Energy Demand Management and Social Norms

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Abstract: The main objective of our study was investigating the impact of norms and financial motivation on the disutility of energy management for Polish households. We analyzed consumer preferences and willingness to accept demand-side management (DSM) programs. Choice experiment was applied for electricity contracts including external control of electricity consumption. Ajzen's theory of planned behavior provided the theoretical framework of the study, which tested hypotheses about the impact of social norms on consumer choices of electricity contracts. We show that people with higher descriptive social norms about electricity consumption are less sensitive to the level of compensation and more responsive to the number of blackouts. People willing to sign a contract for financial reasons were less sensitive to the external control of electricity consumption and less inclined toward the status quo option. Injunctive social norms and personal norms had a non-significant impact on consumer decisions. We conclude that financial incentives can reduce the effect of the norms. Social and personal norms seem to be more important when we analyze the revealed preferences. European countries face significant challenges related to changes in energy policy. This study contributes to understanding the decisions of households and provides insights into the implementation of DSM.

Keywords: choice experiment; demand-side management; electricity; social norms; willingness to accept

1. Introduction

Electricity use has increased exponentially since the Industrial Revolution, affecting the long-term sustainability of our planet [1]. The growing demand for electricity intensifies global warming. Climate change policies focus on reducing electricity consumption, but given the expected growth in demand, more coordination is required in the power systems. Household energy conservation is both a challenge and an opportunity for researchers and decision makers, and energy management offer possibilities for solutions that address energy security and climate change.

Energy is a key factor for economic growth, development, and well-being, and the power systems need to continuously maintain a balance between electricity supply and demand. A power deficit is a typical technical problem that is often experienced during peak load. It occurs when the production and import of electricity cannot cover consumption. When peak demand is high, there is a risk of power shortage. This challenge to the grid often results in supply-side measures, such as investing in power plants to satisfy the demand, as well as higher tariffs for consumers. Researchers have proposed various solutions to this problem, including time-of-use pricing, load control, education, increasing consumer awareness of energy costs and environmental pollution, and providing the information about the current use (feedback). These measures are known as demand-side management (DSM).

DSM reduces the risk of blackouts and could reduce CO_2 emissions [2,3]. It modifies electricity demand through behavioral change by making consumers more aware of their electricity use [4,5].

To date, DSM analysis has focused only on economic factors, and this approach overlooks the psychological factors that may have a dominant influence on the effectiveness of specific DSM mechanisms and programs. In particular, analyses have not considered the involvement of consumers and the consequences of their choices.

The development of the electricity market sources requires an active role of consumers as part of modern intelligent power networks (ISE). The implementation of DSM programs needs social acceptance, and we aim to examine its determinants. A key cause of people's actions and feelings is how they compare with others [6–8], and research suggest that social norms is important determinant of decisions about electricity consumption [9,10]. Yet, there is a need to better understand the impact of social norms on people's decisions about electricity consumption. This study contributes to understanding the role of social norms and personal norms in making decisions about electricity contracts. We develop the hybrid model analyzing the relationship between norms, financial motivation, and preferences for DSM programs.

The innovative part of the study refers to the theory of planned behavior (See: Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In action control (pp. 11–39). Springer, Berlin, Heidelberg). Researchers have highlighted the need for references to social norms in analyses of behavioral change (e.g., Allcott [11], Horne and Kennedy [9], Kažukauskas et al. [12]). Cognitive, motivational, and contextual factors determine electricity consumption, and much more attention should consequently be given to the behavioral aspects of the decision-making process (e.g., Clark et al. [13], Whitmarsh [14], Guo et al. [15]). The theory of planned behavior provides a clear structure for the model that we develop in this study and helps to explain factors that influence people's behavior. Social norms form the basis of the theory, and the model is flexible and can be further extended if significant variables are identified. Using the theory, we focus on the financial motivation for signing the new contracts with power companies. Previous research shows that tension exists between extrinsic incentives and intrinsic motivation [10,16–18], and we assumed that people motivated by financial incentives would require higher compensation for signing the contracts. Considering this, we test the following hypotheses:

1. Consumers who believe that other people control their own electricity use and save energy (descriptive social norm) are less sensitive to the attribute levels and to the level of compensation for restrictions.
2. Consumers who think that controlling electricity use and saving energy are socially approved behaviors (injunctive social norms) are less sensitive to the attribute levels and to the level of compensation.
3. Consumers who feel morally obligated to control electricity consumption (personal norm) are less sensitive to the attribute levels and to the level of compensation.
4. People who would sign the contract because of financial motivation are more sensitive to the level of compensation for restrictions.

In what follows, we use a discrete choice experiment (CE) to examine the value that consumers in Poland place on the changing their electricity use habits (e.g., shifting electricity usage in time). The CE is a method that allows for inferring about consumer preferences based on their stated choices in specifically designed choice situations [19,20]. The method is grounded in the consumer theory of Lancaster [21], which states that goods can be described in terms of their attributes. If we observe people's choices between goods, we can deduce which attributes are the most important to them and what their preferences are. We can estimate a marginal rate of substitution (MRS) between the attributes. The MRS between a monetary and a non-monetary attribute is equivalent to a marginal willingness to pay (WTP) or a willingness to accept (WTA) the change in the non-monetary attribute. The analysis of the choice data relies on the random utility theory [22], and its results offer necessary information to the government and electricity providers regarding consumer preferences on electricity services.

To the best of our knowledge, our study is the first investigation of the impact of norms and financial motivation on preferences for DSM. Poland experiences significant challenges related to changes in energy policy. This study analyzes the preferences related to the DSM of electricity use by Polish households. Little research has been conducted on the DSM in this region (Central and Eastern Europe).

Poland faces many environmental problems caused by its heavy reliance on coal and a rising trend in energy demand. The decline in air quality caused by industry, traffic, and coal stoves has had adverse impacts on Polish health and quality of life. Of the 50 most polluted cities in Europe, 36 are in Poland [1]. In addition, supply shortages and outages pose a problem in Poland, and increased consumption of electricity during peak hours can lead to a situation in which demand exceeds the capacity of the system. According to scores for the system average interruption duration index and the system average interruption frequency index, end-uses in Poland lose their electric power supply more often than consumers in most European countries and blackouts have a longer duration [23]. These factors have collectively turned environmental research interests toward renewable energy sources and energy management.

Progress toward sustainability in Poland requires in-depth analyses of possible solutions. The Polish Energy Policy focuses on energy efficiency, long-lasting security, reduction of greenhouse gas emissions, and decarbonization of the transport system [24]. Energy security is often attained by investing in power plants. Meanwhile, power generation companies must be well equipped and ensure that their facilities are capable of meeting demand. There are three approaches to preventing power deficit from occurring:

- technical, which may involve reducing voltage, switching off the power supply, and using demand-side response (DSR) mechanisms;
- economic, which may use DSR mechanisms (e.g., tariffs with a critical price rate); and
- psychological, which relies on DSR mechanisms in which marketing and consumer reactions to particular stimuli play a very important role [25].

One method for controlling the electricity demand is DSM [2], which creates greater flexibility in energy consumption and enables achieving environmental targets. Balance involves managing the supply in the wake of demand, and households have the potential for balancing real-time energy supply and demand because they make up a large share of total electricity consumption. Previous research has shown that DSM is an effective strategy within energy systems [26–29].

Open questions include whether households know all the opportunities and whether they are willing to engage in the sustainable development of the electric power system and improvement of its efficiency. The power system could be made more secure and efficient by engaging consumers and encouraging them to change their daily routines. One possibility for achieving this goal is to design electricity contracts that put restrictions on electricity consumption. For example, households may be willing to change their use for monetary compensation. Research about preferences for electricity services could help guide recommendations for the politicians and companies responsible for introducing smart technologies, such as smart meters, in Poland. Our aim in this paper is to shed light on the preferences for electricity attributes in Polish households.

Behaviorists assume that people's behavior is influenced by the interaction between intrapersonal factors (e.g., values, attitudes), interpersonal factors (e.g., social comparisons, social norms), and external factors (e.g., financial incentives) [30]. Saving electricity can be triggered by three types of motivations:

- intrinsic motivation leads to behavior that is motivated by internal rewards,
- extrinsic motivation leads to actions to earn external rewards or avoid punishment, and
- reputation or image motivation leads to action that improves one's reputation.

Financial incentives are also effective in behavior control, but the effect depends on the amount paid. Extrinsic motivations may also take the form of non-financial rewards, such as those achieved through competitions and goal setting. Veblen [31] argued that consumption is used both to gain and

to signal social status. Consumption involves a potential element of waste (waste of effort, time, and goods). Public information about the consumption appeal to the desire for social approval, thus can motivate consumers to save electricity. Image motivation appear if pro-social behavior works as a sign of virtuousness and creates a positive perception.

Using feedback information to change daily habits requires that households have adequate motivation. People can benefit from having a "green reputation" and making pro-environmental behavior visible therefore stimulates "green" behavior [32]. Visibly pro-social behavior creates a desirable reputation, and sharing information about electricity consumption can incentivize consumers to save electric power by meeting their need for social approval. Research show that people are inclined to follow the behavior of others, then social proof is crucial in the decision-making process [33].

Providing households with information on how their electricity consumption compares with similar households in their neighborhood reduces electricity consumption among higher-than-average users [11,34,35]. This feedback is sufficient to motivate consumers to reduce their electricity usage, and providing information on the consumption of the average household can encourage electricity savings [10]. For example, households might purchase appliances that consume less energy, or they might try to reduce how much they use appliances. Feedback helps consumers understand their routines that generate load profiles and take energy-saving actions. Furthermore, feedback messages about electricity consumption with normative elements were previously found to be more effective in changing behavior [36]. Feedback literature shows energy savings of 1–23.3%, depending on the information and context. In a review of the studies, Vine et al. [27] found that feedback resulted in 5–20% reduction in electricity usage.

Competition between consumers can lead to electricity savings [37]. Making the results of such competitions visible in a social network (e.g., Facebook) plays a crucial role by encouraging them and providing needed support. According to Gölz and Hahnel [38], reduced electricity use after receiving feedback results from a mix of purposes rather than one motivating factor. Consumption is influenced by the willingness to reduce costs, have fun, learn to save electricity, and control and avoid inconvenience. Providing consumers with information about saving measures increases the willingness to reduce electricity usage in households [39]. Schleich and co-workers [40] found that feedback was effective tool to reduce electricity consumption in households within the 30th to 70th percentile range of usage. For households above or below this range, it had no impact.

Inducing consideration about daily habits can stimulate spread of knowledge among households and reduce electricity consumption even more. One study showed that consumers limited the use of using certain equipment when they knew that they needed more electric power than others [41].

We can explain changes in electricity consumption using the social norms theory. Sociologists claim that electricity usage is collective behavior: "behavior is social in the sense of being oriented to socially sanctioned goals" [42] (p. 29). Studies have shown that norms regulate household energy consumption (e.g., Harries et al. [43] and Horne and Kennedy [9]). In particular, individuals can use information about usage in a similar household as a benchmark [44].

The two types of norms, social (descriptive and injunctive norm) and personal, are distinct from one another [45]. Beliefs about the extent to which other people reduce their electricity use—descriptive social norms—can trigger an individual's willingness to do the same. Such beliefs can increase the perception that changing habits to reduce electricity usage is a desirable activity. Simply by living in society, an individual can be swayed by social influences. Injunctive social norms refer to beliefs about what behavior is approved by society. According to the study by Loock et al. [46], injunctive norms feedback reduces usage, while descriptive norms feedback results in increased consumption among consumers below the average electricity consumption.

Personal norms are the closest indicator of behavior [47]. They represent the moral obligation to adopt certain behavior. Taking pro-social behavior depends on the presence of self-transcendent values. Rewards and sanctions tied to personal norms are included to the concept of self, and in this way, conformism to personal expectations creates pride, self-esteem, security, and so forth. In contrast,

non-conformism to personal norms induces guilt [48]. Personal norms predict intentions, and in turn, are predicted by social norms. Social norms could be adopted as personal norms to the extent that an individual identifies with the group from which the norm comes.

People prefer to present themselves to others as caring about the environment. Horne and Kennedy [9] proved that people have more positive impressions of persons who worry about carbon emissions reduction than those who want to save on electricity bill. Reductions in carbon emissions are supported by both social norms and individual values. Cherchi [49] showed that social conformity effects are highly significant in explaining the demand for electric vehicles. This finding suggests that injunctive social norms boost the demand for electric vehicles. According to literature giving information about the electric power consumption of average neighbor is adequate to encourage individuals to reduce their electric power usage [10]. In a study carried out in Ecuador, providing social comparison messages for households reduced electricity consumption above the referential neighbor by around 1% [16]. The social comparison effect could be more powerful than other motivators such as conserving resources, saving money, and being socially conscious [50]. Feedback can be an effective incentive, similar to monetary reward [51].

Financial motivation has two effects on behavior: direct (price effect) and indirect (psychological effect). Economists expect that higher financial incentives result in more effort and are more effective in changing behavior. However, they can weaken the intrinsic motivation needed to act. These two kinds of motivation may work in opposite directions. Some authors argue that the price effect overshadows incentivized behavior. For example, giving financial rewards to students may signal that the task is difficult or that the agent is not prepared enough to achieve the goal. Titmuss [17] was the first economist to analyze the crowding-out effect. He found that financial incentives for blood donors could reduce the number of people who donate.

Social norms may affect the impact of financial incentives [52]. Dolan and Metcalfe [10] showed that substantial monetary rewards worked online in amending the level of electricity consumption over 4 months, but the effect was absent when they included information on social norms in the study. Furthermore, the impact of the monetary incentive was reduced by the information with the social norm.

A tension appears between intrinsic and extrinsic motivation, and more research in needed on their interactions. In this study, we analyzed the impact of descriptive social norms and the impact of financial motivation on the preferences for electricity contracts including DSM.

2. Materials and Methods

To investigate consumer preferences for changes in electricity supply and verifying our research hypotheses we designed and conducted a CE study. The choice situations included in the survey presented respondents with a hypothetical future electricity supply contracts that implied external control of electricity consumption. The following sections present the details regarding attribute selection, design of the choice experiment and survey and econometric framework for the analysis of choice data (For more information about design and uses of CE see [53–55]).

2.1. Choice Experiment and Experimental Design

The choice situations presented to respondents consisted of two hypothetical electricity contracts and a status quo (SQ) option (current electricity contract). Alternatives described two methods of control of household electricity consumption and information sharing. The design and attributes were inspired by Broberg and Persson [56]. The contracts presented in the experiment specified control of electricity usage from 9:00 to 10:00 a.m. and from 5:00 to 8:00 p.m. weekdays, typical peak hours in Poland. The reference level is "no control". The random external control attribute in the contracts referred to the situation in which the electricity system is affected by production disruptions and sudden changes in the demand (i.e., there are price fluctuations in the wholesale market). Distribution of information allows sharing the data (e.g., to improve the quality of supply, offer personalized

services). The final design of the CE was a result of focus groups, in-depth interviews, and consultations with experts from an electricity supply sector. Table 1 shows all attributes, detailed descriptions, and attribute levels, as used in the study. More information about the experiment can be found in: Gołębiowska, B., Bartczak, A., & Budziński, W. (2019). Impact of social comparison on DSM in Poland. University of Warsaw Faculty of Economic Sciences Working Papers. (No. 2019-10).

Table 1. Attributes and their levels. Reprint with permission Gołębiowska, B., Bartczak, A., & Budziński, W.; Copyright 2020, University of Warsaw Faculty of Economic Sciences. https://www.wne.uw.edu.pl/files/6115/6501/8862/WNE_WP295.pdf.

Attribute	Description of 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); 6:00–9:00 a.m.; 5:00–8:00 p.m.; 6:00–9:00 a.m.; and 5:00–8:00 p.m.
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 a maximum of 4 h. 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 a third party to improve the quality of services."	No (SQ), yes
Compensation (PLN per month)	"A new contract is related to monthly monetary compensation."	0 (SQ), 5, 10, 20, 30, 50, 60

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

Each participant was asked to make six choices. The choice sets were created using NGene software to maximize Bayesian D-efficiency (with fixed priors). The priors were based on the results from a pilot study [57]. The experimental design included 24 choice sets blocked into four subsets (4 blocks × 6 choice tasks). Choice cards were given in a random order to avoid ordering effects [58]. Table 2 presents an example of a choice task.

Table 2. Example of choice task.

	Contract A	Contract B	Current Situation
External control of domestic electricity weekdays	6:00–9:00 a.m.	5:00–8:00 p.m.	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	☐	☐	☐

2.2. Survey Structure and Data Collection

The survey consisted of the following sections:

1. The respondents (selected by the polling agency to provide representativeness) gave information on the last electricity bill. They were informed about how their electricity usage per person per year differed from the electricity usage per capita in their place of residence (social comparison).

2. The respondents were informed that the electricity companies want to engage consumers in the power system to reduce the costs (DSM). Participants were informed that if they accept the annex to the contract, they would receive a compensation for participating in the DSM program, and that the compensation would be given in every billing period: "The monthly electricity bill will be reduced by compensation for your household". Then, the participants were asked to choose between various contracts limiting using electricity when they want (CE part).

3. The next part of the study focused on social-psychological constructs: personal norms, descriptive and injunctive social norms, beliefs about saving energy and beliefs about the effects of climate change. The indicators for norms were based on the answers on the Likert scale to the questions for norms scales (Table 3).

Table 3. Norms scale.

The Scale	Please Answer the Question on the 7-Point Scale								Your Opinion (0–7)
	Strongly Disagree: 1	Disagree: 2	Somewhat Disagree: 3	Neither Agree nor Disagree: 4	Somewhat Agree: 5	Agree: 6	Strongly Agree: 7	Don't Know: 0	
Personal Norms	I feel obliged to save electricity no matter what other people do.								_____
	I feel guilty when wasting electricity.								_____
	I worry about lowering electricity consumption only when saving can reduce electricity bill.								_____
	My household should not be blamed for environmental problems related to electricity consumption.								_____
Injunctive Social Norms	People should control electricity use.								_____
	People should care for the environment.								_____
	People should save electricity.								_____
	People should care for the security of the power system in Poland *.								_____
Descriptive Social Norms	Most people save electricity.								_____
	Most people are interested in the security of the power system in Poland.								_____
	Most people care for the environment.								_____
	Most people control electricity use.								_____

* Security of the power system is a common good, and cooperation with consumers contributes to increased security of supply. The EU's energy policy has established many initiatives to encourage consumers to be an active part of the energy transition and to assist them to save more electricity.

The theory of values beliefs norms was the theoretical framework of the questionnaire. We made use of the results by Ibtissem [47] to choose the questions for social norms scales and personal norms scale. The answer "don't know" was treated as a missing value in the model.

4. At the end of the questionnaire, respondents were asked about their sociodemographic characteristics, such as education, income, and so forth. The questionnaire, the attributes, and their levels were determined through focus groups, pilot study, and consultation with experts.

The survey was administered to the representative sample of 1,000 respondents from the general population of Poland, quota controlled for education, location, age, and sex (the detailed characteristics of the sample in: Gołębiowska, B., Bartczak, A., & Budziński, W. (2019). Impact of social comparison on DSM in Poland. University of Warsaw Faculty of Economic Sciences Working Papers. (No. 2019-10). https://www.wne.uw.edu.pl/files/6115/6501/8862/WNE_WP295.pdf). In the sample, the average household size equaled 3.18, while the average for the whole country was 2.69 in 2017. The mean net monthly income was 3791.25 PLN (mean net income in Poland was 3261.34 PLN in 2018) [59].

2.3. Econometric Framework—The Hybrid Choice Model

The econometric analysis builds on hybrid choice models [60]. This modelling technique has been applied in the transportation literature (e.g., [61–64] with a growing number of applications in environmental economics (e.g., [65–78]).

A hybrid choice model is a structural model that allows incorporating latent constructs (e.g., perceptions) into a random utility framework. The main advantage of this approach is that while latent variables are imperfectly inferred from measurement (indicator) variables, the use of a structural model allows accounting for measurement error and hence avoiding bias associated with incorporating indicator variables directly into a choice model (e.g., as indicators with choice attributes; Budziński and Czajkowski [79]).

The discrete choice component of a hybrid model relies on the random utility framework [80], under which people choose the alternative maximizing their utility. Formally, the utility that person obtains from chosen alternative in the choice task *t* is defined in the following equation:

$$U = X_{ijt}\beta_i + \varepsilon_{ijt} \tag{1}$$

A respondent's utility level consists of deterministic and nondeterministic components. The deterministic elements relate to the observed characteristics of the alternative, and the nondeterministic components relate to unobserved characteristics. Specifically, *X* stands for the levels of attributes associated with available alternatives, and the stochastic component ε, relates to the factors that influence the individual's utility, unobserved by the econometrician. β_i stands for individual-specific parameters to be estimated; thus, express the preferences towards the alternative's characteristics. Following common practice, we assumed that the parameters of the attributes were normally or log-normally distributed (based on model fit).

Following the method provided by Bahamonde-Birke et al. [81], we assume that the parameters β depend on the unobservable latent variables. We determine a vector of respondent-specific latent variables by *LVi* (in our case, this vector consists: personal norms, descriptive social norms, and injunctive social norms). The relation between the latent variables and the non-monetary preference parameters can be illustrated by the following:

$$\beta_i = \Lambda' \, LVi + \beta i^* \tag{2}$$

where Λ stands for a matrix of coefficients to be estimated and βi^*, has a multivariate normal distribution with a vector of means and a covariance matrix to be estimated.

The latent variables in our model capture respondent social norms (descriptive, injunctive), personal norms, and financial motivation. These unobservable factors may be in relation to individual preferences, but they cannot be measured directly and objectively, as is possible with income, education, sex. Instead, our survey included social norms (descriptive, injunctive), personal norms indicators questions. Answers to the indicator questions were expected to be determined by the person's underlying attitudes, which are latent variables. Measurement equations, then, model the self-reported measures of the social norms, attitudes, and motivation as functions of the latent variables. This relationship can be formulated as follows:

$$I_i = LV_i\Gamma + \eta_i \tag{3}$$

where I_i are indicator variables, which are related through Equation (3) to the corresponding LV that they contribute to measuring; Γ is a matrix of coefficients; and η_i, corresponds to a vector of error terms assumed to have a multivariate normal distribution with an identity covariance matrix, and zero means.

The responses to the attitudinal questions related to social norms were collected with the use of 7-point Likert scales (see Table 3). An absolute interpretation of the Likert-scale answers is commonly imposed in the psychometric literature. In the measurement component of our model—to capture the ordinal nature of the response scale, without imposing any restrictions—we used an ordered probit for the indicator variables. This method also allowed assigning (potentially) different weights to each of the possible answer to the indicator statements. This helps to avoid misinterpretation of the responses and potential biases that result from using, for example, linear regressions [82] (Numerous studies assume linear relationships between responses (i.e., the equivalent distance between response scales). For instance, they apply 1 to "I disagree strongly", 2 to "I disagree moderately", and so on. This is a strong assumption to force as the differences between the categories are much subtler. Despite there could be almost no distinction between "I disagree strongly" and "I disagree moderately", there could be more noteworthy difference between "Neither agree nor disagree" and "Agree a little". Using the ordered probit model uses an ordinal scale to interpret the scores provided by respondents, flexibly sets the thresholds between neighboring answers). Secondly, we measure each of the latent variables with the use of several belief and attitudinal questions. In previous studies, the answers to the questions corresponding to the latent variables often were added up, following possible reverse coding, as necessary (e.g., Gosling et al. [83]). However, our framework includes the situation when some of the questions are more efficient than others in measuring a specific latent variable. Therefore, each latent variable enters the measurement equations of each relate indicator question, with a different coefficient, hence taking into consideration an independent relationship. At last, all elements of the model are estimated jointly—the model is estimated using a full-information log-likelihood function. Numerous studies have used a two-step methodology in which, for instance, singular factor scores are determined first and afterward interacted with utility function parameters in a subsequent step (e.g., [84,85]). Our model is statistically more efficient by estimating both steps simultaneously.

The full-information likelihood function is presented in Equation (4):

$$L_i = \int P\,(y_i/X_i,\,\beta_i,\,\Lambda,\,\Gamma)\,P\,(I,\,\Lambda,\,\Gamma)\,f\,(\beta_i^*)\,d\,(\beta_i^*) \tag{4}$$

where y_i represent individual $i's$ choices. The random disturbances of β are not directly observed, then they must be included out of the conditional likelihood. The simulated maximum likelihood method could be used to approximate the multidimensional integral. We used 10,000 Sobol draws with a random linear scramble [86] to simulate the log-likelihood function (The models introduced in this article were estimated using a DCE (discrete choice experiment) package created in Matlab and accessible from github.com/czaj/DCE. The code and data for the specific models, as well as supplementary outcomes, are available on: http://czaj.org/research/supplementary-materials).

3. Results

3.1. The Motivation to Accept DSM

Respondents were asked what motivated them to agree on the new contract (multiple-choice questions). Table 4 shows the answers.

Table 4. The reasons for accepting the contract.

What Motivated You to Accept the Contract?	Share (%)
Improving the stability of the power system in Poland	38.3
Reduction of environmental pollution	52.3
Increasing the energy security of the state	39.9
Reduction of electricity production costs	65.4
A sense of social responsibility	31.6
Receiving monetary compensation	50.4
Reduction of greenhouse gas emissions	22.4

Half of the sample declared that receiving monetary compensation was the reason for signing the contract. More people chose the reduction in electricity production costs (65%) and the reduction of environmental pollution (52%) as the motivators.

The WTA DSM was presented in the Appendix A (the model as well as the results were presented in previous paper).

3.2. Hybrid Models

3.2.1. Model I. Personal Norm, Descriptive Social Norms, and Injunctive Social Norms

The first estimated hybrid model tested the hypothesis about the impact of injunctive social norms, descriptive social norms, and personal norms on consumer preferences for DSM.

Table 5 presents the results of the hybrid model—the estimated parameters of the individual utility functions. The parameters for the attributes were assumed to follow a normal distribution, apart from the parameter for blackouts, which was assumed to follow a lognormal distribution. We do not interpret the coefficients directly, but their signs show whether an increase in a specific attribute was perceived as good or bad (on average). The relative values of the coefficients stand for their relative importance. We included interaction with all attributes of latent variables reflecting three types of norms: personal norms, injunctive social norms, and descriptive social norms to investigate the impact of these norms on preferences.

Overall, the model is highly significant. The size and sign of the status quo alternative specific constant indicate that participants on average preferred signing new electricity contracts compared to the SQ.

The interactions of means with latent variables enabled testing the hypothesis about the impact of norms on consumer preferences. The interaction terms for personal norms are non-significant. Consumers who felt morally obligated to control electricity consumption (personal norm) were not more willing to accept new contracts (DSM) and needed the same compensation for the restrictions on electricity use as other respondents. Regarding the effect of the injunctive social norms on the preferences, we found just one interaction term significant at the 10% level. Consumers who viewed controlling electricity use and saving energy as socially approved behaviors were more sensitive to information sharing. They gained more satisfaction from information sharing.

Regarding the effect of the descriptive social norms on preferences, three interaction terms (with the number of blackouts, the external control in the evenings, and compensation) were significant at the 5% and 1% levels. Consumers who believed that other people control their own electricity use and save energy were more sensitive to the number of blackouts and less sensitive to the control in the evening peak hours, and to the level of compensation (DSM).

Table 5. The results of the hybrid choice model linking respondent social norms perceptions with their economic preferences for electricity supply attributes.

Discrete Choice Component						
	Dist.	Mean	St. dev.	Personal Norms	Injunctive Norms	Descriptive Norms
Status quo (alternative specific constant)	n	−0.2549 ** (0.1208)	2.6473 *** (0.1313)	−0.1207 (0.2375)	−0.0194 (0.2041)	−0.0913 (0.1552)
Blackout no.	l	−3.7620 *** (0.2911)	1.6645 *** (0.2810)	−0.1285 (0.2569)	0.1211 (0.1864)	−0.3905 ** (0.1628)
Usage information shared	n	0.1281 *** (0.0463)	0.4902 *** (0.0978)	−0.0003 (0.0913)	0.1351 * (0.0757)	0.0510 (0.0589)
Electricity reduction—6–9 a.m.	n	−0.0200 (0.0680)	0.6777 *** (0.1159)	−0.0175 (0.1296)	−0.0048 (0.1069)	0.0495 (0.0863)
Electricity reductions—5–8 p.m.	n	−0.4682 *** (0.0787)	0.5629 *** (0.1532)	−0.0193 (0.1689)	−0.1871 (0.1339)	0.1658 * (0.1004)
Electricity reductions—6–9 a.m. and 5–8 p.m.	n	−0.4739 *** (0.0830)	0.6891 *** (0.1564)	0.3089 (0.1952)	−0.1913 (0.1511)	0.0298 (0.1071)
Compensation (10 PLN)	n	0.1978 *** (0.0169)	0.3021 *** (0.0222)	0.0449 (0.0308)	0.0396 (0.0261)	−0.0602 *** (0.0207)
Measurement Equations						
	Personal Norms		**Injunctive Norms**		**Descriptive Norms**	
I feel obliged to save	1.3560 *** (0.1872)					
I feel guilty when wasting	0.9729 *** (0.0963)					
I worry when saving can reduce the bill	0.2407 *** (0.0504)					
My household should not be blamed	0.4627 *** (0.0541)					
Should control el. use			1.8779 *** (0.1230)			
Should save el.			1.8631 *** (0.1251)			
Should care for env.			1.8455 *** (0.1257)			
Should care for en. security			1.4834 *** (0.0888)			
Most people save					1.4155 *** (0.0852)	
Most people interested in security					1.2196 *** (0.0733)	
Most people case for env.					1.4041 *** (0.0849)	
Most people control el. use					1.5556 *** (0.1011)	
Model Diagnostics						
LL at convergence:			−22,380.75			
LL at constant(s) only:			−25,438.81			
McFadden's pseudo-R^2:			0.1202			
Ben–Akiva–Lerman's pseudo-R^2:			0.4299			
AIC/n:			7.4999			
BIC/n:			7.6328			
n (observations):			6000			
r (respondents):			1000			
k (parameters)			119			

Notes: ***, ** and * indicate significance at the level of 1%, 5%, and 10%, respectively. The significant results are bolded in the tables. Standard errors (s.e.) are given in brackets. For the log-normally distributed attribute parameters the estimates of the underlying normal distribution are provided. Ordered probit threshold parameters are skipped for brevity; full estimation results are available in the online Supplement Materials to this paper.

3.2.2. Model II. Descriptive Social Norms and Financial Motivation

In the next step of our analysis, we decided to incorporate another factor affecting consumer choices—financial motivation. We computed the hybrid model to examine the impact of descriptive social norms and financial motivation on preferences.

Table 6 presents the results of the hybrid model used to estimate the parameters of the respondent utility functions. We included interaction with all attributes of latent variables reflecting the descriptive social norms and financial motivation to investigate their effects.

Table 6. The results of the hybrid choice model linking respondent descriptive social norms perceptions and financial motivation with their economic preferences for electricity supply attributes.

	Dist.	Mean	St. dev.	Descriptive Norm	Financial Motivation
Status quo (alternative specific constant)	n	−0.4877 *** (0.1265)	2.3349 *** (0.1988)	−0.0257 (0.1338)	0.7786 *** (0.2863)
Blackout no.	l	−3.9834** (0.3563)	1.6269 *** (0.3176)	−0.3322* (0.1810)	1.6311 *** (0.4073)
Usage information shared	n	0.1855 *** (0.0513)	0.4086 *** (0.1127)	0.0413 (0.0509)	0.0684 (0.0906)
Electricity reduction—6–9 a.m.	n	−0.0529 (0.0763)	0.6712 *** (0.1189)	0.0665 (0.0789)	−0.3851 *** (0.1249)
Electricity reductions—5–8 p.m.	n	−0.5170 *** (0.0864)	0.0968 (0.3659)	0.1241 (0.0916)	−0.9410 *** (0.1378)
Electricity reductions—6–9 a.m. and 5–8 p.m.	n	−0.7883 *** (0.1111)	0.0100 (0.1873)	0.1249 (0.1130)	−1.6921 *** (0.1556)
Compensation (10 PLN)	n	0.1868 *** (0.0173)	0.2684 *** (0.0282)	−0.0292* (0.0177)	−0.0437 (0.0324)
Measurement Equations					
Financial Motivation					
Signing the contract because of monetary compensation		−0.1819 *** (0.0629)			
Model Diagnostics					
LL at convergence:		−11,562.88			
LL at constant(s) only:		−13,488.06			
McFadden's pseudo-R^2:		0.1427			
Ben–Akiva–Lerman's pseudo-R^2:		0.4341			
AIC/n:		4.0562			
BIC/n:		4.1235			
n (observations):		5730			
r (respondents):		955			
k (parameters)		58			

Notes: ***, ** and * indicate significance at the level of 1%, 5%, and 10%, respectively. The significant results are bolded in the tables. Standard errors (s.e.) are given in brackets. For the log-normally distributed attribute parameters the estimates of the underlying normal distribution are provided. Ordered probit threshold parameters are skipped for brevity; full estimation results are available in the online Supplement Materials to this paper.

The model is highly significant. The size and sign of the status quo alternative specific constant show that participants on average preferred signing new electricity contracts compared to the SQ. The outcomes indicate that respondents place disutility on not being allowed to use certain electrical home appliances in the evening peak hours and the mornings and evenings. The control of electricity consumption at 6:00–9:00 a.m. seemed to be non-significant and did not have an impact on individual utility. One possible justification is that consumers do not need the laundry machine, the electric oven, and the dishwasher in the morning hours. Poles tend to spend more time at home during evening hours than in the morning hours and consequently experience inconvenience by the control in the evening peak hours. Average effect for external control in both morning and evening hours is higher in absolute values suggesting that some consumers would like to switch to higher electricity consumption at 6:00–9:00 if using some appliances in the evenings would not be allowed. The significant result for the number of days of control in extreme cases is related to the discomfort experienced by respondents. The effect of information sharing has a significant mean effect. In contrast to previous studies, the outcomes indicate that sharing information about electricity consumption (with a third party) has a positive impact on the probability of choosing a contract. The most straightforward explanation is that respondents anticipate improvements in the service quality if the information is spread and they do not need compensation for this kind of change.

We chose the descriptive social norms to the ultimate hybrid model because the DSM program proposed in the experiment requires the engagement of a large group of end-users; otherwise, the program cannot be effective in peak load reduction. People who believe that others take responsibility for energy security and control energy use are expected to be more willing to sign new contracts.

Regarding the effect of the descriptive social norms on preferences for DSM, we found that just two interaction terms were significant at the 10% level. People who perceived descriptive social norms about electricity consumption—higher descriptive social norms as measured on the survey—were more sensitive to the number of blackouts. They were less sensitive to compensation compared with people with low descriptive social norms.

Financial motivation was proved to influence consumer preferences. Respondents who stated that they would sign contracts because of financial reasons revealed lower responsiveness to the changes in attribute levels (apart from the blackouts). They were less inclined toward the SQ option. Surprisingly, the level of compensation seems to have had a non-significant impact on the probability of signing a new contract. People who stated that they would sign the contract because of financial reasons reacted to the change in compensation to the same degree as those who did not state financial motivation.

4. Discussion

In this study, we examined the impact of social norms and the effect of financial motivation on the acceptance of contracts that decrease the flexibility of electricity usage. So far, this type of energy management, has not been implemented in Poland. We referred to the theory of planned behavior, which states that intentions, norms, and perceived control shape behaviors. To our knowledge, this article is the first to analyze the impact of social norms, personal norms, and financial motivation on consumer preferences toward electricity DSM.

Households could contribute to the security and efficiency of the electric power system, but only if people engage in the management. We need to better understand the determinants of people's acceptance of DSM programs. Receiving compensation was the motivation for signing contracts for half of the sample. Furthermore, people who stated that they would sign the contract because of financial reasons had the same responsiveness to the level of compensation as the rest of the sample. This result suggests that some people would sign a contract because of the monetary compensation, but they were not more sensitive to the compensation level (compared with those not motivated by money). This contradicts the fourth hypothesis; the level of compensation does not seem as important for people with financial motivation as expected. Respondents who stated that they sign contracts because of financial reasons revealed lower responsiveness to the changes in attribute levels (apart from the blackouts). They were less inclined towards the SQ option. Lower discomfort attached to the restriction on the electricity consumption suggests that these respondents were more flexible people who were not motivated by financial motivation were less willing to sign the contract (a positive sign of the SQ alternative specific constant).

Lower compensation would likely have similar effects on people's choices:

- Those motivated by money are not less responsive to the level of compensation.
- Less flexible people prefer the SQ option, and they are not motivated by compensation.

Researchers have highlighted norms and values should be considered when we examine behavioral change or related policies [9,11,12,47,87,88]. Cognitive, motivational, and contextual factors affect electricity consumption; thereby, we included behavioral aspects into the decision-making process. According to the literature, beliefs about the extent to which other people save/reduce their electricity use—descriptive social norms—can trigger individual's willingness to do the same. These beliefs increase the perception that changing habits to save electricity is a desirable activity (see: Loock et al. [89]). In our study, we showed that people with higher descriptive social norms as measured on the survey were less sensitive to the level of compensation (the first hypothesis is partially confirmed). We could therefore deduce that these people were motivated by the descriptive social norm. Nonetheless, the impact of descriptive social norms on the consumer flexibility is not clear (only one interaction term with a non-financial attribute—the number of blackouts—was significant).

Surprisingly, we found no impact of the personal norms on people's choices (the third hypothesis has not been confirmed). The injunctive social norms were found to have little impact on people's

preferences (the second hypothesis has not been confirmed). According to the research, social influence has an impact on the level of electricity consumption [9–11,34–37,40]. Norms are likely a more important factor in the analysis of revealed preferences. It would be very interesting to compare our results with the field experiment using real electricity contracts. Pellerano et al. [16] showed that a tension exists between intrinsic and extrinsic motivation. Adding monetary incentives to reduce electricity usage did not lead to increased savings. In this intervention, for consumers who considered saving energy as a pro-social behavior (that serves to reduce climate risks, and pollution) adding extrinsic motivators changed the frame from social to financial, and pushed out the effect of the social comparison. Financial incentives diminish the extent to which the voluntary contribution signals pro-sociality to oneself. The authors suggest that the first channel through which messages affect consumption is the desire to avoid moral costs.

In some cases, financial incentives stand in contradiction with other motivations [18]. Paying people for voluntary contributions weakens established social norms, which makes individuals more focused on the private value of the behavior. Moreover, monetary rewards could change the perception of the task, with unexpected effects on behavior. The monetary reward changes the framing of the decision from social to private benefit. Financial motivators added to normative messages not only fail to enhance the effect of the social norms, but can actually weaken it.

Social norms are important when explaining the amount of consumption. We deduce that they are less meaningful when it comes to the choices about electricity contracts, especially if people are motivated primarily by money. It would be interesting to verify the research hypotheses in other countries, especially where DSM programs are more popular and we can observe the real choices from among electricity contracts.

The demand for electricity in the residential sector is characterized by low flexibility. Currently used tariffs do not motivate people to save money by changing their habits in the use of electricity [25]. DSM makes the demand for electricity more flexible, thus it helps attain environmental goals thanks to controlled consumption. It is a key aspect of the future energy system scenarios. The effectiveness of DSM mechanisms is, in fact, the effectiveness of their impact on people and the activation of consumers to the appropriate response to the stimuli. Consumer engagement in the power market through DSM improves economic efficiency and reliability of the system and reduces the need to invest in new generation and transmission facilities. The results of our study could enable designing electricity contacts that put restrictions on consumption.

The proposed model and research tools may be used to conduct similar analyses in other countries. However, we need to consider the limitations of our approach—the research is based on the stated preferences. Some researchers argue that people's hypothetical decisions may not always reflect their actual behavior. The studies by Carson [90] and Hausman [91] present the debate concerning the credibility of information provided by the stated preference studies. To minimize the potential hypothetical bias in our CE study, we strictly followed the guidelines how to design and conduct the stated preference studies (see Arrow et al. [92] and Johnston et al. [93]). The fact that we used a hybrid choice model that is computationally very intensive for the estimations one can see as a limitation. Whether the gains from developing such a model justify the increased effort compared to simpler discrete choice models is debatable [70]. Vij and Walker [93] analyzed the possible advantages of employing a hybrid framework and provided general criteria for assessing whether its use is justified.

We showed that most consumers would sign contracts because of financial incentives, and the impact of social norms and personal norms is weak. However, the literature shows that feedback information with social norms could be as effective as monetary incentives. We expect a significant impact of social norms on consumer choices if there is no compensation offered. It would be beneficial to examine the interaction between intrinsic and extrinsic motivation.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Availability of Data and Materials: The code and data for the specific models, as well as supplementary outcomes, are available on: http://czaj.org/research/supplementary-materials.

Appendix A

The willingness to accept DSM (The results were presented in previous paper: [94])

We apply random parameter logit (RPL) to examine individual choices 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 element V_{ijt} and a stochastic element ε_{ijt}:

$$U_{ijt} = V_{ijti} + \varepsilon_{ijt} \tag{A1}$$

Additionally, the systematic component of the utility was assumed to be a linear function of k attributes, cumulated in the vector X_{ijt}, which result in the usual, additive expression of the model:

$$U = X_{ijt}\beta_i + \varepsilon_{ijt} \tag{A2}$$

Equation (1) is quoted here. We assume that the stochastic part ε_{ijt} is independently and identically distributed across alternatives, choice tasks, and individuals, and follow extreme value type one distribution. The RPL model ([55,95]) is a common method to include taste heterogeneity across respondents. The RPL model implies that the vector of marginal utilities β_i follows a specific, potentially multivariate, distribution in the population. This particular distribution must be determined before the estimation of the model. Furthermore, parameters of the chosen distribution are estimated, instead of the parameters of the utility function itself. For instance, if we assume that β_i follows the multivariate normal distribution, then the vector of its means, as well as its covariance matrix, must be estimated. Conditional on respondent-specific parameters, the probability that person i will choose alternative j in choice task t is provided by standard multinomial logit equation:

$$P_{jti}(\beta_i) = P(U_{jti} = max\{U_{lti}\}/\beta_i) = exp(X_{jti}\beta_i)/\Sigma_l(X_{lti}\beta_i) \tag{A3}$$

Because $\boldsymbol{\beta_i}$ are not observed by the researcher, the unconditional probability of all choices respondent i made in the CE is given by a multidimensional integral:

$$L_l = \int \prod_t (\Sigma_j\, y_{jti}\, P_{jti}(\beta_i))\, f(\beta_i/\Omega)\, d\beta_i \tag{A4}$$

where y_{jti} equals one if individual i chose alternative j in choice task t, and equals zero if not. The function $f(\boldsymbol{\beta_i}/\Omega)$ is a density function $\boldsymbol{\beta_i}$, which depends on a set of parameters Ω, to be estimated. As integral in (4) has no analytical solution, the model was estimated using the Maximum Simulated Likelihood method that approximates the multidimensional integral with the use of Monte Carlo simulation. 2000 scrambled Sobol draws per respondent were used in the estimation procedure.

Table A1 presents the median WTA per month for changes in electricity contracts (see: [94]).

Table A1. Median WTA per month—main effects.

	Main Effects
Attributes	**MWTA (€)**
External control of electricity in extreme cases	0.96 ***
Distribution of information	−1.29
External control of electricity on weekdays, 6:00–9:00 a.m.	0.09
External control of electricity on weekdays, 5:00–8:00 p.m.	6.46 ***
External control of electricity on weekdays; 6:00–9:00 a.m. and 5:00–8:00 p.m.	10.08 ***

Notes: *** indicate significance at the level of 1%.

The number of days of external control of consumption in extreme cases was assumed to have a linear effect on the choice. On average, individuals required 0.96 € of compensation (3.9% of the mean bill per month) per day of "extreme occasions". They need 6.46 € of compensation (25.9% of the typical bill per month) for control of electricity usage during the evening peak hours, and 10.08 € of compensation (40.4% of the typical bill per month) for control in the morning and the evening hours. External control leads to the discomfort of not being allowed to use specific appliances during peak hours. People appeared to be more flexible in the morning peak hours, and they did not require compensation for control from 6:00 to 9:00 a.m.

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