large scale, if they are cost-effective, if they can produce absolute reduction in energy consumption (rather than shifts in time of consumption), and if the saving will be persistent. Dynamic tariffs might also require installation of smart meters and implementation of pricing signals which could be costly and too complex for customers to understand and respond to (Layer et al., 2017).

In this paper, we study less commonly known tariffs for saving electricity, which also aim to address behaviour, and which have been previously used to reduce consumption in the residential (and services) sector. The two tariff options analysed are progressive tariffs and electricity saving feed-in tariffs. These do not require smart meters, are fairly simple to implement with pricing signals which are easy to understand, and they can be modified to fit the local situation. Our main research objectives are to: understand whether ESFITs and PTs are effective in saving electricity, identify their respective benefits and drawbacks, understand if punishment (in the form of PT) works better than incentives (in the form of ESFIT) to motivate energy saving. Previous research on these tariffs is detailed in Sections 2.1 and 2.2. This paper presents a first attempt to compare the effectiveness of these tariffs. This is carried out by defining indicators to quantify the effectiveness of the tariffs and comparing them based on these indicators. Subsequently, the impact of psychological loss aversion and the potential implications for optimal tariff design is discussed.

The paper is organized as follows: Section 2 describes in more detail the energy efficiency tariffs (progressive tariffs and electricity saving feed-in tariffs) which are considered in this paper. In Section 3, the methodology used to quantify the effectiveness of these tariffs is presented. Section 4 summarizes the effectiveness of the respective tariffs and a comparison between them across countries and regions. In Section 5 we discuss the implication of loss aversion and propose a modified tariff which operates on the basis of a bonus/malus mechanism. Section 6 provides the conclusions of our work.

2. Description of the two types of electricity saving tariffs studied in this paper

2.1. Progressive tariffs (PTs)

Also called rising block tariffs or increasing block tariffs, PTs apply increasing price of electricity with increasing consumption. Usually, the first block or consumption bracket is a low tariff (e.g. US$/kWh), which corresponds to the minimum electricity consumption of a household. The second block or consumption bracket has a slightly higher unit price of electricity and is set to meet the average electricity consumption of a household. Subsequent consumption brackets are charged at an even higher unit cost, thus with more electricity consumed, the cost of electricity rises progressively.

PTs were first implemented in the early 1970s in Italy, California and Japan, with the aim to keep prices for basic electricity consumption low, and to control rising demand for electricity in the context of rising oil prices (Dehmel, 2011). Even though encouragement of electricity saving is an objective of PTs, the focus is often on ensuring secure supply of electricity and to signal to customers a shortage by raising the price. Compared to other policies incentivizing energy saving, there is only little research on these tariffs. Badouard (2012), Faruqui (2008) and Youn and Jin (2016) find that increasing block tariffs encourage significant energy conservation. Some scholars have analysed the response to PTs by using econometric methods to estimate price elasticity in countries or jurisdictions where PTs have been applied, for example in California, Canada and Japan (Bernstein and Griffin, 2005; Borenstein, 2012; Neenan and Eom, 2008; Okajima and Okajima, 2013; Reiss and White, 2005). Recent literature also includes the use of simulated or synthesized price response to understand the application of PTs in developing countries such as China (Sun and Lin, 2013). In some European countries such as France, Germany, and Belgium, the suitability of PTs has been the subject of political debates (Dehmel and Gumbert, 2011; Tews, 2011; Wanko, 2014). Available literature is therefore mostly focused on selected countries, jurisdictions or even specific utilities and is typically authored in the national language.

2.2. Electricity saving feed-in tariffs (ESFIT)

Also known as saving bonus or saving incentive, ESFITs consist of setting a reduction target for a specified time period and providing a monetary reward for consumers who are able to achieve this target. ESFIT has been discussed in a few published articles, but often in qualitative terms (Bertoldi et al., 2009; Bertoldi and Rezessy, 2007; Cowart and Neme, 2013; Eyre, 2013). Utilities in Canada and California have offered ESFIT programs to their customers and the evaluation reports of these programs provide information about their effectiveness (California Measurement Advisory Council (CALMAC), 2015; Ontario Energy Board, 2015). In Europe some utilities in Switzerland and Germany offer ESFITs. However most of these utilities do not make the program evaluation reports publicly available and only publish the total energy saved due to such programs on their websites.

3. Methodology

Policy instruments such as tariffs are usually evaluated based on their effectiveness (the extent to which they contribute to reaching a specific goal) expressed in quantitative terms. They can also be evaluated based on their cost-effectiveness (financial means required to reach the effect expressed in quantitative terms) and their side effects (multiple benefits, e.g. employment or growth effects) (e.g. Blok, 2006). In addition to these indicators, several others are found in existing literature. For ESFIT programs, the total amount of electricity saved due to a program is often chosen as a measure of effectiveness, and additionally, the total cost of a program divided by the saving achieved from the program (cost effectiveness). Another indicator is the average amount of electricity saved per household. In the case of PTs, since they have historically been implemented at the scale of a country or region, precise data on the total electricity saved attributable solely to the price increase is difficult to find. Based on published literature, the most common method to understand and quantify the response to the price increase due to a PT is through econometric models which estimate the price elasticity of electricity in the country or region of application (using statistical data from the years when the PT is in place).

Due to the absence of consistent indicators across the different types of tariffs, the following indicators were chosen as a measure of effectiveness:

– For the case studies with PT we use the price elasticity of electricity provided in published literature (specifically pertaining to conditions where PT was applied, see Section 3.1).
– For ESFIT, we calculate the incentive elasticity (a modification of price elasticity) based on published data (further explained in Section 3.2).

In addition, the cost effectiveness of both the tariffs is discussed in the Appendix sections A3 and A4.