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Abstract: Poland's energy strategy prioritizes long-term energy security, energy efficiency, reducing greenhouse gas emissions. The country's progress toward sustainable development requires in-depth analyses of possible solutions. In our study we investigate consumers' preferences for Demand Side Management programs for electricity usage in Poland. We apply a discrete Choice Experiment framework for various electricity contracts implying the external control of electricity usage. The main objective of the study is to investigate the value of potential disutility of Polish households from the energy management. Additionally, we elaborate on the effect of social comparison between households' electricity use on the acceptance of new electricity contracts. The results suggest that people require substantial compensations to accept the external control of electricity in extreme cases and in weekdays during certain hours. Turning to the social comparison, we were expecting that people with a higher electricity usage per person in a household will require lower compensations, however we observe the opposite result. The respondents who were informed that they use more electricity than an average person in his administrative district seem to feel higher discomfort from the external electricity control. This suggest that the effect of social comparison might be overbalanced by the differences in perceived utility from electricity usage.

Keywords: choice experiment; demand side management; electricity, social comparison, willingness to accept

JEL codes: C25, D19, D91, Q41, Q48

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1. Introduction

Climate change refers to a shift in the statistical properties of the climate system, due to the natural processes or human influences, mostly burning of fossil fuels (Hulme, 2016). Even small increases in Earth's temperature have observable effects on the environment (IPCC, 2018). The cost of climate change is likely to be significant and to increase over time (IPCC, 2018). IPCC forecasts indicate that global temperatures will continue to rise, largely due to greenhouse gases production caused by human activities. There is an increasing political pressure to identify ways to reduce the environmental impacts of energy use as public concern regarding the effects of climate change escalates. According to IPCC's 15th special report, the limiting of temperature raise to 1.5°C requires far-reaching, rapid and unprecedented changes in all aspects of the society. In order to reduce CO2 emissions, changes in the power systems are required. For these reasons, the environmental research interest has turned to renewable energy sources and energy management. Energy management is expected to contribute significantly to climate change mitigation and energy security. According to the World Bank 2018 estimates, energy conservation and increased efficiency on households level can reduce energy needs by 15% (World Bank, 2018).

Over the past decade Poland has achieved significant progress towards sustainable development - by reducing energy intensity. However, there is still a need for institutional and regulatory reforms of its energy sector and a shift towards green growth. The Polish power mix has remained dominated by hard coal and lignite. There are power shortages and difficulties with balancing supply and demand (i.e. during summers when high temperature cause transmissions lines hot and stretched and the level of water is too low to cool down power plants). The proposal that can make the system more secure and sustainable is the control of households' electricity consumption.

Demand Side Management (DSM) is a well-established solution for energy management. DSM implementation is equivalent to a "virtual power plant". The concept, initially known as load management, was developed by Gellings in 1984 (Gellings, 1985) DSM plays a major role in controlling demand for electricity. For example, it can reduce consumption in peak hours. DSM includes load management, strategic conservation, building loads, and power marketing. It could create a greater flexibility on the demand side of the energy system and help to achieve environmental targets through controlled consumption. Changes in load profiles decrease electric systems running costs, both production and delivery, and allow for deferring or even avoiding investments in supply-side capacity expansion. Residential consumers have a potential for balancing supply and demand in real time since the domestic sector makes up a large share of total electricity consumption.

In literature, there are many proofs that DSM is an effective way of running energy system (see e.g. Sergici, Faruqui, 2010; Vine, 2013, Gelazanskas, Gamage, 2014; Jabir et al., 2018). Time-varying tariffs have been a subject of studies for almost 70 years (see e.g.: Cambridge Economic Policy Associates Ltd, 2014, Houthakker, 1951, Jabir, et al., 2018). Faruqui and Sergici, in a meta-analysis of 15 time-varying pricing pilots studies and experiments, observed that such programs induced reductions in on-peak usage reducing form 3% up to 6% (Sergici, Faruqui, 2010). Cambridge Economic Policy Associates (Cambridge Economic Policy Associates, 2014) summarized studies making estimates of the potential benefits from reliance on implicit DSM in the EU. Among the Member States, the average energy saving is 3% of affected demand, which means a simple resource cost saving of €3/kW/year of peak demand (€1.5bn/year applied across the EU). However, decision-makers are unwilling to introduce policies, which are not accepted by the public. From a scientific and policy point of view, it is important to understand the public preferences toward new policies and estimate compensations people need in order to accept new contracts. Such results could be then incorporated into a cost-benefit analysis.

This paper focuses on preferences related to the DSM of Polish household’s energy use. In a discrete choice experiment study, people reveal their preferences toward external control of household electricity usage e.g. to shift their use of electricity from peak to off -peak hours. The main objective of the study is to examine the value consumers put for the change of their habits regarding electricity use (e.g. shifting consumption in time) and the impact of social norms on this value.

The key reference for this paper is the study by Broberg and Persson (2016) in which authors analyze preferences related to demand management of households’ energy use in Sweden. They adapted a discrete choice experiment (CE) framework to elicit compensations needed for different dimensions of external control of energy usage. Authors analyzed 5 attributes of electricity contracts: external control of heating (Monday-Friday), external control of domestic electricity (Monday-Friday), external control in extreme cases (domestic electricity is turned off), distribution of information and monetary compensation. All significant attributes of the contracts contributed negatively to utility. The highest discomfort was attached to constraints during the evening peak hours. According to the results, there exists preference heterogeneity, namely, socioeconomic factors affect preferences towards perceived discomfort from the external control and information dissemination. The work was an inspiration for this study. We used similar attributes (except control of heating) adapted to the Polish conditions.

As far as we know, this is the first study investigating consumers' preferences toward electricity DSM using the Choice Experiment (CE) in the Central Europe. Additionally, we focus on the impact of social comparison of electricity usage on the electricity DSM acceptance. So far, such a type of contracts has not been present in the Polish energy management. The study will evaluate potential disutility associated with the introduction of DSM. The method is consistent with "Characteristics Demand Theory" developed by Kevin Lancaster in 1966. The theory states that individuals derive utility not from the contents of the basket but from the characteristics of the goods that are in it. It is possible to predict how consumers' behavior changes by relying on a study of the characteristics rather than the goods involved. Another foundation of CE is "Random utility theory" that allows to elicit preferences for complex multidimensional goods from which models of preferences can be estimated (Manski, 1977).

Psychologists claim that peer comparison activate social norms that have a great influence on behavior (Cialdini et al., 1991). Social comparison theory, initially provided by Leon Festinger in 1954, assumes that there is a drive within individuals to gain correct self-evaluations. The theory clarifies how people evaluate their abilities and opinions by comparing themselves to others to reduce uncertainty in the assessment, and to learn how to define themselves. Research shows that provision of feedback, in particular social comparison, can influence consumption behavior, at least in the short run (see e.g. Abrahamse et al., 2005; Faruqui et al., 2010; Fischer, 2008; Kažukauskas et al. 2017). We investigate the effect of social comparison between a household' energy use (per person per year) and an average use in a respondent's *'powiat'*[1] on the acceptance of contracts which decrease the flexibility of electricity consumption.

[1] A *'powiat'* (pronounced [ˈpɔvʲjat]) is the second-level unit of local government and administration in Poland, equivalent to a county, district or prefecture (LAU-1, formerly NUTS-4) in other countries. The term *'powiat'* is most often translated into English as "county" or "district".

This study would be beneficial to the government, the electricity providers and users, as it would provide the necessary information on the preferences toward services concerning electricity. Results could help to design electricity contacts which put restrictions on the consumption. This, in turn, will enable to control the demand and achieve expected targets, for example: increasing energy efficiency, improving the security and prevent the need for constructing new power plants. Researchers highlight the need for references to norms and values as soon as behavioral change or related policies are examined (see e.g.: Alcott, 2011, Horne and Kennedy, 2017, Kažukauskas et.al, 2017). The literature shows (see e.g. Clark et al., 2003; Whitmarsh, 2009; Guo et al. 2018) that motivational, cognitive, and contextual factors affect energy use, therefore much more effort needs to be devoted to the inclusion of behavioral aspects into the decision- making process. Consumers could contribute to the safety and effectiveness of the power system only if they engage in the management. As far as we know, this is the first study investigating the impact of social comparison on preferences toward electricity DSM.

The rest of the paper is organized as follows. The second section provides background information on electric power system in Poland. Literature review concerning the impact of feedback and social comparison on the implementation of DSM is presented in the third section. The next part reports methodology and describes the survey followed to collect the data. The fifth section presents the results. The last part summarizes the main conclusions.

2. The study's background

The main document laying out Poland's long-term energy policy is the Polish Energy Policy until 2040. The country's new energy strategy priorities long-term energy security, putting stress on increasing energy efficiency, reducing greenhouse gas emissions and air pollution, decarbonizing the transport system (Ministry of Energy, 2018). The energy security may be accomplished by building new power plants which requires significant investments. Politicians stand at the crossroads of important decisions regarding the energy system.

The Polish power mix is dominated by hard coal and lignite. Between 2020 and 2035, about 60 power plants are expected to be closed down (RAP, 2018). This accounts for more than 50% of total installed capacity. In Europe-wide assessments of grid stability: System Average Interruption Duration Index and System Average Interruption Frequency Index, Poland's score is significantly higher than the EU average (RAP, 2018). The Polish consumers lose the electricity supply more often than their neighbors, and the amount of time without electricity is longer. Power shortages in the peak hours constitute a real threat for the energy system in Poland. The daily and seasonal peak hours on the demand side put pressure on increased flexibility to sustain balance in the grid systems. In this context, controlling consumption of the electricity seems to be a promising solution.

The residential sector is a substantial consumer of electricity in Poland. Household electricity use in Poland constitutes about 30% of the total annual consumption of electricity. In 2017 the mean electricity usage in the residential sector in Poland was 701 kWh per capita (772 kWh in villages). In Poland the total energy consumption per capita in 2017 was 2.8 toe[2]. It is 13% below the EU average. Electricity consumption per capita amounted to 3 900 kWh (30% below the EU average) (Enerdata, 2019). Poland is one of the last places in Europe in terms of electricity consumption. In Luxembourg, Sweden, Finland or other Scandinavian counties, electricity usage per capita is two or three times larger (Eurostat, 2019). According to forecasts, energy consumption in Poland will grow rapidly - chasing the European average. The rising trend in energy demand is one of the main causes of increasing environmental burden.

In Poland the Energy Law sets up the standards and general rules ensuring security for the grid and the energy system as well as the equal treatment of all users. It includes the rates for the electricity and terms for the provision of services. Retail market concentration is high, with the four largest companies, holding a total market share of 87%. The demand side of the retail electricity market includes couple of end-users groups. There are approximately 17.05 million of end-users (90.3% belong to G tariff group) and among them 14.5 million are the household consumers (Nafkha et al., 2018). The Energy Law requires the separation of payment for electricity and the service of its transmission. Electricity sellers use different electricity pricing systems for customers.

The most common household tariff group for households is G11—customers have single-time zone meters with a single electricity rate per kWh. The G12 tariff is effective from 10 p.m. to 6 a.m. and from 1 p.m. to 3 p.m., while G12w tariff is additionally effective on the weekends (from 10 p.m. on Friday to 7 a.m. on Monday). G12r is effective seven days a week from 10 p.m. to 7 a.m. and from 1 p.m. to 4 p.m. The electricity bill consists of: electricity charge, fee for commercial service, the variable component for the network, the quality rate, distribution fee, license fee. Most utility companies approximate how much the consumer should pay based

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[2] tonne of oil equivalent

on a mean usage from the previous billing period. This information is updated every 6 or 12 months so the monthly charge can differ from the actual usage of the household. As a result of the liberalization of the electricity market in Poland since July 1, 2007, individual users of electricity have obtained the right to change the electricity supplier. However, the switching rate remains very low when compared with other EU countries.

Access to a continuous and reliable supply of electricity is crucial for all economic activities. Electricity is expensive and difficult to store, it has to be consumed at the same time that is being generated. Transmission System Operator is required to plan, on a day-ahead basis, for a 9% reserve margin (de-rated) above planned demand on the system for every hour of the following day. However, it is complicated to forecast the electricity demand for households. Residential sector is not well understood because of the following reasons:

- There is a variety in the structure of the sector: geometries and thermal insulation materials, the household size.
- Detailed metering of households' electricity usage has a prohibitive cost and data collection is difficult. Smart meters have not been implemented in Poland so far.
- The behavior of consumers varies widely.

In Poland the implementation of Automated Metering Infrastructure (AMI - smart meters) is still at an early stage. However, it will be deployed on a mass scale in the near future. By 2026 the power companies will have to install smart meters in 80 percent of end-users (Wysokie Napięcie, 2018). Currently, less than 9% Poles have such a device. The Ministry of Energy predicts that the introduction of new meters will drive forward the process of changing the power supplier and will encourage Poles to be more active on the market. Smart meters enable to issue bills for the actual consumption. The development of AMI gives an opportunity to acquire detailed information on customers' electricity usage by hours. Such knowledge can be used to create products which directly correspond to the needs of customers, and the character and load profiles of the end-users (PWC, 2017).

3. Literature review

In the literature there is an increasing interest in the role of feedback and social comparison on households' electricity usage. Consumers can learn how to reduce electricity usage from self-monitoring and feedback. Detailed information on electricity usage help users to understand their habits and routines that generate consumption patterns and thus make the worthwhile energy saving actions available to them. Social scientists recognize that electricity consumption is not individual but rather collective behavior: “behaviour is social in the sense of being oriented to socially-sanctioned goals” (Lutzenhiser, 2009:29). Researchers analyze how the individuals compare themselves with others in order to find out how to motivate the individual to change (Allcott, 2011). Studies show that norms regulate household energy consumption (see e.g. Harries, et al 2013; Horne, Kennedy, 2017). Providing information about what is normal behavior could improve the role of feedback because such information can simplify decision-making (see e.g.: Thaler and Sunstein, 2008). Furthermore, information on the consumption of a similar household can be used a benchmark. In this context, we want to examine the impact of social comparison on peoples choices about people’s preferences for DSM in Poland.

3.1 Demand side management

DSM consists in the modification of consumer demand for electricity through various methods such as behavioral change through education and financial incentives. Examples include the provision of more information to users to support efficient behavior and new smart technologies that can be automatically controlled. Ordinarily, the goal of the DSM is to encourage consumers to use less energy during the peak hours, or to move the time of energy consumption to the off-peak times such as night-time and weekends. Peak demand management does not necessarily decrease total energy usage but it could be expected to reduce the need for investments in distribution networks or power plants, thanks to a more balanced pattern of consumption throughout the day. In fact, by reducing the overall load on an electricity network, DSM has many beneficial effects (both economic and environmental), including mitigating electrical system emergencies, increasing the reliability of the system and reducing the number of blackouts. Possible benefits can also include deferring high investments in generation, transmission and distribution networks. Demand Side mechanisms improve energy efficiency and help balance electricity supply and demand (Smart Energy Demand Coalition, 2016). According to the literature, total demand response potential in Europe amounts 52.35 GW, what represents 9.4% of the peak load (ENTSO-E estimation for its 34 represented countries) (Vine et al., 2013). It is, however, more and more acknowledged that there are many factors influencing the effectiveness of DSM programs.

Direct management of household’s consumption can be seen as more extreme than dynamic pricing. For example, consumers may sign a contract specifying that they disclaim the right to control a part of their electricity usage at specific hours of the day, or on specific occasions. In practice, a deliverer may adjust the domestic heating system during cold periods, or block the washing machine in the peak hours, to smoothen daily energy use over time. In any case of behavioral control, it affects and reduces household daily comfort as the demand for electricity follows a pattern over time (Vesterberg et al., 2013). According to Mesaric et al (2017), people have a positive predisposition toward home demand-side-management and smart technologies but are less likely to accept automation system controlled by an electricity supplier. There are peaks in the morning and in the evening besides the seasonal patterns. Life-like scenarios of DSM would then mean turning off the dishwasher, domestic heating, etc. during certain hours, which, in turn, would affect people's utility.

3.2 The role of feedback in DSM implementation

There is a rich literature documenting the impact of feedback on electricity consumption. Smart meters with customer feedback help residential customers to reduce their electricity usage (Carroll et al., 2013). In order to design and adapt feedback for efficient demand response programs with long lasting results, it is important to frequently communicate with consumers (Vassileva et al., 2012). They should be well informed, not only about their usage, but also about some of the latest electricity related news that are of their concern and how they could affect them. The customers should have the possibility to choose between different options of receiving feedback. The type of data visualization has the impact on people's ability to interpret domestic energy usage data (Herrmann et al., 2018). Table 1 summarizes studies about the effect of feedback on electricity consumption.

Table 1. The effect of feedback on electricity consumption – results from studies

Authors	Intervention	Sample	Results
McClelland, Cook (1980)	feedback	101 families	12% saving
Hutton (1986)	feedback and information	3 cities	4-5% savings in 2 out of 3 cities
Dobson, Griffin (1992)	feedback	100 households	12.9% savings
Ek, Söderholm (2010)	information	1200 Swedish households	results indicate that costs, environmental attitudes and social interactions are all important determinants of electricity saving activities
Loock (2011)	feedback	220 customers	injunctive feedback always reduces consumption, descriptive feedback leads to increased consumption for below average consumers
Carroll, Lyons, Denny(2014)	feedback	Ireland	1.8% reduction in electricity usage
Delmas, Lessem, (2014)	real-time feedback, public information about usage	66 rooms in the residence halls, Los Angeles	private information alone was ineffective, public information combined with private information motivated a 20% reduction in electricity consumption
Dolan, Metcalfe (2015)	information with descriptive and injunctive norms	569 households (1) 2,142 households (2), London	6% reduction – the impact of descriptive social norms, large financial rewards worked very well online in reducing consumption, with a 0.35σ change, the large effect of financial incentives is completely removed when information on social norms is added online
Gölz, Hahnel, (2016)	energy feedback systems	108 participants Freiburg, Germany	energy feedback usage behavior is shaped by a combination of pre-set goals rather than a single motivation
Lossin, Loder, Staake, (2016)	individual feedback	17,500 randomly selected customers	signup rates to participate in ICT based programs: for the monetary incentive group - 4.96%, for the non-monetary incentive group - 3.92%
Pellerano,	normative	27,634	social comparison message reduced electricity use

Price, Puller, Sánchez (2017).	messaging and financial incentives	households, U.S.	above the referential neighbor by 1%, adding extrinsic financial incentives to reduce consumption does not lead to increased conservation
Anderson, Song, Lee, Krupka, Lee, Park (2017)	normative messaging campaign	Seoul, South Korea, 495 students	individuals with a high concern for social norms consumed 14% less; individuals with a low concern for social norms had treatment effect of 5%; after the intervention had been withdrawn, individuals used 1.2% less energy per week
Schleich, Faure, Klobasa (2017)	feedback	Linz, Austria; 775 and 750 (control); households	5.5% savings in weekdays, 5.1% in weekend days
Horne, Kennedy (2017)	vignette experiments,modified trust game	U.S. residents N1=334 (study 1), N2=506, N3=102	participants both value reducing carbon emissions and expect that others support reductions
Kendel,Lazaric, Maréchal (2017)	feedback (less and more detailed)	141 households from Southern France	13-23.3% reduction in electricity consumption
Weber, Puddu, Pacheco (2017)	feedback	France, 62 households followed over 18 months	information feedback had no significant impact on load shifting, households who received feedback decreased electricity usage
Thampanishvong (2015)	Feedback, energy saving hints	Thailand, 161 households	6% of reduction

Surveys of the existing feedback literature report savings from 1 to 23.3 percent, depending on the type of information provided. According to the literature review conducted by Vine et al. (2013), feedback for households can reduce electricity consumption by 5 - 20%.

Although researchers still continue to question the types of feedback that are most effective in encouraging conservation and peak load reduction, some trends have emerged. These include as follows: feedback should be received as quickly as possible immediately after the time of consumption; it should be related to a standard; should be clear and meaningful and where possible both direct and indirect feedback should be customized to the customer. In general, the literature finds that feedback can reduce electricity consumption in homes by 5 to 20 percent, but that significant gaps remain in our knowledge of the effectiveness and cost benefit of feedback.

According to the literature, information on possible savings measures is an effective tool to increase the willingness to save electricity (Ek and Söderholm, 2010, Thampanishvong, 2015). Electricity saving behaviors among households can be induced by raising awareness of negative environmental effects of electric power generation. Stimulating reflections about everyday habits can encourage knowledge spill overs from one household to another and make additional reductions in households' electricity consumption. Consumers would limit the use of certain appliances if they knew that they need more electricity than others (Vassileva et al., 2012). Households might purchase less energy consuming appliances as substitutes or try to reduce the time of using such appliances when possible. Providing information on the electricity usage of average neighbor can promote energy savings (Dolan and Metcalfe, 2015; Thampanishvong, 2015). According to the literature, it is enough to motivate consumers to reduce their electricity usage. Feedback effects can be persistent over time. It can lower electricity demand during peak hours as well as base load.

In the literature we can find three main types of motivations to save electricity:

- intrinsic motivation,

  Intrinsic motivations consist of altruism. Pure altruism is motivated by an interest in the welfare of other people. Warm-glow altruism is motivated by an improve in self-esteem associated with improving the wellbeing of others (Andreoni, 1990).
- extrinsic motivation

  Extrinsic motivations consist of pecuniary rewards although some non-financial rewards have been used to stimulate conservation in terms of electricity saving competitions and the goal setting. Financial incentives are a very powerful instrument to control behavior but the effectiveness depends on the amount paid.
- reputation or image motivation

  Reputation motivation occurs when visibly prosocial behavior acts as a signal of virtuousness, creating a positive reputation. Public information can motivate individuals to save electricity by appealing to their desire for social approval.

Feedback information can be as powerful motivator as monetary reward (Lossin et al., 2016). Pellerano et al. (2017) found that financial incentives added to normative messages not only fail to strengthen the effect of the feedback but can even reduce it. They proved that there is a tension between extrinsic incentives and intrinsic motivation. The same results were obtained by Dolan and Metcalfe (2015). They found that large monetary rewards are effective in changing electricity consumption over a four-month period but the effect was completely mitigated when information on social norms was included.

The change in electricity usage after receiving feedback is influenced by a combination of goals rather than a single motivation. Gölz and Hahnel (2016) identified goals that shape changes in behavior: reducing costs, having fun, learning to save electricity, controlling and avoiding inconvenience. Their findings extended previous qualitative research by using quantitative methods to identify and examine feedback goals across different samples.

Feedback with a goal-setting in the internet platform can stimulate consumers to save energy (Loock et al., 2013). Default has a normative character that informs consumer of the savings he or she can achieve. Setting default goals for consumers can induce engagement because they have to change their behavior to obtain energy conservation. Research show that feedback provided by post and via a web portal have the same effectiveness (Schleich et al., 2013).

Some scientist claim that people are bound rational when it comes to electricity consumption and the impact of feedback. However, research shows that giving monetary information on energy consumption is more effective than giving information in physical units. Blasch and co-workers (2017) show that displaying energy consumption of appliances in cost increases the probability that consumers perform an investment analysis and probability that they identify the most efficient appliances.

Some researchers claim that influencing households behavior in the long term is impossible while using temporary tools. In the experiment carried out by Weber et al. (2017). electricity usage returns to its pre-treatment level after the end of the study. Households neglected more complex information given in the experiment. Feedback had no significant effect on load shifting - participants decreased electricity consumption in all periods of the day. Authors suggest that results prove the Hawthorne effect. Consumers react because they know they are included in the study and observed.

The important factor that affects the effectiveness of feedback is trust and involvement of participants. Both low and high-income households have the potential for changing electricity usage. Low-income individuals are interested in how to reduce their bills. Research shows more sophisticated feedback about consumption is more effective (Buchanan et al., 2013). Some authors claim that it is possible that feedback is effective because it acts as a motivator and reminder rather than an educational support (Clark et al., 2003). Allcott (2011) suggests that many electricity saving behavior, such as adjusting thermostats, turning off lights are likely to be actions that most consumers are aware of already, and feedback drives savings by putting attention to or increasing the 'moral cost' of energy consumption.

The average daily electricity consumption before the implementation of Demand Side Programs could differentiate households. Schleich et al. (2017) found that feedback was an effective tool to reduce electricity usage in households from the 30th to the 70th percentile of consumption. For households in percentiles below or above this range, feedback had no effect (Kendel et al., 2017).

3.3 The impact of social comparison on electricity consumption

It seems that without adequate motivation, households will not incur the costs of taking, interpreting and using feedback information. It is crucial to identify the motivational and contextual factors influencing the decision-making of households to adopt or not to adopt interventions in the power sector. Ziegler (2018) examined the determinants of the change of electricity contracts. Econometric analysis shows a strong relevance of behavioral factors and individual norms and values. Reductions in electricity consumption can be accomplished by involving the consumers in a competition to lower overall consumption. Social networking sites, such as Facebook, could play a crucial role in decreasing electricity consumption in the households by making monitoring more enjoyable (Foster et al., 2010).

Alrowaily (2012) showed a significant reduction in the participants' electricity consumption when the competition was held. Reduction increased from 4 per cent (while real-time feedback was provided) up to 15 per cent (when the participants compete). The author claims that allowing individuals to set up their own challenges could encourage them to be deeply involved in the competition to achieve these goals. He proposes the challenge card which users could post to their Facebook friends and invite them to a competition. Making the competition result visible to all users' friends provides the encouragement and needed support.

Alrowaily (2012) found that social relations in one community and strong affinity have a great impact on people's conservation behavior.

Electricity comparison among households put social pressure on residents to understand why consumption levels differ, thus stimulate ambition for electricity saving and competition. The OPOWER program is an example of application of normative feedback. It contains social-normative messages that compare household's electricity usage to that of average neighbors, and to that of their most efficient neighbors. Alcott (2011) conducted a natural field experiment of 600,000 households, where residents could receive normative feedback of electricity. The results show the cost effectiveness of non-price electricity conservation programs.

Research conducted in China (Wang et al., 2018) shows that residents with a strong sense of energy saving tend to use less electricity when their electricity usage is larger than or equal to average electricity usage. Consumers who have a relatively weaker behavioral variability and stronger energy-saving awareness, have higher willingness to perform electricity conservation under feedback.

Nolan et al. (2008) showed that the effect of social comparison is more effective than incentives such as saving money, being socially conscious or conserving resources. According to the literature, people tend to imitate behavior of others so the social proof is important in human decision-making (Cialdini, 2003). There are studies in which consumers have indicated that the comparison would be of interest to them (Egan et al., 1996, Wilhite et al., 1999). People prefer comparison based on similar demographics such as house size and occupancy levels (Egan et al., 1999). Neighbor-based comparison are meaningful because neighbors tended to report similar behaviors and attitudes (Iyer et al., 2006). In the study by Kempton and Layne (1994), 70% of participants had discussed their bills with other people (neighbors).

Public information can stimulate green behaviors so that people obtain the benefits of a green reputation. Upon making unobservable pro-environmental behavior such as energy conservation visible, individuals have an additional motivation to involve in such a behavior. Delmas and Lessem (2014), made public information regarding electricity consumption for a subset of participants, thus engaged reputational motivations for conservation. Information dissemination induced a 20% reduction in electricity consumption above median electricity consumers. Furthermore, after two months of the treatment, these previously large electricity consumers had formed substantially better electricity consumption habits, which persisted three months later. Most participants learned how much electricity consumption came from cooling and heating, but only individuals in the information dissemination treatment reduced the consumption of their cooling and heating system.

Fischer (2007) found that savings achieved by high electricity users who received the comparison may have been cancelled out by low electricity users being inadvertently encouraged to increase usage because of the comparative standard. This phenomenon has been defined the "boomerang" effect. In the study by Schultz and colleagues (2007), respondents who consumed less than the average and received the message of encouragement (the smiley face), maintained low usage, whereas, those who did not receive the message, increased their consumption.

4. Materials and Methods

We apply a discrete Choice Experiment framework for various electricity contracts implying the external control of electricity usage. The CE is based on the consumer theory of Lancaster (1966) and assumes that any good can be described in terms of its attributes. People making choices between different bundles of attributes express their preferences. Subsequently, based on the observed choices, it is possible to infer which attributes significantly influence choice, and to derive a marginal rate of substitution between those attributes. If one of the attributes of the good is a compensation, then the marginal rate of substitution between a non-monetary and a monetary attribute is equivalent to a marginal willingness to accept for the non-monetary attribute. The theoretical foundations for the analysis of our CE data are provided by the random utility theory (McFadden, 1981).

4.1. Econometric approach

We employ random parameter logit (RPL) to analyze choices individuals made in a CE. We assume that random utility of individual *i*, from choosing alternative *j* in choice task *t* can be decomposed into a systematic component $\left(V_{jti}\right)$ and a stochastic component $\left(\varepsilon_{jti}\right)$:

$$U_{jti} = V_{jti} + \varepsilon_{jti}. \tag{1}$$

Furthermore, we assume that the systematic part of the utility is a linear function of *k* attributes, stacked in the vector $\mathbf{X}_{jti}$, which leads to the usual, additive formulation of the model:

$$U_{jti} = \mathbf{X}_{jti}\boldsymbol{\beta}_i + \varepsilon_{jti}. \tag{2}$$

The stochastic component, ε_{jti}, is assumed to follow extreme value type 1 distribution, and to be independently and identically distributed across alternatives, choice tasks and individuals. The RPL model (Hensher and Greene, 2003; Train, 2003) is a common approach to account for taste heterogeneity across individuals. The model assumes that vector of marginal utilities, $\boldsymbol{\beta}_i$, follows a certain, potentially multivariate, distribution in the population. This distribution needs to be specified by the research before estimation of the model. Then, parameters of the chosen distribution are estimated, rather than parameters of the utility function itself. For example, if $\boldsymbol{\beta}_i$ is assumed to follow multivariate normal distribution, then the vector of its means as well as its covariance matrix needs to be estimated. Conditional on individual-specific parameters, probability that individual *i* will choose alternative *j* in choice task *t* is given by standard multinomial logit formula

$$P_{jti}(\boldsymbol{\beta}_i) = P\left(U_{jti} = \max_l \{U_{lti}\} \mid \boldsymbol{\beta}_i\right) = \frac{\exp\left(\mathbf{X}_{jti}\boldsymbol{\beta}_i\right)}{\sum_l \exp\left(\mathbf{X}_{lti}\boldsymbol{\beta}_i\right)}. \tag{3}$$

Because $\boldsymbol{\beta}_i$ are unobserved to the researcher, the unconditional probability of all choices individual *i* made in the CE is given by a multidimensional integral:

$$L_i = \int \prod_t \left(\sum_j y_{jti} P_{jti}(\boldsymbol{\beta}_i) \right) f(\boldsymbol{\beta}_i \mid \Omega)\, d\boldsymbol{\beta}_i, \tag{4}$$

where y_{jti} is equal to 1 if individual *i* chosen alternative *j* in choice task *t*, and is equal to 0 otherwise. Function $f(\boldsymbol{\beta}_i \mid \Omega)$ is a density function of $\boldsymbol{\beta}_i$, which depends on set of parameters, Ω, to be estimated. As integral in (4) does not have an analytical solution, we estimate the model using Maximum Simulated Likelihood method, which approximate the multidimensional integral using Monte Carlo simulation. We used 2000 scrambled Sobol draws per individual in the estimation procedure.

4.2. Survey structure, data collection and sample

The survey consisted of five major parts. The respondents were asked to find their last electricity bills before proceeding with the experiment and then state how much (recently) they used electricity in their households. They were asked to provide information on the number of inhabitants in the households and the billing period (this varies between households). The program calculated the average consumption per person in the household for a year and showed the value. The first section provided respondents information if their electricity usage per person per year was higher or not then the electricity usage per capita in the 'powiat' of their residence.

The next part of the survey presented general information concerning electricity usage in Poland and DSM. The participants were informed that the politicians and electricity companies are searching for a new ways to reduce costs in power system *inter alia* by engaging households: “The main objective of this experiment is to learn your opinion about cooperation between the customers and distribution company. This cooperation consists of change in your daily habits e.g. in reduction electricity usage during peak hours. Cooperation between consumers and energy suppliers may result in:

- improvement of the power system,
- decrease of environmental pollution,
- energy security of the state,
- reduction of electricity production costs.

Your acceptance does not require the change of the electricity supplier or paying any penalties for changing the contract. The changes would be introduced as an annex to the existing contract. Let us assume that a change in the terms of the agreement could come into force in a year and last for three years. The cooperation would involve the installation of a set of devices in the household that record the consumption of electricity by different receivers, in short time intervals, and transmit this information to the energy plant (without additional costs for the recipient).”

Respondents were informed that everyone who accepts the annex to the contract will receive monetary compensation for participating in the program, paid for every billing period: “the monthly electricity bill will be reduced by compensation for your household”.

In the second part of the survey the respondents were asked to complete the choice tasks. For each choice task they were asked to choose their preferred option from among three alternatives (one alternative was always status quo - SQ) regarding hypothetical contracts restricting people from using energy when they want. The next section included several social-psychological constructs such as e.g.: injunctive and descriptive social norms and beliefs about the energy saving and the climate change The last part of survey collected socio-demographic characteristics of the respondents such as age, education, etc.

Understanding of the scenario, the questionnaire, attributes and their levels were consulted with experts and tested in focus groups and a pilot study.

4.3. Choice attributes and experimental design

The final design comprised 18 choice sets that were blocked into 4 subsets. Each set comprised two policy options (changes in electricity contracts) and a status quo alternative. SQ in each choice task was presented as respondent's current electricity contract. Each option described two measures of external control of household electricity and information dissemination. Attributes and their levels were based on the research by Broberg and Persson (2016), determined by the research question. The final design of electricity contracts is a result of qualitative interviews, focus groups and consultations with experts from an electricity supply sector. Table 2 shows all attributes, their detailed descriptions and levels.

Table 2. Attributes and their levels

Attribute	Description in the study	Levels
External control of domestic electricity in weekdays	"During these hours you are not allowed to use the dishwasher, the electric oven and the laundry machine."	lack (SQ); 6am-9am; 5pm-8pm; 6am-9am and 5pm-8pm
External control in extreme cases	"During certain days there are extreme situations on the energy market. You will be notified one day ahead that the domestic electricity will be turned off for max 4 hours. Extreme situations are more or less random and will be limited to a certain number of days per year."	lack (SQ); 3; 7; 10
Distribution of information	"Information from your electricity meter can be communicated to entities to improve the quality of services."	no (SQ); yes
Compensation (PLN per month)	"A new contract is related to a monthly monetary compensation."	0 (SQ); 5; 10; 20; 30; 50; 60

Note: Nominal exchange rate in 2018: 1 Euro= 4,28 PLN.

The choice sets were created using a Bayesian D-efficient design with fixed priors using the NGene software. The priors were gained using the responses from a pilot study. As efficiency measure the so-called S-estimate was used (Bliemer and Rose, 2011). Choice cards were shown in a random order to avoid ordering effects (Day et al., 2012). Each respondent faced six choice sets in total. An example of the choice set is presented in Figure 1.

	Contract A	Contract B	Current situation
External control of domestic electricity weekdays	6am-9am	5pm-8pm	lack
External control in extreme cases	max 7 days	lack	lack
Distribution of information	no	yes	no
Compensation (PLN per month)	10	50	0
Choice	□	□	□

Figure 1. Example of choice set

5. Results

5.1. Descriptive statistics

Internet-based survey took place in December 2018. There are 1000 participants in the main experiment. It is a representative sample of the Polish population with respect to age, location, the education and sex. A summary of respondents' characteristics is presented in Table 3.

Table 3. Characteristics of the sample: descriptive statistics

	Share (%)	Mean	Std. Dev.	Min	Max
Women	53.16				
Age (years)		46.5	15.43	18	80
Stated net monthly income (PLN)		3791.25	1542.6	500	10500
Net monthly household income (PLN)		5765.14	1981.17	500	10500
Education:					
Primary and Secondary	5.15				
Upper secondary education	58.46				
Higher	36.39				
Place of residence					
Village	40.61				
Town up to 500,000 inhabitants	48.53				
Town above 500,000	10.86				

The average household size in the sample amounts to 3.18 while the average in Poland was 2.69 in 2017. The mean net monthly income accounts for 3791.25 PLN (mean net income in Poland was 3261.34 PLN in 2018) (GUS, 2018).

In Table 4 we compare households with the monthly electricity usage below and above average (for corresponding *'powiat'*).

Table 4. Households with the monthly electricity usage below and above average – comparison

	Usage lower or equal to the average in a *'powiat'*	**Usage higher than the average in a *'powiat'***	**The sample**
Share of respondents %	63.4	36.6	100
Number of inhabitants in a household (mean)	3.46	2.70	3.19
Net monthly individual income (PLN)	3877.19	3644.14	3791.25
Net monthly household income (PLN)	5989.17	5378.51	5765.14
Share of respondents who always choose SQ option (%)	13.6	15.6	14.6
Stated annual electricity usage per person in a household (kWh/year)	424.54	1288.63	737.44

In our study, mean stated electricity usage per person amounts to 737.44 kWh per year. The mean electricity usage in Polish households amounts to 701 kWh per person per year (772kWh in villages) in 2017. 36,6% of respondents used more electricity than average (comparison to the mean value per person in '*powiat*').

5.2. Status quo option

The majority of respondents have always chosen an alternative other than the future status quo (SQ). These people (85.4%) prefer to receive the compensation for the change in the attribute levels compared to the current situation. In Table 5 we present the descriptive statistics for respondents who always choose SQ (14.6%).

Table 5. Respondents who always choose SQ and respondents who want to change the contract – comparison

Variable	**Respondents who always choose SQ**	**Respondents who prefer to change the contract**
Mean stated usage (year) in kWh	765.81	732.59
Mean stated electricity usage higher than average per person in a *‘powiat’* (%)	38	35,7
Net monthly individual income (PLN)	3573	3838
Net monthly household income (PLN)	5463	5824
Age	49.8	45.7
Women (%)	57	52

Respondents who always choose an alternative other than the SQ, on average use less elelctricity than respondents who always choose SQ but the difference is not statistically significant ($t=-0.5358$; $p>0.05$). People with mean stated electricity usage higher than average per person in a ‘*powiat*’ do not choose SQ alternative more often than people with lower usage ($t=-0.6137$; $p>0.05$). Turning to the descriptive statistics, we find the significant difference in age ($t= -2.9734$; $p<0.05$). Older people chose SQ contract more often.

5.3. Estimation results

Table 6 presents the results of the RPL model used to estimate parameters of the respondents' utility functions. Consumers' preference heterogeneity is incorporated into the model by making the utility function parameters random according to a priori selected parametric distributions. The parameters for the non-monetary atributes are assumed to follow normal distribution, whereas parameter for the monetary attribute (i.e. monthly compensation) is assumed to follow lognormal distribution. We allow for full correlation between random parameters. For each non-monetary attribute we report the estimate of the mean and standard deviation of normal distribution. The coefficients do not have direct interpretation, but their signs indicate whether more of a particular attribute is perceived as good or bad on average. Their relative values reflect their relative importance. In order to investigate the effect of the social comparison of electricity usage we include interaction with all attributes of a dummy variable for which 1 indicates a higher electricity usage than average in the ‘*powiat*’.

Table 6. Estimation results RPL

Attributes	**Dist.**	**Main effects**		**Interaction Effects (social comparison)**
		Mean (s.e.)	**Std dev. (s.e.)**	**Coef. (s.e.)**
ASC_SQ	n	- 0.280* (0.167)	2.630*** (0.170)	-0.087 (0.244)
External control of electricity in extreme cases	n	- 0.059*** (0.008)	0.089*** (0.010)	-0.006 (0.012)
Distribution of information	n	0.093 (0.076)	0.689*** (0.095)	0.067 (0.105)
External control of electricity on weekdays, 6am-9am	n	0.027 (0.103)	0.755*** (0.152)	-0.093 (0.141)
External control of electricity on weekdays, 5pm-8pm	n	- 0.419*** (0.084)	1.330*** (0.187)	-0.477** (0.191)
External control of electricity on weekdays; 6am-9am & 5pm-8pm	n	- 0.707*** (0.148)	2.600*** (0.937)	-0.348 (0.214)
Monthly compensation (in PLN)	ln	-2.436*** (0,199)	1.510*** (0.189)	0.261 (0.189)
Model diagnostics				
LL at convergence:		-5291.996		
LL at constant(s) only:		-6545.450		
McFadden's pseudo-R^2:		0.192		
Ben-Akiva-Lerman's pseudo-R^2:		0.435		
AIC/n:		1.778		
BIC/n:		1.8249		
n (observations):		6000		
r (respondents):		1000		

Note: Dist. – distribution; n - normal distribution, ln – log-normal distribution. For lognormally distributed parameters the coefficients of the underlying normal distribution are reported.
***, **, * indicate 1%, 5%, 10% significance level, respectively.

Overall, the model is highly significant. The sign and size of the alternative-specific constant (ASC) indicate that respondents on average prefer change in their electricity contracts compared to the SQ. Our results indicate that disutility is placed on not being able to use certain electrical appliance in evenings and both in mornings and evenings. The control of electricity usage 6am-9am seems to be not significant and does not affect respondents utility. One possible explanation may be that people do not need electric power to use the dishwasher, the electric oven and the laundry machine in the morning. Maybe most people hurry up in the morning and leave their homes early. We note, however, that significant standard deviation indicates some preference heterogeneity in this regard. People in Poland seem to spend time at homes in the evening and may therefore experience discomfort by external control during those hours. The higher average effect (in absolute values) for external control in both, morning and evening (when compared with the evening only) may indicate that some people would like to switch to higher electricity usage in the morning if it would not be possible to use some devices in the evenings. The number of days of external control in extreme cases is significant thus related to discomfort experienced by people. The attribute reflecting sharing information about the electricity consumption does not have a significant mean effect. The most straightforward reason is that people expect improvement in the quality of services when the information is spread and they do not expect compensation for this change in the contract. In Table 7 we report the median willingness to accept changes in electricity contracts (WTA per month).

Table 7. Median WTA per month

	Main effects	**Interaction effects**	
		Usage lower or equal to the average in a *'powiat'*	**Usage higher than the average in a *'powiat'***
Attributes	**MWTA (€)**	**MWTA (€)**	**MWTA (€)**
External control of electricity in extreme cases	0.96***	1.01***	0.88***
Distribution of information	- 1.29	- 1.13	- 1.62
External control of electricity on weekdays, 6am-9am	0.09	0.23	0.72
External control of electricity on weekdays, 5pm-8pm	6.46***	4.61**	9.75***
External control of electricity on weekdays; 6am-9am & 5pm-8pm	10.08***	8.98***	11.69***

Note: Nominal exchange rate in 2018: 1 Euro = 4.28 PLN

The number of days of external control of electricity in extreme cases is assumed to have a linear effect on the choice. On average, respondents require 0.96 € (3.9% of average electricity bill per month) per day of “extreme occasions”. The maximum number of days is ten in the choice design, thus any extrapolation beyond ten may give questionable predictions. The control of household electricity consumption during the evening peak requires 6.46 € (25.9% of average electricity bill per month) of compensation, while control in the morning and in the evening hours requires 10.08 € (40.4% of average electricity bill per month). The latter two outcomes are to some extent expected, given intuition. External control increase the discomfort of not being able to use electric oven, wash clothes or dishes during peak hours. People are more flexible in the morning – they do not require compensation for restrictions put from 6 am to 9 am.

When it comes to the effect of the social comparison on electricity usage, we find that just one interaction term – between the social comparison (of average electricity consumption per person per year) and the evening external control - is significant at 5% level.

People who stated that they use more electricity than an average person in their ‘*powiat*’ have higher disutility when having their electricity usage controlled during 5 pm-8 pm. They need twice as high compensation as people with lower consumption to accept external control (22 PLN = 5.1 € higher compensation). However, there is no other effect when we analyze other attributes of the offered contracts. The result is surprising, it seems that people informed they use more electricity than average do not feel obliged to save the electricity and participate in demand management programs. Perhaps, they are less flexible in electricity consumption and they put higher value in the accessibility and availability of the electric power.

6. Discussion

In this paper we examine the individuals’ preferences regarding electricity demand management in Poland. Additionally, we investigate the effect of social comparison (between a electricity use per capita per year in the respondent’s household use and the average in the respondent’s place of residence - ‘*powiat*’) on the acceptance of contracts which decrease the flexibility of electricity usage. As far as we know, this study is the first to investigate the effect of normative feedback on consumers’ preferences towards DSM programs using discrete choice experiment. We refer to the social comparison theory which states that people compare themselves to others to further self-improvement and a positive self-image. According to psychologists, individuals are constantly evaluating themselves and others across a variety of domains.

In our study we find that the respondents require statistically significant compensation to accept external control of electricity in extreme cases and external control of electricity on weekdays during certain hours. The results are consistent with the literature (Broberg and Persson, 2016; Torriti, 2012). According to Broberg and Persson (2016), the Swedish require 1409 SEK (132 €) of yearly compensation to accept the control of household electricity during the evening peak, while the morning hours require 833 SEK (78 €) per year. In the case of Poland, external control of electricity usage in the morning does not affect consumers. Results suggest that people in Poland are more flexible in their morning energy use and thus require compensations to reschedule their energy use only in the evenings (6.5 €) or in the peak hours during all day (10 € for external control from 6am-9am and 5pm-8pm).

By contrast to previous research, the results indicate that information sharing does not have a significant effect on the probability of choosing a contract. It is important to recall the description of the attribute given in the experiment. Respondents were informed that after signing a contract, their electricity consumption can be communicated to entities (such as research institutes, public authorities, energy companies) to improve the quality of services. The simple interpretation is that people expect the better quality of the services when they share information about electricity usage and they do not need compensation for information sharing. They might prefer transparency of electricity consumption to know the usage of other households. The Poles may be not afraid of losing information about electricity consumption because they are not aware this is confidential data.

The study gives rise to research question: how social comparison affects willingness to accept DSM programs? From a large sample of the Polish population, we find that people who were informed they use more electricity per person per year (compared to the average in a respondent's *'powiat'*) requires higher compensation for external control of electricity in the evenings (weekdays, 5pm-8pm). However, there is no other effect when we analyze other attributes of the offered contracts. It seems that the awareness that their consumption is greater does not encourage people to accept the contracts. It is contrary to the results obtained by Allcott (2011). Perhaps individuals with higher (than average) consumption are not willing to save energy regardless of received feedback. According to Wang et al. (2018), only individuals with strong sense of energy saving end up using less electricity when their electricity usage is larger than or equal to average electricity usage. Social comparison theory shows that individuals may compare to others to improve their self-esteem (Wood, 1989). People may ignore the information given by social comparison to pursue their self-enhancement goals and to see themselves more positively. According to the literature, people prefer comparison based on similar demographics (Egan et al., 1999). Neighbor-based comparison could be more meaningful because neighbors tended to report similar behaviors and attitudes (see: Iyer et al., 2006). Some of the respondents may consider the average usage per person per year, in *'powiat'* not a good benchmark. Another explanation is that financial incentives together with normative messages not only fails to strengthen the effect of the feedback but can even reduce it (see Pellerano et al., 2017; Dolan and Matcalfe, 2015). There is a conflict between extrinsic incentives (compensation) and intrinsic motivation (the impact of social comparison).

We provides the estimation of compensation for participating in demand management. Results suggest that households in Poland are willing to accept restrictions in energy usage and they need a compensation for changing their behavior. Our findings could help to design new electricity contracts including demand management. The results indicate that information sharing does not inconvenience respondents. A policy aimed at compensating people for information sharing is aimless. Providing consumers with normative feedback does not affect their choices in an expected way. Including normative feedback in DSM programs requires reflection. More research is needed to better understand the impact of social comparison on public preferences toward new policies. Respondents were asked to provide consumption on the basis of the electricity bill. There was no control on the accuracy of the values enumerated by them. Some respondents could give false data. In the future, it is worth expanding the research and conducting Computer Aided Personal Interviews where people are asked to show their electricity bills.

The implementation of smart meters in Poland and new solutions in the demand side is promising for the improvement in energy efficiency. We hope that this study will provide insights on the policy options for Poland's energy transition towards sustainable development. It is essential to understand the conditions under which people will accept new electricity contracts – how much compensation they need. The results can be used for cost benefit analysis of possible DSM programs.

We still need to investigate the generalizability of these results. For future research, a few extensions of the experiment can be done. The choice experiment could include another attributes related to electric power services, for example new tariff plans, external control of usage for another electric appliances or the load reduction. It would be interesting to combine data from the choice experiment with the readings from electric meters. It will be possible to examine the relationship between electricity usage, the profile of consumption and the willingness to accept changes in electricity contracts. It would be beneficial to collaborate with electric power distributors who have the electric readings to test different Demand Side Management programs and find out the impact of social comparison on electricity usage. Automated Metering Infrastructure will provide detailed data about electricity consumption profiles and thus allow for deeper insight. The studies about DSM are important for energy related policy-making.

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