FREE NETWORK   POLICY BRIEF SERIES

Rebecca Ly, SITE
Chloé Le Coq, SITE
October 2018

Energy Demand Management: Insights from Behavioral Economics

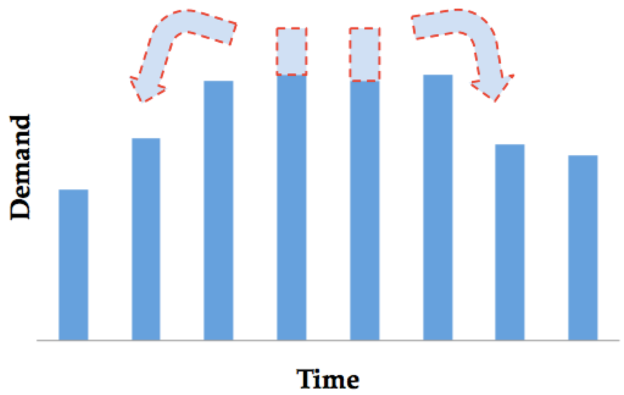
It has long been recognized that consumers fail to choose the cheapest and most efficient energy-consuming investments due to a range of market and non-market failures. This has become known as the 'Energy Efficiency Gap'. However, there is currently a growing interest in terms of understanding on how consumers make decisions that involve an energy consumption component, and whether the efficiency of their decisions can be improved by changing the market incentives and governmental regulation.

Meeting this interest, the most recent SITE Energy Talk was devoted to Demand Side Management. SITE invited Eleanor Denny, Associate Professor of Economics at Trinity College Dublin, and Natalya Volchkova, Assistant Professor at the New Economic School (NES) in Moscwo and Policy Director at the Center for Economic and Financial Research (CEFIR) to discuss the Demand Side Management process.

The aim of this brief is to present the principles of Demand Side Management and discuss a few implemented programs in Europe, based on the discussions during this SITE Energy Talk.

For the last two decades, climate change policies have mostly been focused on the energy supply side, constantly encouraging new investments in renewables. But reducing energy demand may be as effective. Indeed, Denny and O'Malley (2010) found that investing 100MW in wind power is equivalent, in terms of emissions, to a decrease in demand of 50MW. Hence, there is a clear benefit of promoting energy saving. This has been the central point of different Demand Side Management (DSM) programs that may diversely focus on building management systems, demand response programs, dynamic pricing, energy storage systems, interruptible load programs and temporary use of renewable energy. The goal of these programs is to lower energy demand or, at least, smoothen the electricity demand over the day (i.e. remove peak-hour segments of demand to off-peak hours) as illustrated in Figure 1.

Figure 1 - Smoothing electricity demand during the day



A behavioral framework

DSM encompasses initiatives, technologies and installations that encourage energy users to optimize their consumption. However, the task does not seem easy, given the well-documented energy efficiency gap problem (e.g. Allcott & Greenstone, 2012 or Frederiks et al., 2015): consumers do not always choose the most energy efficient investments, despite potential monetary saving. One reason why might be that energy savings per se are not enough to trigger investment in energy efficient solutions or products. As Denny mentioned in her presentation, consumers will invest when the total private benefits are higher than the costs of investment. This trade-off can be summarized by the following equation:

$$\sum_t \delta^t \cdot \left(\underbrace{\Delta e_{it}}_{\substack{Energy\\ savings}}\right) + \underbrace{\xi_i}_{\substack{Consumer\\ non-monetary\ net\ benefit}} > \underbrace{C_i}_{Cost}$$

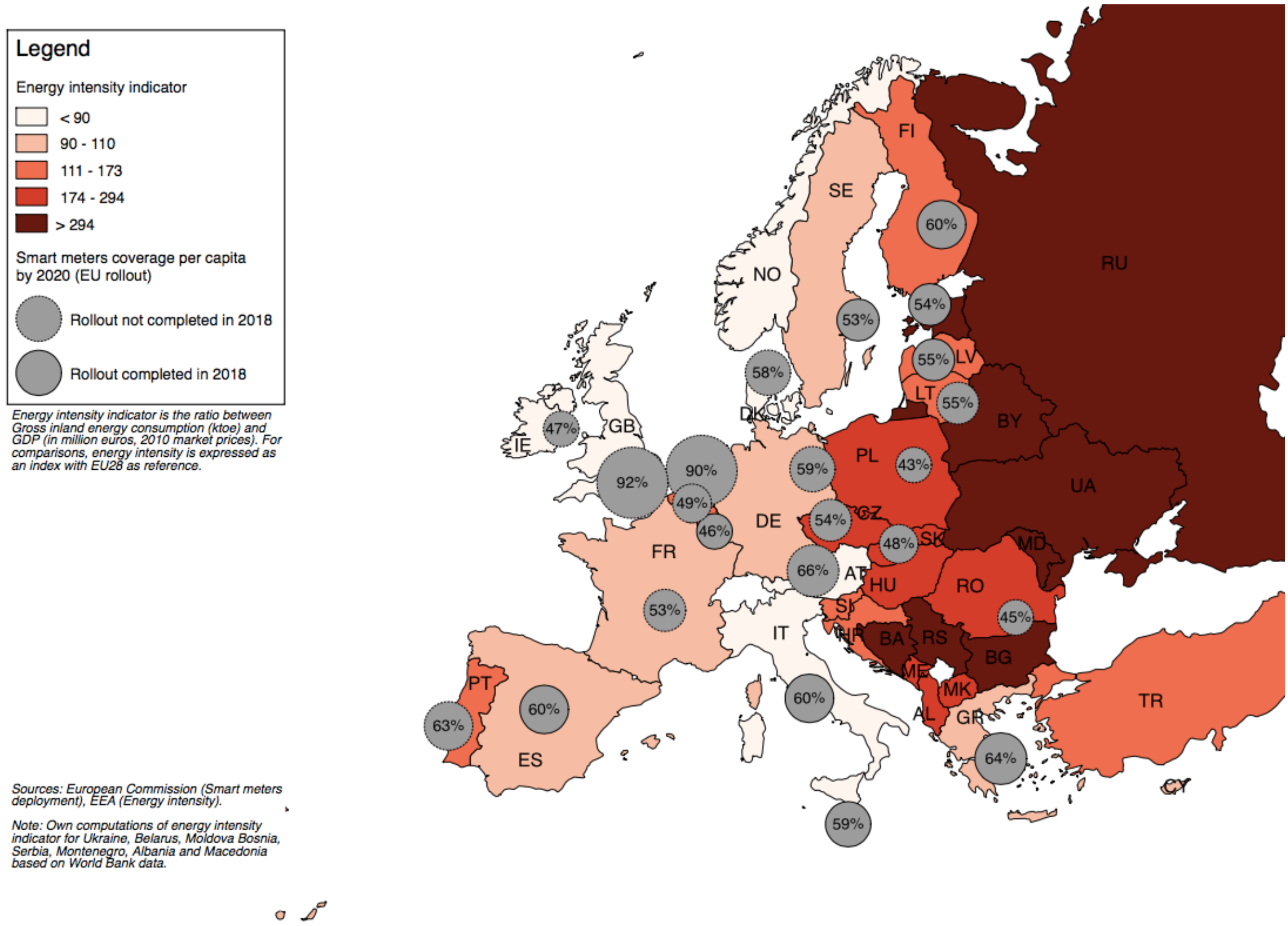
This equation illustrates that any DSM design should take into account both non-monetary benefits and consumers' time preferences. The non-monetary benefits, such as improved comfort, construction and installation time, but also warm glow (i.e. positive feeling of doing something good) or social comparison, may play a major role. Moreover, the consumers' time preferences (reflected here by the discount rate δ) are also crucial in the adoption of energy efficient products. In particular, if consumers have present biased preferences, they would rather choose a product with a lower cost today and greater future cost than the reverse (i.e. higher cost today with lower future cost). Since energy-efficient products often require higher upfront investment, consumers that are impatient for immediate gains, may never choose energy efficient products.

Ultimately, it is an empirical (and context specific) question when and why DSM programs can reduce the energy efficiency gap. We describe below some DSM programs that have been implemented and discuss their impact.

Smart meters, a powerful DSM tool

A common DSM program is the installation of smart meters, which measure consumption and can automatically regulate it. The adoption of smart meters allows real-time consumption

Figure 2 - Energy Intensity in Europe



measures, unlike traditional meters that only permitted load profiling (i.e. periodic information of the customer's electricity use).

As illustrated in Figure 2, many European countries have implemented smart meter deployment programs. Interestingly, most of those countries have a relatively high level of energy efficiency (proxied by the energy intensity indicator of final energy consumption). On the contrary, in the Balkans and non-EU Eastern Europe countries, which fare poorly on the energy intensity performance scale, no smart meter rollout programs seem to be implemented.

Following the European Commission (EC) directive of 2009 (Directive 2009/72/EC), twenty-two EU members will have smart meter deployment programs for electricity and gas by 2020 (see Figure 2). These programs are targeting end-users of energy, e.g. households that represent 29% of the current EU-28's energy consumption, industries (36.9%) and services (29.8%) (EEA). With this rollout plan, a reduction of 9% in households' annual energy consumption is expected.

The situation across the member states is however very different. Spain was one of the first EU countries to implement meters in 1988 for industries with demand over 5MW. All the meters will be changed at the end of 2018. 27 million euros for a 30-year investment in smart meter installations is forecasted (EC, 2013). Sweden started to implement smart meter rollout in 2003 and 5.2 million monthly-reading meters were installed by 2009. Vattenfall, one of the major utilities in Sweden, assessed their savings up to 12 euros per installed smart meter (Söderbom, 2012). Similarly in the United Kingdom, the Smart Metering Implementation Programme (SMIP) is estimated to bring an overall £7.2 billion (8.2 billion euros) net benefit over 20 years, mainly from energy saving (OFGEM, 2010). In general, smart metering has been effective, but its effectiveness may diminish over time (Carroll et al, 2014).

From smart-meter to real-time pricing

The idea of real-time pricing for electricity consumers is not new. Borenstein and Holland (2005) and Joskow and Tirole (2006) argue that this price scheme would lead to a more efficient allocation, with lower deadweight loss than under invariant pricing.

By providing detailed information about real-time consumption, smart meters enable energy producers to adopt dynamic pricing strategies. The increasing adoption of smart meters across Europe will likely increase the share of real-time-pricing consumers, as well as the efficiency gains. With the digitalization of the economy, it is likely that smart metering will grow. Indeed, Erdinc (2014) calculates that the economic impact of smart homes on in-home appliances could result in a 33% energy-bill reduction, due to differences in shift potential of appliances.

In 2004, the UK adopted a time-of-use programme called *Economy 10*, which provides lower tariffs during 10 hours of off-peak periods - split between night, afternoon and evening - for electrically charged and thermal storage heaters. The smart time-of-use tariffs involving daily variation in prices were only introduced in 2017.

Likewise, France's main electricity provider EDF, implemented *Tempo tariff* for 350,000 residential customers and more than 100,000 small business customers. Based on a colour system to indicate whether or not the hour is a peak period, customers can automatically or manually monitor their consumption by controlling connection and disconnection of separate water and space-heating circuits. With this program, users reduced their electricity bills by 10% on average.

In Russia, the "consumptions threshold" program discussed by Natalya Volchkova, gave different prices for different consumption thresholds. But it seems that the consumers' behaviour did not change. This might be due to the thresholds being too low, and an adjusted program should be launched in 2019.

Joskow and Tirole (2007), argue that an optimal electricity demand response program should include some rationing of price-insensitive consumers. Indeed, voluntary interruptible load programs have been launched, mainly targeting energy intensive industries that are consuming energy on a 24/7 basis. These programs consist of rewarding users financially to voluntarily be on standby. For instance, interruptible programmes in Italy apply a lump-sum compensation of 150,000 euros/MWh/year for 10 interruptions and 3000 euros/MW for each additional interruption (Torriti et al., 2010).

Nudging with energy labelling

Energy labelling has been also part of DSM. Since the EC Directives on Ecodesign and Energy Labelling (Directives 2009/125/EC and 2010/30/EU), energy-consuming products should be labelled according to their level of energy efficiency. For Ireland, Eleanor Denny has tested how labelling electrical in-home appliances may affect consumers' decisions, like purchasing electrical appliances or buying a house. First, Denny and co-authors have nudged buyers of appliances, providing different information regarding future energy bills saving. They find that highly educated people, middle income and landlords are more likely to be concerned with energy-efficiency rates, rather than high-income people.

In another randomized control trial, Denny and co-authors manipulate information on the energy efficiency label for a housing purchase. In Ireland, landlords are charged for energy bills even when they rent out their property. The preliminary findings are that landlords informed about the annual energy cost of their houses are willing to pay 2,608 euros for a one step improvement in the letter rating - the EU label rating for buildings ranges from A to G - compared to the landlords that do not receive the information (see CONSEED project).

Similar to the European Directive, the 2009 Russian Energy efficiency law includes compulsory energy efficiency labels for some goods and improvements of the building standards (EBRD 2011). Volchkova and co-authors run a randomized controlled experiment on the monetary incentives to buy energy efficient products. In 2016, people in the Moscow region received a voucher with randomly assigned discounts (-30%, -50% or -70%- for the purchase of LED bulbs. Vouchers were used very little, irrespective of the income. It seems that consumption habits and not so much monetary rewards were the main driver of LED bulb purchase.

How can DSM be improved?

Any demand response program requires some demand elasticity. For example, smart meters and dynamic pricing only improve electricity consumption efficiency if demand is price elastic. As Jessoe and Rapson (2014) show, one should provide detailed information (e.g. insights on non-price attributes, real-time feedback on in-home displays) to try to increase demand elasticity. Hence it seems that the low adoption of energy efficient goods is partly due to a lack of information or biased information received by the consumers. First, it is difficult for many to translate energy savings in kWh in monetary terms. Second, many consumers focus on the short-term purchase cost and discount heavily the long run energy saving. These information inefficiencies can, in principle, be diminished by private actors and/or governmental regulation. Denny mentioned the possibility of displaying monetary benefits on labels in consumers' decision-making in order to improve energy cost salience. For instance, in the US or Japan, the usage cost information is also displayed in monetary terms. Moreover, lifetime usage cost (i.e. cost of ownership) should also be given to the customers since it has been shown that displaying lifetime energy consumption information has significantly higher effect than presenting annual information (Hutton & Wilkie 1980; Kaenzig 2010).

Summing up, DSM programs, including those with a behavioral framework, are an important tool for regulators, households and industries helping to meet emissions reduction targets, significantly decrease demand for energy and use energy more efficiently.

References

Allcott, Hunt ; Greenstone, Michael. 2012. "Is There an Energy Efficiency Gap?", *Journal of Economic Perspectives*, 26 (1): 3-28.

Borenstein, Severin; Holland, Stephen. 2005. "On The Efficiency Of Competitive Electricity Markets With Time-Invariant Retail Prices", *Rand Journal of Economics*, 36(3), 469-493.

Carroll, James; Lyons, Seán; Denny, Eleanor. 2014. "Reducing household electricity demand through smart metering: The role of improved information about energy saving," *Energy Economics*, 45(C), 234-243.

Denny, Eleanor; O'Malley, Mark. 2010. "Base-load cycling on a system with significant wind penetration", *IEEE Transactions on Power Systems 2.25*, 1088-1097.

Erdinc, Ozan. 2014. "Economic impacts of small-scale own generating and storage units, and electric vehicles under different demand response strategies for smart households", *Applied Energy*, **126**(C), 142-150.

European Bank for Reconstruction and Development. "The low carbon transition". Chapter 3 Effective policies to induce mitigation (2011).

European Commission. Electricity Directive 2009/92. Annex I.

European Commission. Ecodesign and Energy Labelling Framework directives 2009/125/EC and 2010/30/EU.

European Commission. "From Smart Meters to Smart Consumers", Promoting best practices in innovative smart metering services to the European regions (2013).

European Commission. "Benchmarking smart metering deployment in the EU-27 with a focus on electricity" (2014).

European Environment Agency. Data on Final energy consumption of electricity by sector and Energy intensity.

Frederiks, Elisha R.; Stenner, Karen; Hobman, Elizabeth V. 2015. "Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour", *Renewable and Sustainable Energy Reviews*, 41(C), 1385-1394.

Hutton, Bruce R.; Wilkie, William L. 1980. "Life Cycle Cost: A New Form of Consumer Information." *Journal of Consumer Research*, 6(4), 349-60.

Jessoe, Katrina; Rapson, David. 2014. "Knowledge is (less) power: experimental evidence from residential energy use", *American Economic Review*, 104(4), 1417-1438.

Joskow, Paul; Tirole, Jean. 2006. "Retail Electricity Competition", *Rand Journal of Economics*, 37(4), 799-815.

Joskow, Paul; Tirole, Jean. 2007. "Reliability and Competitive Electricity Markets", *Rand Journal of Economics*, 38(1), 60-84.

Kaenzig, Josef; Wüstenhagen, Rolf. 2010. "The Effect of Life Cycle Cost Information on Consumer Investment Decisions Regarding Eco-Innovation", *Journal of Industrial Ecology*, 14(1), 121-136.

OFGEM. "Smart Metering Implementation Programme" (2010).

Söderbom, J. "Smart Meter roll out experiences", Vattenfall (2012).

Torriti, Jacopo; Hassan, Mohamed G.; Leach, Matthew. 2010. "Demand response experience in Europe: Policies, programmes and implementation", *Energy*, 35(4), 1575-1583.

Project links

Eleanor Denny and co-authors' European Research projects:

CONSEED (Consumer Energy Efficiency Decision making) https://www.conseedproject.eu/

NEEPD (Nudging Energy efficient Purchasing Decisions) https://www.neepd.com/

Rebecca Ly

Stockholm Institute of Transition Economics
rebecca.ly@ens-paris-saclay.fr
www.hhs.se/site

Rebecca Ly is a research assistant at SITE. She holds a BSc in Economics from Toulouse School of Economics and a joint MSc in Economics from Ecole Polytechnique and ENSAE. Her research interests are industrial organization and energy markets.

Chloé Le Coq

Stockholm Institute of Transition Economics
chloe.lecoq@hhs.se
www.chloelecoq.org

Chloé Le Coq is Associate Professor at the Stockholm School of Economics at the Stockholm Institute of Transition Economics. Her research areas are industrial organization and behavioral economics. She works on topics related to energy markets, anti-trust policy, consumer financial behavior and social innovation.

FREE NETWORK

freepolicybriefs.com

The Forum for Research on Eastern Europe and Emerging Economies is a network of academic experts on economic issues in Eastern Europe and the former Soviet Union at BEROC (Minsk), BICEPS (Riga), CEFIR (Moscow), CenEA (Szczecin), KEI (Kiev) and SITE (Stockholm). The weekly FREE Network Policy Brief Series provides research-based analyses of economic policy issues relevant to Eastern Europe and emerging markets. Opinions expressed in policy briefs and other publications are those of the authors; they do not necessarily reflect those of the FREE Network and its research institutes.