St. Petersburg University
Graduate School of Management

Master in Smart City Management

FACTORS STIMULATING ENERGY CONSERVATION AND ENERGY EFFICIENCY OF HOUSEHOLDS: THE CASE OF ST. PETERSBURG

Master’s Thesis by the 2nd year student
Concentration — Master in Smart City Management
Pererva Vladislav Igorevich

Research advisor:
PhD in Economics, Associate Professor
Ekaterina Vladimirovna Sokolova

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АННОТАЦИЯ

Автор	Перерва Владислав Игоревич
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Научный руководитель	Соколова Екатерина Владимировна
Описание цели, задач и основных результатов	Данное исследование посвящено проблеме стимулирования энергосбережения и повышения энергетической эффективности домохозяйств. Усилия автора направлены на поиск ответа на вопрос: «Какие факторы влияют энергосбережение домохозяйств и их инвестиции в энергоэффективность?» Целью данной работы является разработка рекомендаций для органов государственной власти Санкт-Петербурга по стимулированию энергосбережения и повышения энергетической эффективности домохозяйств. Для достижения данной цели используются качественные методы исследования в форме обзор литературы в области потребления энергии и энергосбережения домохозяйств, а также количественные методы в форме анализа первичных данных, полученных в ходе опроса населения Санкт-Петербурга. Помимо практической ценности, которые несут разработанные рекомендации, данная работа имеет теоретическую ценность, благодаря выработанной теоретической модели потребления энергии домохозяйствами, а также сформированной методологии эмпирического исследования.
Ключевые слова	Энергопотребление домохозяйств, энергосбережение, энергоэффективность, профили потребителей энергии, домохозяйства Санкт-Петербурга

ABSTRACT

Master Student's Name	Pererva Vladislav Igorevich
Master Thesis Title	Factors stimulating energy conservation and energy efficiency of households: the case of St. Petersburg
Educational Program	Master in Smart City Management
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Description of the goal, tasks, and main results	This study is devoted to the problem of stimulating energy conservation and energy efficiency of households. The author's efforts are aimed at finding an answer to the question: "What factors influence the energy conservation of households and their intentions to invest in energy efficiency?" The purpose of this research is to develop policy recommendations for the authorities of St. Petersburg to stimulate energy conservation and energy efficiency of households. To achieve this goal, qualitative research methods are used in the form of a literature review in the field of energy consumption and energy conservation of households, as well as quantitative methods in the form of analysis of primary data obtained through the survey of the population of St. Petersburg. In addition to the practical value of the developed recommendations, this work has a theoretical value in the form of developed theoretical model of energy consumption by households, as well as the formulated empirical research methodology.
Keywords	Household energy use, energy conservation, energy efficiency, energy consumer profiles, households of St. Petersburg

ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

Я, Перерва Владислав Игоревич, студент второго курса магистратуры направления «Менеджмент», заявляю, что в моей магистерской диссертации на тему «Факторы стимулирования энергосбережения и повышения энергетической эффективности домохозяйств: пример Санкт-Петербурга», представленной в службу обеспечения программ магистратуры для последующей передачи в государственную аттестационную комиссию для публичной защиты, не содержится элементов плагиата.

Все прямые заимствования из печатных и электронных источников, а также из защищенных ранее выпускных квалификационных работ, кандидатских и докторских диссертаций имеют соответствующие ссылки.

Мне известно содержание п. 9.7.1 Правил обучения по основным образовательным программам высшего и среднего профессионального образования в СПбГУ о том, что «ВКР выполняется индивидуально каждым студентом под руководством назначенного ему научного руководителя», и п. 51 Устава федерального государственного бюджетного образовательного учреждения высшего образования «Санкт-Петербургский государственный университет» о том, что «студент подлежит отчислению из Санкт-Петербургского университета за представление курсовой или выпускной квалификационной работы, выполненной другим лицом (лицами)».

30.05.2023

STATEMENT ABOUT THE INDEPENDENT CHARACTER OF THE MASTER THESIS

I, Pererva Vladislav Igorevich, second year master student, program «Management», state that my master thesis on the topic «Factors stimulating energy conservation and energy efficiency of households: the case of St. Petersburg», which is presented to the Master Office to be submitted to the Official Defense Committee for the public defense, does not contain any elements of plagiarism.

All direct borrowings from printed and electronic sources, as well as from master theses, PhD and doctorate theses which were defended earlier, have appropriate references.

I am aware that according to paragraph 9.7.1. of Guidelines for instruction in major curriculum programs of higher and secondary professional education at St. Petersburg University «A master thesis must be completed by each of the degree candidates individually under the supervision of his or her advisor», and according to paragraph 51 of Chapter of the Federal State Institution of Higher Education Saint-Petersburg State University «a student can be expelled from St. Petersburg University for submitting of the course or graduation qualification work developed by other person (persons)».

30.05.2023

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INTRODUCTION

In recent decades, the world has been experiencing the problem of global climate change, which is associated with an increase in temperature and increase in the concentration of greenhouse gases in the atmosphere. The risks associated with climate change are characterized by ubiquitous and irreversible consequences for anthropogenic and natural systems and cause the occurrence of extreme weather events, the negative combined effect of high temperature and air pollution, and also the degradation of various ecosystems as a result of changes in thermal and humidity conditions (Government of the Russian Federation, 10/29/2021). At the same time, the problems of climate change are complex and affect primarily the population, infrastructure and climate-dependent sectors of the economy, such as agriculture.

From the perspective of the international community, climate change has become a global concern, leading to the adoption of the United Nations Framework Convention on Climate Change in 1992, the Kyoto Protocol to the Framework Convention in 1997 and the Paris Climate Agreement in 2015. The main goal of these documents is to stabilize the concentration of greenhouse gases in the atmosphere at a level that prevents dangerous anthropogenic impact on the climate, meanwhile the measures of these documents provide for the obligations of participating states to limit or reduce emissions of greenhouse gases into the atmosphere (United Nations, 5/5/1992).

At the moment Russia takes part the Framework Convention, the Kyoto Protocol and the Paris Agreement, has ratified these international legal acts, and has also assumed obligations to reduce greenhouse gas emissions into the atmosphere. Recently Russian Government issued a Socio-Economic Development Strategy with low level of greenhouse gas emissions that aims at 60% emissions reduce by 2050 as compared to 2019 levels (Government of the Russian Federation, 10/29/2021). The main activities of the strategy are aimed at industries that consume the most energy resources and include electricity production, industrial production, as well as the building and housing sector. At the same time, experts note that in the areas of electricity and industrial production, there is a steadily positive trend in energy efficiency improvements, while the residential sector is of concern due to deteriorating equipment and wasteful energy consumption by the population (Vedomosti, 7/11/2021).

The problem of reducing greenhouse gas emissions in the residential sector is also stressed by the fact that about 70% of all greenhouse gas emissions into the atmosphere come from cities, according to UN-Habitat (UN-Habitat, 2022). At the same time, intensive urbanization and the corresponding growth of agglomerations lead to the fact that this share continues to grow due to an increase in population density, economic and social activity (Bibri, Krogstie, 2017).

The main tool for reducing greenhouse gas emissions in the residential sector is rapidly developing energy-efficient technologies that have come under public attention as the main means to reduce energy consumption and increase energy efficiency. However, the introduction of these technologies in existing residential buildings is often problematic due to the high investments required and the lack of willingness of people to take part in their financing. Moreover, the energy behavior of households is often unconscious and wasteful, which entails economic, environmental, and social costs for society as a whole (Chen et al, 2017).

With the impossibility of making complex investments in the energy efficiency of the housing stock, as well as escalating environmental issues associated with increasing energy consumption, it is of great importance to stimulate sustainable household behavior in the field of energy consumption. In this context, it is necessary to identify the factors influencing household energy conservation and energy efficiency, which can become the focus of appropriate policy regulation.

The goal of this work is to develop policy recommendations for the authorities to stimulate energy conservation and energy efficiency of households on the example of St. Petersburg. To achieve this goal, it is necessary to perform the following objectives:

1. To classify households' energy behaviors and their characteristics.
2. To identify factors that influence household energy conservation and energy efficiency.
3. To estimate the impact of these factors on household intentions to conserve energy and increase energy efficiency.
4. To identify user profiles based on cluster analysis of the most significant factors.
5. To describe the portraits of household's profiles that are typical for St. Petersburg, their preferences, and possible options for influencing their energy behavior.

This work is focused on studying the behavior of people in the process of energy consumption. In this case, the subjects of research are energy conservation and energy efficiency of households and factors that influence various types of energy behavior. The investigation of the problem situation and the solution of the goal of the work are carried out in the format of an empirical study, which is aimed at putting forward and testing hypotheses about the significance of factors affecting related energy behavior. This study will use methods such as reviewing the literature on household energy consumption and conservation, collecting information through a survey, and applying econometric analysis.

The result of this work is recommendations for stimulating household energy conservation and energy efficiency, which are prepared on the basis of an econometric analysis of primary information obtained through a survey in social networks among communities of residential complexes.

This master's thesis includes two chapters. The first chapter is devoted to the review of literature in the field of household energy conservation and is divided into five paragraphs. The first paragraph reveals the origin of the research direction of household energy conservation and energy efficiency, defines and classifies energy behavior, reveals approaches to determining the factors influencing energy behavior, as well as the problems and results achieved by research in this direction. The second and third paragraphs contain a review of the literature on the factors influencing households' energy conservation and energy efficiency and identify groups of factors, according to the approaches that have been developed in scientific research. The fourth paragraph is composed of overview of the methodologies used in previous studies and systematizes possible approaches to the organization of the study. The fifth paragraph forms the theoretical framework of the research, on the basis of which the empirical research is carried out and includes the research hypotheses that need to be tested using empirical research.

The second chapter is devoted to an empirical study of the factors that stimulate households' energy conservation and energy efficiency and includes four paragraphs. The first paragraph provides a description and justification of the used econometric methods, a description and characteristics of the data, as well as the results of the primary processing of variables. The second paragraph contains the constructed models and the interpretation of the obtained results. The third paragraph reflects the recommendations developed on the basis of the results of the obtained models. The fourth paragraph focuses on the limitations of the study and directions for future research.

1. STATE-OF-THE-ART OF RESIDENTIAL ENERGY CONSERVATION

1.1 Theoretical background of household energy conservation studies

Research on household energy behavior originates from research on pro-environmental behavior, which is one of the major branches of environmental psychology that developed in the United States in the 1960s and studied a number of complex interactions between people and the environment. In this branch of research pro-environmental behavior is defined as behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world, for example, minimizing the consumption of resources and energy, the use of non-toxic substances, reducing the production of waste (Kollmuss, Agyeman, 2002).

At the turn of the last century, factors influencing individual differences in relation to the pro-environmental behavior received particular demand and interest among the academic community. Because of the complex and inconsistent nature of pro-environmental behavior, many hypotheses were formulated and supported by research to explore the factors that influence environmentally important decisions and actions. As a result, several of the most frequently cited points of view, theories and models of pro-environmental behavior were promoted, among which are Hines et al.'s model of responsible environmental behavior, Ajzen's theory of planned behavior, Guagnano et al.'s attitude-behavior-external conditions model, Blake's conceptualization of barriers between environmental concern and action, the value-belief-norm theory of Stern et al and many others (Bamberg, Möser, 2007).

The results achieved in this broad area have extended to the narrower sphere of household energy conservation and energy efficiency, and as scientific thought in this area develops, there is an increased attention to definition of specific factors that affect household energy consumption and changes in energy use of households that occur over time. Behaviors related to household energy behavior can be divided into two categories: efficiency and curtailment behaviors (Abrahamse et al, 2005).

Efficiency behaviors can be defined as one-time behavior that entails purchasing energy efficient equipment and technologies. Academic literature usually identifies two main dimensions of efficiency behavior, namely buying energy efficient appliances and adapting energy efficient retrofits (Trotta, 2018). Investments in energy efficient appliances include the purchasing of appliances of the highest energy efficiency classes (A or B), which have the lowest energy consumption. Moreover, appliances differ in size, duration, and intensity of use, what affect their contribution in the total household energy consumption. Traditionally, the biggest contributors to energy consumption are large appliances that have a long or continuous working periods, such as heater, air conditioner, fridge, and dishwasher (Imran et al, 2022). Energy efficient retrofit can be defined as major structural improvements to a home or substantial physical changes in the building (Dixon, Eames, 2013). They usually include changing or upgrading of the building envelopes and its technical characteristics, which affect the building's ability to store or release energy, especially heat, and therefore allow households to spend less energy on maintaining a comfortable temperature. The examples of such investment are the installation of solid, cavity or loft insulation, double glazing, low energy light bulbs, ground source heat pumps, boilers, and solar water heating (Trotta, 2018). Since the efficiency behavior of households is aimed at increasing energy efficiency in the process of energy consumption, in the following text this term is used to refer to all household actions to improve energy efficiency.

Curtailment behaviors can be defined as the daily and habitual practices of households that focus on specific reductions in energy use and include such decisions as turning off lights and appliances, keeping windows closed when heating is on, choosing the mode and intensity of use of appliances that is characterized by the lowest consumption of electricity and others (Trotta, 2018). Considering that curtailment behavior reflects the intentional daily actions of households to reduce energy consumption, in the following text this term is used as a reference to the totality of household energy conservation practices.

The existing literature provides convincing arguments for dividing the energy behavior of households into two dimensions. Types of energy behavior can be classified by frequency of implementation and associated financial or behavioral costs (Karlin et al, 2014). On the one hand, curtailment behavior involves performing actions with a high frequency, but does not imply financial costs for their implementation. On the other hand, efficiency behavior is carried out relatively rarely and takes the form of an investment decision making, since it involves financial costs for its implementation. In this regard, a conclusion can be drawn concerning the peculiarities of curtailment and efficiency behavior. The former is more intuitive and automatic based on people's habits, while the latter involves decision making based on rational and objective factors. The diagram characterizing the classification of energy behavior of households by frequency and financial costs is shown in the Figure 1.

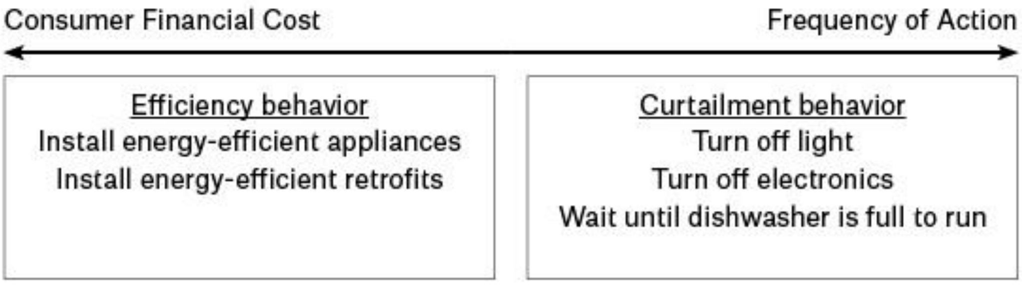

Figure 1 Classification of energy behavior.

Source: compiled by the author with use of (Karlin et al, 2014).

Some researchers have attempted to adapt theoretical models of pro-environmental behavior to study household curtailment and efficiency activities, unconscious habits, and technological patterns that influence household energy behavior in living spaces. These models were intended to explain decision-making and household behavior in the context of energy conservation and energy efficiency, especially in terms of the implementation of energy-saving methods and products (Frederiks et al, 2015).

Despite the fact that various theoretical concepts have appeared in the scientific community that describe peculiarities of household energy behaviors, none of them has been generally accepted and did not contain a comprehensive explanation and prediction of individual differences in household behavior. The currently available literature indicates that the issue of differences between energy-saving and energy-wasting consumers is so complex that it cannot be covered by a single approach that would work in any context, sample of participants and time (Kollmuss, Agyeman, 2002). While empirical evidence suggests that some variables may be better at explaining household behavior than others, the results are still far from complete validity and consistency. In the current circumstances, it becomes especially important to correctly formulate the research question and the research framework, as well as what is meant by the studied behavior. It can be measured in terms of total household consumption in kilowatt-hours, changes in daily activities, such as intentional reduction in consumption or the propensity to adopt energy efficient technologies in a dwelling (Frederiks et al, 2015). In this case, the role of various explanatory variables may change, depending on how studied behavior is defined and measured.

Examples of such differences in the direction and degree of influence of the same factors on different dependent variables can be found in the existing literature. For instance, one study that examined factors affecting household energy consumption (in physical terms) and household intention to reduce energy consumption (expressed in the percentage of energy savings declared by respondents) found that household socioeconomic variables had significant impact on energy consumption without significant influence of variables reflecting knowledge and habits in relation to energy conservation (Abrahamse, Steg, 2011). At the same time, the subjective intention to reduce energy, on the contrary, strongly depended on the of households' energy conservation knowledge and habits with poor explaining power of socio-economic parameters. The same differences were found in another paper that studied factors influencing efficiency and curtailment behaviors of households – higher-income households were less likely to take daily action to reduce energy consumption, but more likely to adopt energy efficient retrofits (Trotta, 2018). Thus, the same variables affect the different behaviors of households in different ways, what in one case leads to growing intentions to reduce energy consumption, and in the other – to their decreasing.

Taking into account the high dependency of research results on the definition of the studied behavior, in this paper we divide the behaviors of households into groups depending on the entailed consequences. On the one hand, we have a change in the amount of energy consumed by households, expressed in natural terms, which is the output of regulatory intervention. Output of energy conservation does not always controllable and depend on human behavior, for example, in the case of cold weather, energy consumption will be higher regardless of human behavior comparing to the case of mild weather (Calvillo et al, 2016). On the other hand, we are talking about a shift in the behavior of households, expressed in the tendency to change their habits and daily activities, which is the outcome of regulatory intervention. Sustainable behavioral change is a priority because it directly affects the way people live and the amount of energy consumed, all other things being equal, and is less dependent on external factors such as climate and technological features of energy supply systems. That's why in this work we focus on behavioral change of households expressed in their propensity to reduce energy consumption through the application of curtailment and efficiency behavior.

Despite the differences in studied behaviors across the household energy behavior research, another reason for their failure to achieve uniform and consistent results is the fact that very few studies rigorously test causal relationships using experimental design and time-series variables (Frederiks et al, 2015). In the context of the low prevalence of such studies, it is impossible to draw unambiguous conclusions about the presence of causality of the studied effects, because the usual observational study allows to draw a conclusion only about the presence of a correlation between the studied variables.

Nonetheless, individual efforts have shed light on the issue of household energy consumption, and research aimed at studying the multiplicity of forces underlying energy behavior has become the most widespread. Researchers more often prefer integrative approaches that consider household energy conservation and efficiency as an interaction of many different groups of factors, and there has recently been general agreement that there are a wide range of categories of variables that affect household energy behavior. However, at the moment in scientific community there is no unified and generally recognized classification of groups of factors that would completely cover the multiplicity of forces underlying households' behavior towards energy conservation and efficiency (Frederiks et al, 2015).

Currently, the most of scientific studies use different sets of factors, but use a similar approach to their definition, taking into account the potential influence of the factors included in the group on the studied behavior. Early research identifies groups of factors as psychological, i.e., factors that shape information processing and decision-making by consumers (e.g., perception, evaluation, understanding, and memory), and positional, i.e., factors that contribute to or hinder the studied behavior of consumers (e.g., disposable income, home ownership, home improvement skills, and owned technologies in home) (Costanzo et al, 1986). Alternatively, there were proposed groups of micro-level factors, i.e., factors that form individual differences in behavior (e.g., preferences, attitudes, values, abilities, opportunities), and macro-level factors that shape the environment in which people and institutions exist (e.g., availability of new technology, economic and population growth, government regulations and policies, socio-cultural change) (Abrahamse et al, 2005).

The most common classifications used in subsequent studies distinguish between internal (or personal) and external (or situational) groups of factors. Internal factors comprise psychological factors (people's beliefs, values, attitudes, emotions and environmental knowledge) (Kollmuss, Agyeman, 2002; Grilli, Curtis, 2021), demographic factors (e.g.: education, age, and income), awareness of energy efficient measures and attitudes towards their implementation (Nair et al, 2010), dwelling factors (e.g.: age, size, type of dwelling, etc.) (Frederiks et al, 2015). External factors are related to the context in which individuals behave and make choices, i.e., formal regulation, social norms, cultural taboos (Grilli, Curtis, 2021), institutional, economic, social and cultural conditions (Agyeman, 2002), available technologies, pricing, built environment, etc. (Frederiks et al, 2015).

In our paper, we also support the approach to the classification of factors influencing energy behavior, which is common in the scientific literature, and we divide the factors into internal and external according to the nature and reasons for influencing household behavior. The results of the classification are presented in Table 1. A more detailed description of all groups of factors is presented in the next paragraph.

Table 1 Classification of factors influencing household energy consumption and energy behavior.

Group of factors	Subgroup of factors	Effect on energy consumption and conservation
Internal	Demographic	Influence energy consumption in terms of needs and preferences (Wilson, Dowlatabadi, 2007) (e.g., wealthy households consume more energy than low-income households; working people spend less time at home, respectively, consume less energy). Influence the propensity to energy behavior in terms of opportunities and limitations (e.g., low-income households are more inclined to curtailment behavior, and wealthy households have more opportunities to adapt energy-efficient appliances and technologies) (Abrahamse, Steg, 2011).
	Psychological	Influence the propensity to energy conservation in terms of awareness, values and attitudes (for example, people which believe they should conserve energy in different ways) (Frederiks et al, 2015). Energy saving households consume less energy than other households, other things being equal (Abrahamse, Steg, 2011).

External	Dwelling (characteristics)	Influence energy consumption in terms of characteristics of the place of residence that determines the needs and preferences of households. For example, larger houses use more appliances and use more energy (Santin, 2011). Influence efficiency behavior in terms of motivation to introduce energy efficient appliances and technologies (e.g., residents of older houses are more likely to implement energy efficient retrofits to ensure comfortable indoor temperature) (Nair et al, 2010).
	Situational	Influence energy consumption and energy behavior in terms of external technological, economic, political, social, cultural and other constraints and opportunities (Frederiks et al, 2015). For example, efficiency behavior is impossible in the absence of energy-efficient technologies available to people.
	Environmental	Influence energy consumption and energy behavior in terms of climate conditions (e.g., cold weather requires more energy to maintain a comfortable indoor temperature than warm weather (Calvillo et al, 2016); households living in cold climates are more motivated to implement energy efficient appliances and improvements because the bills are high (Nair et al, 2010)).
	Technological	Influence energy consumption and energy behavior in terms of building and material characteristics (e.g., some materials are better at retaining heat in cold weather and providing air conditioning in hot weather than others (Pulselli et al., 2009))

Source: compiled by the author.

Since the territory of consideration is a separate region of the country represented by the federal city of St. Petersburg, special attention is paid to internal and external factors which determine the energy behavior of city’s households and may influence shifts in their behavior. We focus on socio-demographic, psychological and dwelling variables from the list of internal factors, environmental and technological variables from the list of external factors. Situational factors are not presented in this paper, since they determine the behavior of all households in the city and do not allow to explain the variability in the behavior of different households.

1.2 Literature review of factors influencing household energy consumption and conservation

1.2.1 Socio-demographic factors

As far as the energy behavior of households is associated with habitual and daily actions which require recurring efforts to reduce energy use, or with purchasing activities which require a monetary investments and sometimes structural adjustments, the household energy conservation and efficiency are related to the wide range of socio-demographic variables (Frederiks et al, 2015). When people are involved in some certain activities they can be affected by some opportunities and constraints which are characteristic of people in certain living conditions. Such socio-demographic factors as household income, education level, and many others can influence people's abilities and limitations, and therefore determine the amount, frequency, and duration of energy use.

In academic papers, researchers usually identify the following socio-demographic factors: age, gender, level of education, income, employment status, household size, stage of the family life cycle (Frederiks et al, 2015). Age and gender are among the most frequently used variables in household energy behavior studies. Some studies suggest that energy consumption increases with the age of the household head, so they indicate the positive relationship between age and energy consumption (Nair et al, 2010). This may be because older people are less likely to apply measures increasing energy efficiency. At the same time, there are suggestions of a presence of the relationship between gender and energy consumption, namely that women are more likely to exhibit pro-environmental behavior than men (Zelezny et al, 2000). However, many other studies reject the existence of any statistically significant relationship between energy consumption and such factors as age and gender, suggesting that there is no consistent empirical support for age and gender differences in energy consumption (Abrahamse, Steg, 2009; Frederiks et al, 2015).

Some studies highlight a significant effect that the level of education has on pro-environmental behavior and energy use (Semenza et al, 2008; Nair et al, 2010). The level of education of a person reflects the knowledge that he possesses and his awareness of various issues, including energy consumption. Thus, greater awareness of environmental issues and energy consumption can influence intentions to save energy and invest in energy efficiency. However, a high level of education does not always translate directly into pro-environmental behavior: in fact, in many domains of human behavior there is often a "knowledge-action gap", not only in terms of pro-environmental behavior, but also concerning the household energy consumption and conservation (Kollmuss, Agyeman, 2002; Barr et al, 2005; Frederiks et al, 2015).

The employment status of household members can indirectly influence energy consumption by reflecting the household's socioeconomic status and financial capacity. It is positively correlated with household income, which is one of the most powerful predictors of energy behavior according to most studies in this area (Frederiks et al, 2015). There is an assumption that the high-income households tend to consume more energy than low-income households as they use appliances more intensively and more sensitive to comfortable conditions (Abrahamse, Steg, 2009). At the same time, high-income households may have more intentions to use energy more efficiently, as they can afford the financial costs of energy efficient appliances and investments in energy efficient retrofits (Trotta, 2018). In this regard, the electricity consumption of high-income households per unit of time or per unit of performed function should be lower than that of low-income households, what is achieved through the purchasing energy efficient technologies.

According to many studies, total household energy consumption is positively related to household size and composition, so that larger households tend to consume more energy as compared to smaller households (Frederiks et al, 2015). This can be explained by the fact that larger households tend to have more energy-intensive appliances, larger incomes to spend on energy, and greater energy demands, including cooking, washing, cleaning, heating, or air conditioning. In addition, the presence of children in the family can also explain variability in energy consumption of different households. Having children can mean higher household requirements and demands, which also increases appliance usage and energy consumption (Chen et al, 2017).

1.2.2 Psychological factors

While socio-demographic factors have an important influence on energy consumption and conservation at the household level, personal and psychological factors can also play an important role. Such psychological factors as knowledge and awareness of issues (both environmental and energy); values and attitudes; intentions; personal and social norms are most commonly associated with household energy use (Frederiks et al, 2015).

In terms of energy consumption, energy-related knowledge reflects the level of knowledge, awareness and understanding of energy costs, energy-saving behavior and the consequences of such behavior, which can translate into benefits from energy conservation and lower bills (Frederiks et al, 2015). At the same time, greater awareness and knowledge of environmental issues, such as global warming, greenhouse gas emissions, are usually positively associated with pro-environmental behavior, which also includes energy conservation (Trotta, 2018).

Values reflect an abstract and relatively stable set of beliefs, ideals and standards that serve as guiding principles in life (for example, a person's general sense of right and wrong), while attitudes reflect more specific positive or negative assessments of a particular idea, object, person, situation or activity (Frederiks et al, 2015). Many studies aimed at studying the role of values and attitudes in the context of pro-environmental behavior, including sustainable energy behavior, have found empirical evidence of a positive relationship between these variables. People who exhibited more environmental values were more likely to report a positive intention towards energy conservation (Trotta, 2018). Nevertheless, many studies indicate that the strength of these associations is weak or insignificant (Frederiks et al, 2015). It is stated that values and attitudes can contribute to sustainable energy behavior or to demonstrated willingness to perform in this way, but they do not directly lead to an actual reduction in energy consumption and were called “value-action gap” and “attitude-action gap” respectively (Huddart-Kennedy et al, 2009). In this context, many people express beliefs about the negative effects of environmental problems, positively assess sustainability, green or energy efficient technologies, and demonstrate intentions to reduce household energy use, but in practice they often fail to translate them into real actions.

Personal comfort, in particular the perceived loss of comfort from energy conservation activities, can be negatively associated with household energy consumption (Barr et al, 2005). Actually, any reduction in personal comfort may be perceived by people as a threat to quality of their life and create incentives to abandon pro-environmental behavior. Considering that household energy consumption may not be directly related to energy demand, but demand for energy-intensive activities such as lighting, water heating, cooking, space heating and air cooling, high household's requirements for comfort and quality of life may be driving an increase in their energy consumption (Trotta, 2018).

People driven by certain intentions may be more prone to energy conservation behavior, although the presence of these intentions does not automatically lead to a reduction in energy consumption (Frederiks et al, 2015). For example, people's intention to engage in pro-environmental behavior may entail a consequent intention to reduce energy consumption. However, there is evidence in the literature of a discrepancy between demonstrated intentions and actual behavior, referred to as the intention-action gap, and can be described by the weak explanatory power of intentions in predicting actual behavior, as well as weak support for the effect of change in behavioral intentions on subsequent change in behavior (Sheeran, 2011).

1.2.3 Behavioral biases and anomalies

Traditional economic theory states that human behavior and decision making are based on rational choice. Neoclassical approaches are also based on fundamental assumptions associated with rational choice theory. According to them, people have rational preferences among possible alternatives and act independently, having complete and reliable information. Based on these assumptions, traditional economic models claim that a person makes decisions that maximize his utility and comply with given budget constraints (Trotta, 2018). Thus, the behavior of economic agents can be improved by providing people with economic incentives, better information, and more alternatives.

However, empirical research devoted to behavioral economics shows that consumer behavior and actions systematically deviate from neoclassical assumptions about rationality. Actually, human decision making is rarely rational and contains fundamental and persistent biases that cannot be accounted for according to neoclassical teachings (Trotta, 2018). Many of these biases stem from simple "rules of thumb", "heuristics", and mental "shortcuts" that alleviate the need for more intensive information processing, thereby speeding up problem solving and decision making, especially in situations characterized by high levels of choice complexity, risk, and uncertainty (Tversky, Kahneman, 1974). Such examples of behavioral biases as retention of the status-quo, loss aversion and risk aversion are the most typical for energy consumption in terms of predicting and changing household behavior towards sustainability.

Many studies in this area have confirmed that people tend to stick to the status quo or default settings because the disadvantages of leaving it are perceived more painful than the benefits (Kahneman et al, 1991). It means that people tend to resist change, even if the alternatives offer greater material or financial benefits. For example, a field study of electrical consumer behavior found that consumer preferences are strongly associated with an option labeled as the status quo (Kahneman et al, 1991). Another side of the retention to status quo bias can be the endowment effect, which reflects the fact that people often demand much more to give up an object than they would be willing to pay to acquire it (Kahneman et al, 1991). An example of the endowment effect in household energy consumption and conservation is the tendency of consumers to use old energy appliances, even when it becomes economically disadvantageous. In addition, status quo bias can be provoked by the formulation of choice outcomes, which is called "framing of outcomes". This phenomenon means that choices can be formulated in different ways: as gains and losses relative to the status quo, or as new wealth relative to the original level. The results of studies show that the requirement of invariance of the order of preferences when the description of outcomes changes, is violated in the decision-making process, which makes it possible to judge the presence of a status quo bias (Kahneman, Tversky, 1984).

Another characteristic feature of irrational behavior is loss aversion, which is expressed in the fact that people usually perceive the loss of some amount of money more sensitively than an equivalent gain. Thus, the hypothetical value function of decision in the conditions of risk will be much steeper in the loss domain than in the gain domain (Kahneman et al, 1991). Typically, people focus on the risks, benefits, and costs associated with changing behavior to a new one or purchasing a new product or device. For example, concerning household energy efficiency investments, loss aversion makes people feel the loss of money from buying a more expensive and energy efficient appliance more painfully than the benefits of subsequent energy bill savings. And for household energy conservation, loss aversion can lead people to value the time and psychological cost of behavior change higher than the potential financial benefits of energy saving.

Numerous studies have been conducted to confirm the effect of risk aversion, as a result of which it was found that people avoid risk when it related to a guaranteed gain and seek risk in the event of an equivalent guaranteed loss (Kahneman, Tversky, 1979). Moreover, in other studies, the dependence of the degree of desire for risk on the size of bets was noticed, then called the “peanut effect”. This effect describes the tendency for people to be more risk-seeking in small-stakes games and risk-averse in high-stakes games (Trotta, 2018). Given that investments in energy efficiency measures are usually associated with high costs, it can be assumed that consumers will be less inclined to make these investments. In addition, when comparing the cost of a conventional and energy efficient appliance, the consumer may associate the additional cost of purchasing the second one as a waste if the benefits of subsequent savings are not taken into account. In this case, the definition of payments as deadweight losses can affect the perception of purchase by the decision-making person (Kahneman, Tversky, 1984).

1.2.4 Technological and environmental factors

In urban reality, commercial and residential buildings are the largest consumers of energy and are responsible for about three quarters of the city’s total greenhouse gas emissions (Calvillo et al, 2016). In this regard, one of the biggest challenges of modern buildings and structures is to reduce energy consumption without sacrificing the comfort of end users. The academic literature indicates a significant influence of the technical characteristics of building envelopes on the energy consumption during its exploitation. In fact, the physical properties of the various materials used in construction lead to significant differences in the further heat loss observed in the building, or in the presence of the greenhouse effect in hot weather. Some materials retain heat better in cold weather and provide better air conditioning in hot weather, allowing building occupants to save more energy for heating or air conditioning (Pulselli et al., 2009). It was stated in early research that considering technological factors together allows to explain at least half of the household energy use with the remaining half determined by the features and behavior of occupants (Schipper et al, 2003).

The technology used in the construction of building envelope can be an example of how the technical characteristics of a building affect energy consumption during its exploitation. Thus, when comparing buildings with traditional air-cavity walls, insulated walls and ventilated walls, it was found that the use of the latter two technologies allows to store more heat in the cold season and release more heat in the hot season, which saves more energy for heating and air conditioning. It is noted that the geographic location and climate have a significant impact on the amount of savings obtained and the payback period of the investment (Pulselli et al, 2009). In this context, technical characteristics of building envelopes are closely connected with the climate conditions. For example, above mentioned study concludes that the energy-efficient building envelope can achieve better results and has a shorter payback period in locations with extreme climatic conditions by the example of Berlin (northern location) and Palermo (southern location) as compared to locations with a temperate climate by the example of Barcelona (Pulselli et al, 2009).

The technical characteristics and materials of the production of the building not only affect the energy consumption during the operation of the building, but also require direct energy costs for their production. As a rule, recommendations regarding the use of certain materials also depend largely on the geographic location of the building and the climate, with emphasis on the use of recyclable materials (Pulselli et al, 2009).

When taking into account only technical characteristics of buildings envelopes we assume that households are passive consumers of the energy provided. In this case, they consume all the energy provided and react only to changes in environmental conditions. However, household-level energy consumption surveys have found significant variation in energy consumption in identical houses that cannot be explained by infrastructural differences alone (Trotta, 2018). Therefore, the availability of technical systems that allow manual or automatic regulation of energy consumption is considered to be a significant factor explaining energy consumption in residential buildings (Calvillo et al, 2016). Such systems include thermostats that allow you to turn the heating on and off, as well as regulate the air temperature in the room, systems that control lighting and household appliances usage.

1.2.5 Dwelling factors

Various studies highlight factors associated with building parameters in addition to the technological aspects of the used materials. For instance, the type of dwelling (for example, an apartment or a private house) has a direct effect on the energy consumption of the households living in them, since different types of dwellings vary in important characteristics such as number of rooms, floor area, surface area of walls and others (Frederiks et al, 2015). Considering dwelling characteristics, it was demonstrated that households living in larger dwellings in terms of number of rooms or floor area tend to use more energy because a larger dwelling requires more electrical appliances and a correspondingly higher energy consumption (Santin, 2011). In addition, a large dwelling should retain less heat and require additional household heating efforts compared to smaller dwellings due to a larger volume of internal space and a larger area of walls' contact with the external environment.

Also, it is often expected that the age of the house is positively associated with energy consumption, since older houses have a lower energy efficiency standard, which can be expressed by less efficient heating or cooling, poor insulation, or the impossibility to use energy efficient appliances (Nair et al, 2010). In this context, the year of the last renovation, which usually raises the energy efficiency standard of the whole house, can also be taken into account as significant factor.

Additionally, home ownership should also have an impact on household energy consumption. Homeowners are more likely to invest in energy efficiency measures as compared to tenants because they usually have more incomes and financial possibilities; they get a greater return on energy efficiency investment because they own the realty on a full-time basis. In contrast, tenants generally have no incentives to invest in energy efficiency measures due to their short tenure period and low return on investment (Chen et al, 2017).

1.3 Summary of key findings

The review of the literature shows that energy behavior of households is associated with many socio-demographic, psychological, dwelling and technological factors, but this relationship is not always statistically significant or straightforward. Most of the considered factors actually interact in complex ways with other variables, which creates the possibility of a moderation effect, consisting in the fact that the influence of one of the factors on energy conservation and energy efficiency depends on the presence of another variable. In this case, it is difficult to say that there is a direct relationship between a certain pool of individual-level factors and household energy consumption. It is more likely that there are many factors that collectively determine the nature, intensity and duration of household energy consumption (Frederiks et al, 2015). These complexity and inconsistency make it difficult to draw specific conclusions about the effects in terms of the size and direction of the impact of a single variable on household energy behavior, especially with the aim of generalizing the results to the population. The set of identified factors and their relationship with scientific research that revealed their influence on the target variable are systematized and shown in Table 2.

Regarding environmental and technological factors, it can be concluded that they form the most stable trends in consistency and replicability, since they demonstrate the influence of objectively reliable conditions without considering the human factor. It was determined that some materials are much better adapted to maintain a comfortable indoor climate, regardless of the external environment. On the other hand, climate conditions also deserve attention, since they shape the environment in which a person lives and the difficulties that he faces in the process of energy usage. This allows us to conclude that environmental factors should be taken into account in the analysis as an objective environment as determining the behavior of people in it, all other things being equal. Technological factors, such as the material of the building envelopes, as well as dwelling characteristics, such as area, type, age, number of rooms, are more likely to vary within the same location, and therefore should be taken into account in the process of researching individual characteristics of households and their influence on energy consumption and efficiency.

Concerning socio-demographic variables, it was concluded that factors such as household income, family size and composition are strongly associated with household energy consumption and their propensity to conserve energy and invest in energy efficiency. However, these effects are often mixed, as shown in studies suggesting a curvilinear relationship between certain socio-demographic factors and energy behavior, often drawing conclusions that are not supported by other studies. For example, some studies show that households with average incomes are more likely to conserve energy as compared to households with low or high incomes (Frederiks et al, 2015). At the same time, most studies consider just a linear relationship, which leads to the conclusion that household energy consumption increases with income growth (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011). This overlooks the idea that higher income households have more opportunities to invest in energy efficiency through the purchase and adaptation of energy efficient appliances and retrofits. It can be concluded that the extent to which socio-demographic variables affect household energy consumption depends on complex and dynamic relationships between different variables, sometimes even unfolding over time.

From the perspective of psychological predictors of energy usage in the academic literature, it is possible to identify a group of factors that play an important role, with normative social impact usually having the strongest influence (Frederiks et al, 2015). The difficulty lies in determining the influence of such psychological variables as knowledge and awareness, beliefs, values and attitudes, goals, motives and intentions, which are usually poor predictors of energy consumption patterns. The lack of systematic and consistent findings indicates that environmentally friendly knowledge, goals, and intentions are poor predictors of environmentally friendly actions because good intentions are poorly converted into actual behavior. In addition, empirical evidence suggests that the influence of many psychological variables is often small and does not reach statistical significance compared to socio-demographic predictors (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011). Based on the review of psychological factors, it can be concluded that recommendations regarding energy conservation of households should help people act in accordance with their true values, beliefs and attitudes, and ultimately stimulate desired behavior in accordance with their good intentions.

Also, a small review of theories of behavioral economics, revealing the behavioral biases and anomalies of human's behavior, allows to better understand and explain the problems of the low significance of psychological factors. Often people act intuitively and neglect their knowledge, intentions, values and goals due to the way the human brain works. It is necessary to take into account these problems in the course of developing recommendations that are aimed at stimulating people to act in accordance with their true motives. In addition, it is important to remember that at the stage of implementing a strategy aimed at improving energy conservation of households, unexpected and undesirable results may emerge, since framing of this strategy leads to a negative perception of the proposed solutions by the target population.

Based on the review of the literature, a research gap was identified in studies on energy behavior. Most studies take into account socio-demographic and psychological factors, while some of them examine the influence of individual groups of variables without taking into account the objective personal parameters of households. At the same time, the list of socio-demographic parameters differs in studies, and it is rather difficult to trace the rationale for the choice of certain variables for analysis: the choice of variables is mainly determined by the formulated research hypothesis. Nevertheless, according to a review of the literature, we found that stimulating factors differ significantly in different groups of consumers, united by socio-demographic or behavioral characteristics. This may explain the low strength of the influence of the studied variables in current studies, where heterogeneous data are usually taken for analysis and only a small part of the variation in the dependent variable, reflecting the energy behavior of households, can be explained. Thus, this study focuses on the application of an integrated approach that combines socio-demographic factors, psychological factors, and considers the differences in stimulating factors of various users' profiles, in response to the limitations of previous research in this area.

General findings regarding the theoretical aspect of the factors stimulating energy conservation and energy efficiency of households allow us to conclude how strong differences can be in the socio-demographic, psychological and behavioral characteristics of different types of consumers. When developing recommendations, it is necessary to rely on certain portraits of users that exist in the target population in a certain area. Differences in personal characteristics create significant gaps in the needs, living conditions and environment of particular categories of consumers, which suggests that their ability and willingness to control energy use through certain actions will also be different. Understanding the unique profiles of users allows to better formulate recommendations for effective behavior change, as well as strategies that can support these changes in the groups of interest.

1.4 Research methodology

1.4.1 Overview of previous research

The review of the literature shows the wide variety of approaches that are used in studies on household energy consumption, conservation and efficiency. In addition to differences in the definition of explanatory variables, or factors that influence household energy behavior, studies differ in approaches to determining the dependent variable to study, or studied behavior, the statistical models used, sample sizes, geographic location, and other parameters. Methods for studying the energy consumption, energy conservation and energy efficiency of households, which were used in different academic works, are systematized and compared in Table 3.

Table 2 Factors determining household energy consumption and conservation.

Research	Technological factors			Socio-demographic factors								Dwelling factors						Psychological factors							
	Presence of energy control systems	Network configuration	The material of the building envelope	Age	Gender	Marital Status	The level of education	The level of income	Employment status	Household size	Presence of children	Dwelling type	Dwelling age	Dwelling size	Living period	House ownership	Bill payment	Pro-environmental knowledge	Pro-environmental beliefs	Pro-environmental attitudes	Normative social influence	Need for personal comfort	Personal norms	Perceived costs and benefits	Perceived level of control
Kollmuss, Agyeman (2002)	---	---	---	X	X	---	X	---	---	---	---	---	---	---	---	---	X	X	X	X	X	X	X	X	X
Schipper et al (2003)	X	X	X	X	X	X	X	X	---	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---
Barr et al (2005)	---	---	---	X	X	---	X	X	---	X	---	X	---	---	---	X	---	X	X	X	X	X	X	X	X
Bamberg, Möser (2007)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	X	X	X	X	---	X	---	X
Sardianou (2007)	---	---	---	X	X	X	X	X	---	X	---	X	---	X	---	X	---	X	---	X	---	---	---	---	---
Semenza et al (2008)	---	---	---	X	X	---	---	X	X	---	---	---	---	---	---	X	---	X	---	---	---	---	---	---	---
Abrahamse, Steg (2009)	---	---	---	X	---	---	---	X	---	X	---	---	---	---	---	---	X	X	X	X	---	---	X	---	X
Pulselli et al (2009)	---	---	X	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Huddart-Kennedy et al (2009)	---	---	---	---	---	---	---	X	---	---	---	---	---	---	---	---	X	X	X	X	---	---	X	---	X
Nair et al (2010)	---	---	---	X	X	---	X	X	---	---	---	X	X	X	---	---	X	X	X	X	---	X	---	---	X
Santin (2011)	X	---	---	X	X	---	X	X	---	X	X	X	X	X	X	X	X	---	---	---	---	---	---	---	---

Research	Technological factors			Socio-demographic factors								Dwelling factors						Psychological factors							
	Presence of energy control systems	Network configuration	The material of the building envelope	Age	Gender	Marital Status	The level of education	The level of income	Employment status	Household size	Presence of children	Dwelling type	Dwelling age	Dwelling size	Living period	House ownership	Bill payment	Pro-environmental knowledge	Pro-environmental beliefs	Pro-environmental attitudes	Normative social influence	Need for personal comfort	Personal norms	Perceived costs and benefits	Perceived level of control
Gaspar, Antunes (2011)	---	---	---	X	X	---	X	X	---	X	X	---	---	---	---	X	---	X	---	X	---	---	---	X	---
Abrahamse, Steg (2011)	---	---	---	X	X	---	---	X	---	X	---	---	---	---	---	---	X	---	X	X	X	---	X	---	X
Ajzen (2012)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	X	X	X	---	---	---	X
Karlin et al (2014)	---	---	---	X	X	X	X	X	---	X	---	---	---	---	---	X	X	---	X	---	X	---	---	X	---
Frederiks et al (2015)	X	---	---	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Calvillo et al (2016)	X	X	X	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		---
Chen et al (2017)	X	---	---	X	X	---	---	---	---	X	---	---	---	---	---	X	X	X	X	X	X	X	X	---	X
Trotta (2018)	---	---	---	X	X	X	X	X	---	---	---	X	X	---	---	---	---	X	X	X	X	---	X	---	---
Russell, Knoeri (2019)	X	---	---	X	---	---	X	X	---	X	---	X	---	---	---	X	---	---	X	X	X	---	---	---	X

Source: compiled by the author.

Among the studies reviewed, it is noteworthy that longitudinal studies are not frequently used as compared to cross sectional studies which are often conducted by researchers. Longitudinal study is a research design that involves the repeated observation of the same respondents over a period of time in the context of the same variables, which is used to study rapid fluctuations in behavior or to study causal relationships between different variables (Shadish et al, 2002). At the same time, cross sectional study involves the study of variables that characterize a general population or its representative subset at a particular point in time. Cross sectional study does not allow establishing causal relationships between the target behavior and a set of factors and is used only for detecting a correlation between them.

As a variable for a study, authors often choose actual energy consumption or the implementation of certain actions aimed at reducing energy consumption or improving the energy efficiency of dwelling. At the same time, depending on the chosen dependent variable of the model, the authors use similar methods to detect and describe relationships: for actual energy consumption and curtailment behavior, it is possible to use hierarchical regression analysis (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011), and for efficiency behavior – factor analysis (Barr et al, 2005; Chen et al, 2017), principal component analysis (Huddart-Kennedy et al, 2009; Chen et al, 2017; Trotta, 2018), and logistic regression models (Semenza et al, 2008; Trotta, 2018). In the first case, the researcher's motivation is to measure the marginal effect that occurs when one of the variables changes while the other variables remain constant, which allows to understand in what ways it is possible to manage household curtailment behavior. In the second case, researchers are interested in grouping factors with similar properties and measuring the probability that respondents will carry out efficiency behavior depending on a change in a particular factor.

In addition, for all types of research, it is possible to use cluster analysis methods (Santin, 2011) to group energy consumers depending on their propensity to curtailment and efficiency behaviors or socio-demographic and psychological characteristics.

1.4.2 Organization of the study

As a result of the review of the literature, which covers approaches to identifying factors that influence household energy conservation and energy efficiency, as well as the types of behaviors for the study and the methods used to identify relationships between variables, the organization of this study can be drawn. The next paragraph will present a theoretical model of household energy behavior depending on the groups of factors identified as a result of the literature review. In addition, hypotheses will be put forward regarding the influence of various factors on household energy behavior, which are also obtained as a result of studying the experience of researchers in this field.

Table 3 Methods for analysis of household energy consumption.

Year	**Author(s)**	**Country**	**Dependent variable(s)**	**Sample size**	**Data source**	**Methods used**
2005	Barr S., Gilg A.W., Ford N.	Devon, United Kingdom	Energy saving purchase decisions, habits and recycling practice	1265 households	Hand-delivered survey	Cross-sectional study: Factor analysis, cluster analysis
2007	Sardianou E.	Greece	Energy conservation behavior	500 respondents	Face-to-face home interviews	Cross-sectional study: Ordinary least squares regression analysis
2008	Semenza J.C., Hall D.E., Wilson D.J., Bontempo B.D., Sailor D.J., George L.A.	Portland, Houston, USA	Behavior change related to climate change	1202 respondents	Random-digit-dial telephone survey	Cross-sectional study: Logistic regression models, Chi-square and Pearson correlation analyses
2009	Huddart-Kennedy E., Beckley T.M., McFarlane B.L., Nadeau S.	Ten provinces of Canada	Self-reported gap between households' environmental values and factual behavior	1664 households	e-mail survey	Cross-sectional study: Principal components analysis, explanatory data analysis

Year	Author(s)	Country	Dependent variable(s)	Sample size	Data source	Methods used
2009	Abrahamse W., Steg, L.	Groningen, Netherlands	Energy use: calculated according to appliances owned and reported frequency of its use.	189 households	An internet-based questionnaire	Longitudinal study (3 questionnaires were provided during the 5 months): Correlation analysis, Hierarchical regression analysis
2010	Nair G., Gustavsson L., Mahapatra K.	Sweden	Actions to reduce energy use, investments in energy measures during the last 2 years	1025 households	e-mail stratified survey	Cross-sectional study: Correlation analysis
2011	Santin O.G.	Leidsche Rijn, Wateringse Veld districts, Netherlands	Energy consumption for space and water heating	313 households	Hand-delivered survey	Cross-sectional study: Correlation analysis, exploratory factor analysis, Cluster analysis
2011	Abrahamse W., Steg L.	Netherlands	Annual gas and electricity use, the percentage of energy households were intending to save during the course of the study.	199 households	Online survey through web-site	Longitudinal study (2 questionnaires before and after the course of the study): Hierarchical regression analysis

Year	Author(s)	Country	Dependent variable(s)	Sample size	Data source	Methods used
2011	Gaspar R., Antunes D.	Ireland, Germany, Portugal, Greece, Poland, Spain, Italy	Purchase of energy efficient appliance	1432 respondents	Face-to-face in-store interviews	Cross-sectional study: Correlation analysis, regression analysis
2014	Karlin B., Davis N., Sanguinetti A., Gamble K., Kirkby D., Stokols D.	USA	Energy conservation behavior	540 respondents	Internet-based survey	Cross-sectional study: Factor analysis, correlation analysis, regression analysis
2017	Chen C.-F., Xu X., Day J.K.	50 states of USA	Intention to conserve energy: intention of performing asked behaviors over the next three months.	248 households	Internet-based survey	Cross-sectional study: Principal Component Analysis, Hierarchical regression analysis, Factor analysis

Year	Author(s)	Country	Dependent variable(s)	Sample size	Data source	Methods used
2018	Trotta G.	England, United Kingdom	The frequency of energy-saving behavior, the probability of having bought an energy efficient appliance or having made at least one energy efficient retrofit measure.	2009 respondents	Face-to-face interviews	Cross-sectional study: Nonlinear principal components analysis, ordinary least squares (OLS) regression, probit models
2019	Russell S., Knoeri C.	United Kingdom	Water conservation intentions	1196 respondents	Internet-based survey	Cross-sectional study: Hierarchical regression analysis,

Source: compiled by the author.

Second chapter will present the results of empirical research and testing of theoretical hypotheses. The empirical part includes a description of the methodology and data used for analysis, namely methods for researching data and models construction, the source of data collection and modeled results. Also, the empirical part includes the interpretation of the results obtained in the course of the empirical study, as well as recommendations for the development of the policy regulation, which can be used by the authorities of St. Petersburg, resource-supplying organizations and development institutions to formulate policies to stimulate energy conservation and energy efficiency of households. Finally, empirical part represents limitations that are typical for this type of study in accordance with the type of data, the size and representativeness of the sample.

Finally, conclusion contains a summary of the study, including the results of the classification of household energy behaviors and the identification of influencing factors used in the literature, as well as recommendations formed on the basis of an econometric analysis of curtailment and efficiency behaviors models and household profiles based on the cluster analysis.

1.5 Theoretical study

1.5.1 Theoretical framework

The review of the literature and the integration of approaches that are most common in studies devoted to the household energy conservation and efficiency allows to construct the model which can be used as a theoretical framework of this study. The model is an integrative approach to determining the factors that affect household energy conservation and energy efficiency, which are mostly preferred by modern researchers. The theoretical model of energy consumption, energy conservation and energy efficiency of households is schematically presented in Figure 2.

Energy consumption in physical terms depends both on technological factors, including the type of configuration of the energy supply network, type and size of the dwelling, the age of the dwelling, the material of the external walls of the building (Pulselli et al, 2009), and on the behavioral factors of the people who live in it.

At the same time, the energy behavior of households is the subject of closer study by researchers due to its complexity and ambiguity. The approach to identifying factors influencing household behavior applies ideas from early studies of pro-environmental behavior that suggest a strong consistent relationship between knowledge, intention, and action. Subsequently, the model was expanded and supplemented by psychological factors that better explained the intentions of people and how they are transformed into actual behavior. Thus, the role of psychological factors in the energy behavior of households in various articles is explained taking into account the developed Models of predictors of environmental behavior (Hines et al, 1986), Theory of

Reasoned Action, Theory of Planned Behavior (Ajzen, Fishbein, 1975; Ajzen, Fishbein, 1980), Model of ecological behavior (Fietkau, Kessel, 1981) and others. At the same time, the integrative approach also includes socio-demographic factors in the model, which are decisive in the formation of preferences and needs of households, and also describe differences in the behavior of people with different social and economic status (Van Raaij, Verhallen, 1983; Wilson, Dowlatabadi, 2007). As for a studied types of energy behavior, researchers usually take households' curtailment behavior which is expressed in daily actions to reduce energy consumption, and efficiency behavior which is expressed in purchase and adoption of energy-efficient appliances and investments in energy-efficient retrofit.

In addition, researchers note the great importance of situational factors, for example: socio-cultural, economic, political, legal and institutional, which explain differences in energy consumption and energy conservation behavior in different communities, cities and countries (Frederiks et al, 2015). Behavioral biases and anomalies deserve special attention, which were applied to explain the energy behavior of households after the popularization of Prospect theory and other heuristics and biases during decision making under uncertainty (Kahneman, Tversky, 1979; Kahneman, Tversky, 1984). Consideration of situational factors and behavioral biases is beyond the scope of this paper, since the former should not lead to differences in the behavior of people in a single environment in the form of a city, and the latter require the use of an experimental study design and are not amenable to study in the framework of an observational study.

Summing up, we can conclude that household energy behavior is a complex process influenced by many factors, including socio-demographic, psychological, technological, environmental and situational, their intersections, which together affect the behavior of households when consuming energy.

1.5.2 Research hypotheses

Based on the results of existing research in the field of energy behavior of households, and on the theoretical research framework defined in the previous paragraph, we can formulate hypotheses regarding the relationship and significance of influence of stimulating factors. Among the socio-demographic factors there are income and household composition that are most often identified as significant since they directly determine the preferences and opportunities of the household in terms of energy conservation and energy efficiency (Frederiks et al, 2015). Other socio-demographic factors such as gender, age, education and employment status are not expected to be significant, what corresponds to the results of recent years research (Frederiks et al, 2015).

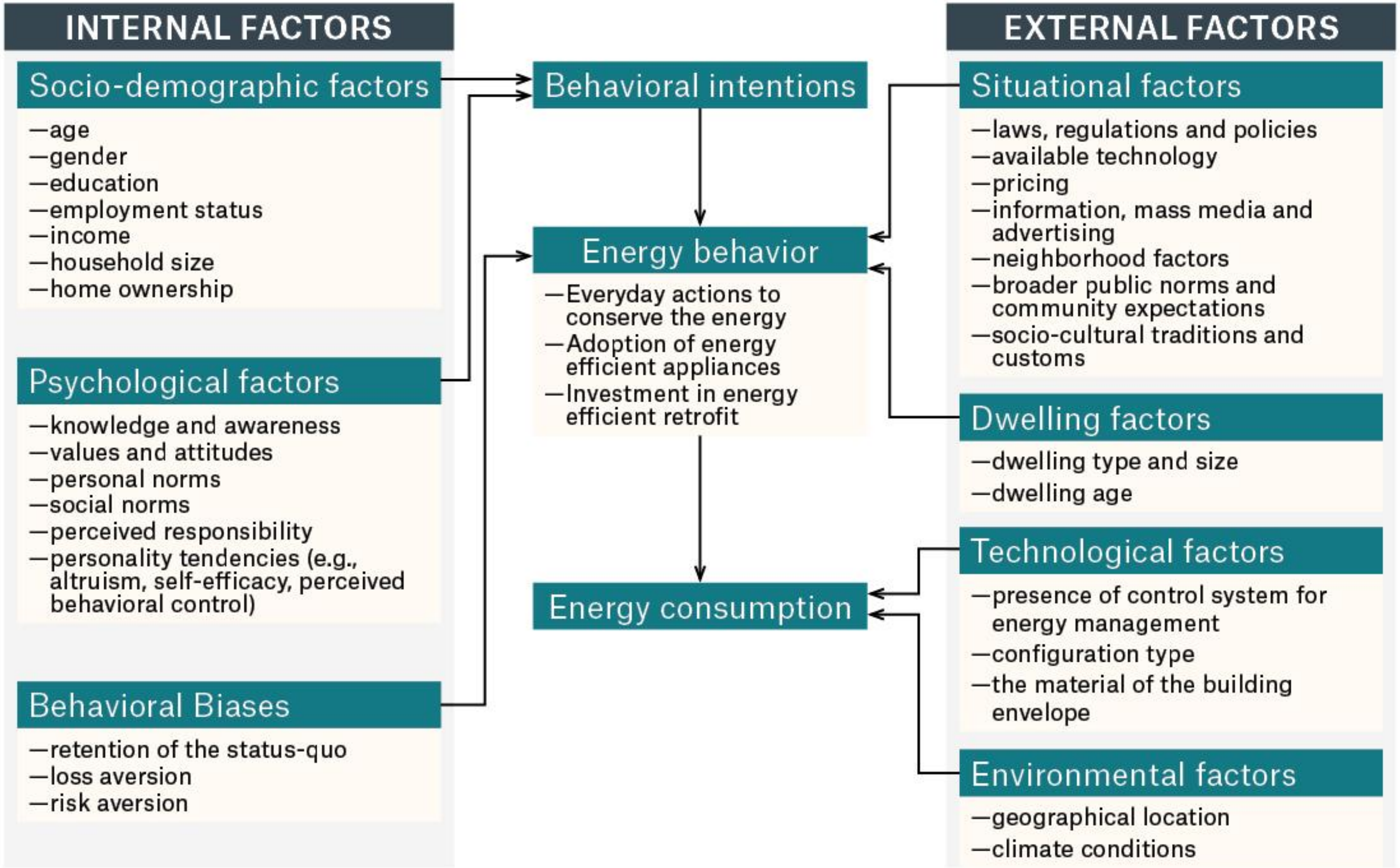

Figure 2 Theoretical framework of household energy behavior

Source: compiled by the author with use of: (Frederiks et al, 2015, p. 577; Kollmuss, Agyeman, 2002, pp. 241-246; Barr et al, 2005, p. 1428; Blasch, Daminato, 2020, p. 186)

H(1): The socio-demographic characteristics of the household influence its energy behavior. Income and household size and composition are more likely to affect the curtailment and efficiency behavior in different ways, on the one hand, leading to an increase (decrease) in the intensity of curtailment behavior, and on the other hand, to a decrease (increase) in efficiency behavior.

Psychological factors are expected to be significant when influencing curtailment behavior of respondents. Nevertheless, we expect that psychological factors to a lesser extent influence the efficiency behavior of households, which is associated mainly with objective factors and rational reasons.

H(2): The psychological characteristics of the household determines its energy behavior. Knowledge, values, personal and social norms, and other psychological factors are more likely to explain the intentions to carry out the curtailment behavior than the efficiency behavior.

Consistent with previous research, dwelling characteristics are objective factors that establish living conditions and form rational reasons for investing in efficiency behavior. It is also expected that dwelling factors explain to a lesser extent the curtailment behavior of households, which is driven by personal characteristics and psychological profiles.

H(3): The dwelling characteristics of the household has an impact on its efficiency behavior. Dwelling type, age and size, period of living, ownership status, presence of control systems and configuration of energy supply systems are more likely to determine the intentions to carry out the efficiency behavior than curtailment behavior.

In general, a combination of various socio-demographic, psychological and dwelling factors should form a statistically significant model that can determine whether the respondent demonstrates the curtailment and efficiency behavior or whether he has intentions to implement it.

Moreover, households can be grouped according to intensity and frequency of energy conservation, socio-demographic, psychological and dwelling factors, what will form different preferences, opportunities and demands in terms of energy behavior. In this context, it is expected that households can be successfully divided into energy-wasting and energy-saving consumers.

H(4): Households can be grouped according to intensity and frequency of energy behavior, explained in terms of different socio-demographic, psychological and dwelling characteristics reflecting their interests and preferences in terms of energy conservation and energy efficiency and classified as an energy-wasting or energy-saving type of consumer.

2. EMPIRICAL STUDY OF FACTORS STIMULATING ENERGY CONSERVATION AND ENERGY EFFICIENCY OF HOUSEHOLDS IN ST. PETERSBURG

2.1 Methodology and data

2.1.1 Methods used for empirical study

The methodology of this empirical study is based on the accumulated experience of conducted research in the field of household energy behavior. In this work we do not limit ourselves by studying a single aspect of energy behavior but use a variety of methods used in previous studies to build models. This section presents the methods that formed the basis of econometric analysis, indicating the logic and premises of application, as well as references to previous studies.

In the first part of the empirical study, the quantitative measurement and assessment of the intensity of energy conservation behavior of households was carried out, according to the answers to questions 17-18 of the questionnaire. Similarly, it was necessary to evaluate and measure psychological characteristics of the respondents, according to the answers to questions 23-23 of the questionnaire. To solve this problem, G. Trotta, in the study of factors affecting energy saving and investment in energy efficiency of UK households, uses the principal component analysis (PCA), which is a statistical method for reducing the dimensionality of a data set (Trotta, 2018). Technically, PCA search for new variables which are the linear combinations of original variables by maximizing their explained variance (Das, 2019). In this case, the first principal component explains the maximum variance in the initial sample, the second principal component has the second largest variance and does not correlate with the first. The total number of principal components that can be obtained from a given dataset is equal to the number of variables in the set, however, one or more principal components is enough to explain most of the data variance and thus reduce the dimensionality of the data. In general terms, the implementation of PCA on a dataset with n- number of variables can be illustrated by following formulas (Das, 2019):

$$PC_1 = \phi_{11} * X_1 + \phi_{12} * X_2 + \cdots + \phi_{1n} * X_n \quad (1)$$

$$PC_2 = \phi_{21} * X_1 + \phi_{22} * X_2 + \cdots + \phi_{2n} * X_n$$

...

$$PC_n = \phi_{n1} * X_1 + \phi_{n2} * X_2 + \cdots + \phi_{nn} * X_n$$

while:

$\rho(PC_i, PC_j) = 0$ and $Var(PC_1) > Var(PC_2) > \cdots > Var(PC_n)$

Thus, the use of the PCA allows us to identify new variables that explain the maximum variance of the corresponding sets of questions. As a result of the first part of the empirical study, we obtained variables that characterize the intensity of energy conservation of households and the psychological characteristics of respondents which describe the attitude of respondents to energy conservation and pro-environmental behavior.

The second part of the empirical study is to build econometric models that characterize different energy behaviors of households. The review of the literature, carried out in the Chapter 1 of this work, made it possible to highlight the main aspects of households' energy behaviors depending on the frequency and financial and behavioral cost of their implementation. Similarly with many previous studies, the multiple linear regression model is used to identify factors that influence curtailment behavior (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011; Chen et al, 2017; Trotta, 2018). Multiple linear regression is used to study how much the dependent variable changes when one independent variable changes, assuming that the other variables remain unchanged, and can be expressed as follows (Das, 2019):

$$Curtailment_{\,i} = \beta_0 + \beta_1 * X_1 + \cdots + \beta_n * X_n \qquad (2)$$

while:

Curtailment $_i$ – dependent variable expressing the intensity and frequency of various daily energy conserving actions of households.

X1, …, Xn – independent variables, factors influencing the energy conservation of households.

At the same time, in order to identify the factors influencing the efficiency behavior of households, namely the purchase of energy-efficient appliances and the installation of energy-efficient retrofits, it is necessary to take into account the features of the dependent variables which characterize them. The corresponding dependent variables are binary, that is, they take only 2 values (0 and 1), which indicate, respectively, the absence of the fact and the presence of the fact of purchasing an energy-efficient appliance or installing an energy-efficient retrofit. Therefore, in the case of efficient household behavior, we turn to linear probability models using logit transformation as a link function, as well as in similar studies of household energy conservation (Semenza et al, 2008; Trotta, 2018). These models can be represented as follows (Das, 2019):

$$P(Appliances_i = 1\,|X_1, X_2, \ldots, X_n|) = F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ \ldots + \ \beta_n X_n) \qquad (3)$$

$$P(Appliances_i = 1\,|X_1, X_2, \ldots, X_n|) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n)}} \qquad (4)$$

while:

Appliances $_i$ – dependent variable expressing the purchase of an energy-efficient appliance.

X_1, X_2, …, X_n – independent variables, factors influencing the energy conservation of households.
$F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ ... + \ \beta_n X_n)$ – link function.

$$P(Retrofits_i = 1\,|X_1, X_2, \dots, X_n|) = F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ \dots + \ \beta_n X_n) \quad (5)$$

$$P(Retrofits_i = 1\,|X_1, X_2, \dots, X_n|) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ \dots + \ \beta_n X_n)}} \quad (6)$$

while:
Retrofits $_i$ – dependent variable expressing the fact of energy-efficient retrofit installation.
X_1, X_2, …, X_n – independent variables, factors influencing the energy conservation of households.
$F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ ... + \ \beta_n X_n)$ – link function.

The third and final stage of empirical analysis includes the application of cluster analysis to identify the main categories of consumers, their preferences and attitudes towards energy conservation and energy efficiency in accordance with previous studies (Barr et al, 2005; Santin, 2011). Hierarchical clustering was chosen as a method, the purpose of which is to search for and build a hierarchy of clusters based on the observation distance metric and the rule for combining observations into clusters. For grouping we chose agglomerative hierarchical clustering, that is the clustering method in which observations start in their own clusters, and then, at each step, the two most similar clusters are combined until only one cluster remains (Kaufman, Rousseeuw, 1990).

The algorithm for conducting agglomerative cluster analysis is based on the implementation of several fundamental steps. First of all, it is necessary to choose a distance metric for the points in the clustering dataset and build a dissimilarity matrix based on the selected metric. The second step is the choice of the cluster merging rule, which are combined on the basis of a certain distance metric between them. The third step is to determine the number of clusters based on statistical methods. Taking into account the presence of interval, nominal and binary variables, Gower distance was chosen as the distance metric, since it allows taking into account different types of variables including continuous, discrete and nominal (Kaufman, Rousseeuw, 1990). Based on the Gower distance metric, a dissimilarity matrix was built for the data set under study. Ward distance which uses the sum of squares within the clusters as the joining criterion is taken as the cluster merging rule, what makes it possible to obtain clusters balanced in size that meet the requirements of sufficient detail and homogeneity (Gatignon, 2014). The dissimilarity matrix obtained at the first step is processed using the Ward distance algorithm, which makes it possible to obtain a hierarchy of clusters, starting from each individual point up to one cluster that includes all observations. Of the many statistical methods used to estimate clusters and decide on the number of clusters, we use the traditional Elbow and Silhouette methods, which consist of calculating and plotting statistics for each possible number of clusters. Together, these methods allow to make a decision on the number of clusters that will be the most compact and significantly different from each other, while maintaining a balanced size and representativeness. Consequently, the distribution of the obtained clusters over a wide range of variables is analyzed in order to interpret the results obtained and describe the characteristics of the identified groups.

2.1.2 Research data

Data collection for the construction of econometric models presented in Section 2.1.1 was carried out using a survey of citizens of St. Petersburg. Household energy behavior studies currently use online surveys (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011; Chen et al, 2017), face-to-face surveys (Barr et al, 2005; Santin, 2011; Trotta, 2018), email questionnaires (Huddart-Kennedy et al, 2009; Nair et al, 2010), and telephone surveys (Semenza et al, 2008). However, face-to-face interviews are slowly losing popularity due to the ease and flexibility of computer-assisted surveys for both interviewers and respondents.

The disadvantages of a face-to-face survey over an online survey are obvious: when collecting data on the street and at the workplace, respondents tend to refuse to take the survey, and the apartment survey does not allow covering different social groups, which may cause difficulties with the representativeness of the resulting sample. Also, conducting a street survey leads to additional time costs if the questionnaire consists of a large number of questions. Due to the shortcomings of a face-to-face survey, as well as the lack of a formed base of respondents ready to take part in the survey, an Internet survey was conducted. To do this the questionnaire was sent to users of social networks and distributed on forums and communities of residential complexes on the territory of St. Petersburg. Unlike a face-to-face survey, an online survey is much easier to implement and much less time consuming. Also, when conducting an Internet survey, the received data can be encoded automatically by a computer, which simplifies the data processing process and reduces the number of errors that occur during manual processing.

The survey questionnaire, which is presented in Appendix 1, included questions characterizing the frequency and intensity of implementation of various types of energy behavior, as well as questions containing groups of factors that can influence this behavior of households. The city of St. Petersburg was chosen as the area of study, as the second largest city in Russia, for which the classification of households in relation to energy conservation and energy efficiency, as well as the cultivation of sustainable energy behavior among households, may be the most relevant. As a result of this work, 421 responses from respondents living in St. Petersburg were collected. Taking into account the fact that the population of St. Petersburg is 5,600,044 people (Office of the Federal State Statistics Service for St. Petersburg and the Leningrad Region), the size of the resulting sample corresponds to the required value to cover the study area.

The territory of St. Petersburg includes 18 districts, most of which were covered by the survey. The exception was the Kronstadtsky district, where we failed to collect a single response as a result of the survey. Given its remoteness from the rest of the city, as well as the relatively low population, we assume that the absence of representatives of this district will not affect the final results of the study, which can be generalized to the entire city as a whole. It should be noted that the distribution of population among the districts of the city is not uniformed. The distribution of the population in relative terms by districts of St. Petersburg is shown in the Figure 3.

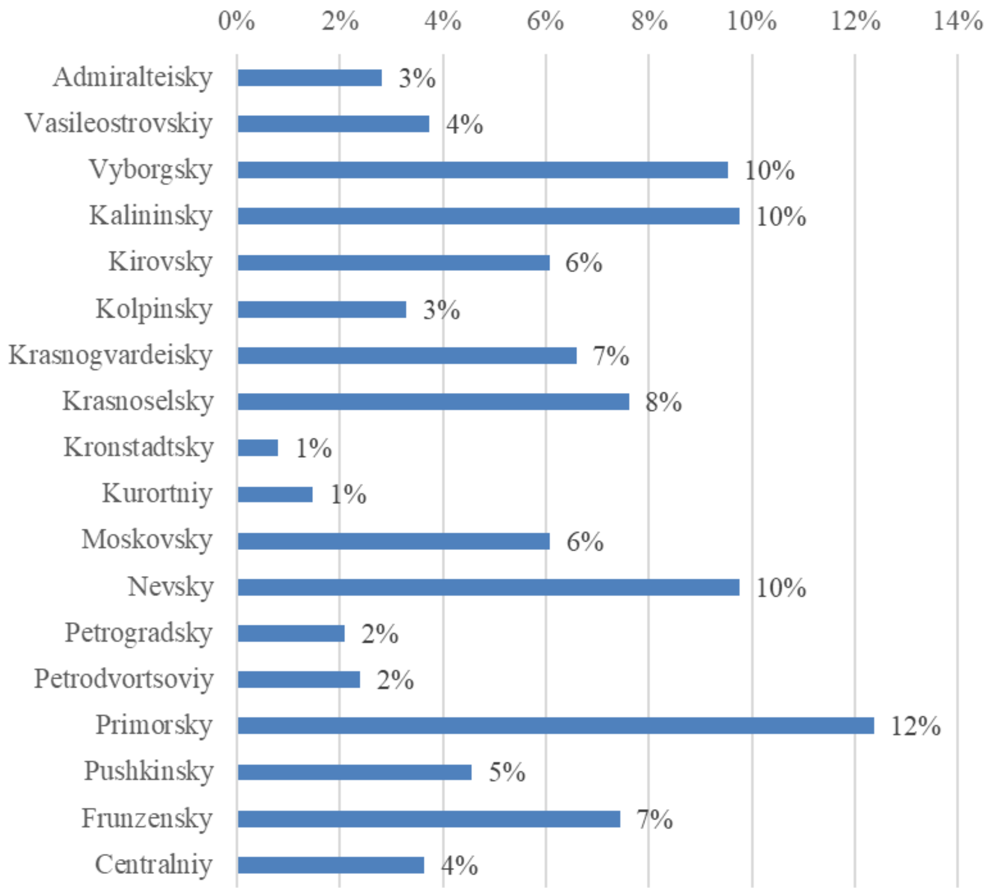

Figure 3 Distribution of the population of St. Petersburg by districts.

Source: compiled by the author with use of: (Office of the Federal State Statistics Service for St. Petersburg and the Leningrad Region).

Taking into account the presented distribution of the population of St. Petersburg by districts, the distribution of survey questionnaires was carried out in social networks among communities of residential complexes located on the territory of the respective districts. The resulting structure of the distribution of respondents by districts of St. Petersburg generally corresponds to the actual distribution of the population, with the exception of the Kronstadtsky district which is not represented in the study. Also it should be taken into account that the respondents of the Nevsky and Primorsky districts are overrepresented in obtained sample since they are the main audience of residential communities in social networks. A detailed description of the structure of the obtained sample in terms of socio-demographic parameters is given in Section 2.1.3.

The survey was conducted from the beginning of March to the end of April 2023. During this period of time, constant tariffs for utilities, including electricity, water supply and sanitation, heat supply and gas supply, were established at the end of 2022 by the regulations of the Tariff Committee of St. Petersburg (Tariff Committee of St. Petersburg, 11/18/2022, 11/18/2022, 11/21/2022, 11/29/2022). Thus, during the period under review, there are no prerequisites for a change in the perception and behavior of the population related to the problem of climate change, energy conservation and energy efficiency.

2.1.3 Generation and description of variables

Before building models and analyzing the obtained variables, it was necessary to generate the necessary variables using PCA and calculate descriptive statistics for the remaining variables. As input parameters for the PCA, we use groups of questions of the questionnaire, which are closely related in meaning and characterize energy-conserving behaviors or the corresponding psychological characteristics of respondents. To assess the degree of consistency of respondents' answers to these groups of questions, Cronbach's alpha was used, which is a measure of reliability showing how closely a number of items (questions) of the questionnaire are related as a group (Cronbach, 1951). Acceptable values of Cronbach's alpha, at which we can judge the consistency of respondents' answers, are values higher than 0.5. In addition, correlation coefficients between the resulting variables and the original variables were evaluated, and Pearson's tests for statistical significance were performed to ensure that the new variables are valid and reflect the characteristics of the original groups of variables.

Dependent variables

To obtain a dependent variable that would quantitatively characterize the **curtailment behavior** of households, the variables obtained from questions 17-18 of the survey questionnaire were used. Cronbach's alpha was 0.6, which indicates an acceptable level of respondents' answers consistency. The resulting first principal component is highly correlated with each of the variables that reflect the frequency and intensity of certain energy-conserving action, and also explains 38% of the variance of the used set of variables. As a result of the analysis, a quantitative estimate of the intensity of energy-conserving behavior of households was obtained: the higher the value of the first principal component, the more often and more actions the household takes to conserve energy.

To assess efficiency behavior, we use variables that characterize two possible types of this behavior, namely: the use of **energy-efficient appliances** and the installation of **energy-efficient retrofits** (questions 12, 19 of the questionnaire). The resulting variables are binary and take values of 0 or 1, meaning, respectively, the absence or presence of the fact of using at least one energy-efficient appliance or installing at least one energy-efficient retrofit. The results of the analysis are presented in the Table 4.

Table 4 Dependent variables of energy saving behavior.

Variables	Mean (%)	Std Dev	Min	Max	α	ρ
Curtailment behavior (PCA – 1st principal component)	0	1.3	-3.3284	2.2796	0.6	–
Reduction of water consumption (Likert's scale) (1 – never, …, 5 – always)	3.162	1.2	1	5	–	0.67^{***}
Reduction of electricity consumption (Likert's scale) (1 – never, …, 5 – always)	3.197	1.2	1	5	–	0.76^{***}
Leave the lights on in an empty room (Likert's scale) (1 – always, …, 5 – never)	4.086	1.0	1	5	–	0.63^{***}
Turn off the heating when leaving the house (Likert's scale) (1 – never, …, 5 – always)	2.033	1.5	1	5	–	0.44^{***}
Wash clothes at 40 degrees or below (Likert's scale) (1 – never, …, 5 – always)	3.461	1.1	1	5	–	0.55^{***}
Energy efficient appliances (0 – no, 1 – yes)	63.9%	0,5	0	1	–	–
Energy efficient retrofits (0 – no, 1 – yes)	33.7%	0,5	0	1	–	–

Source: compiled by the author.

*** Significant at 0.1% level.

Psychological factors

In a similar way, we obtain psychological variables that reflect the attitudes of households towards energy behavior, as well as towards the problem of climate change. Questions 23-24 of the questionnaire contain variables related to various psychological influencing factors that were identified in the literature review and described in Section 1.2.2. The questions were arranged randomly to avoid bias in the responses. The results of applying PCA, measuring Cronbach's alpha and assessing the correlation between the obtained and original variables are presented in the Table 5.

Table 5 Generation of psychological variables using PCA.

Variables	Mean (%)	Std Dev	Min	Max	α	ρ
Need for personal comfort (PCA – 1st principal component)	0.0	1.7	-2.955	5.073	0.81	–
I don't conserve energy because my quality of life will decrease (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	2.575	1.0	1	5	–	0.86***
Energy conservation means I live less comfortably (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	2.52	1.3	1	5	–	0.86***
I don't conserve energy because it takes too much time and effort (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	2.511	1.0	1	5	–	0.63***
Cost-Benefit ratio (PCA – 1st principal component)	0.0	1	-1.55	2.39	0.14	–
I won't help nature if it requires additional expenses from me (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	2.784	1.1	1	5	–	0.09
Helping nature is worth it if it saves money (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	2.575	1.0	1	5	–	1
Normative social influence (PCA – 1st principal component)	0.0	1.3	-2.899	2.095	0.79	–
If the government did more to deal with climate change, I would do more too (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	3.466	1.1	1	5	–	0.91***
If the business did more to deal with climate change, I would do more too (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	3.173	1.2	1	5	–	0.91***
Personal norms (PCA – 1st principal component)	0.0	1.3	-3.914	2.469	0.58	–
I feel guilty if my actions harm the environment (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	3.356	1.2	1	5	–	0.73***
It worries me a lot when I see how people waste heat and electricity (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	3.245	1.2	1	5	–	0.85***
I conserve energy, no matter what other people do (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	3.743	0.9	1	5	–	0.63***

Variables	Mean (%)	Std Dev	Min	Max	α	ρ
Beliefs (PCA – 1st principal component)	0.0	1.4	-3.780	2.314	0.7	–
I believe that all people should conserve energy to handle climate change (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	3.613	1.0	1	5	–	0.83***
I don't believe my lifestyle is contributing to climate change (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	3.159	1.3	1	5	–	0.76***
I believe the effects of climate change are too far in the future to really bother me (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	3.608	1.1	1	5	–	0.79***
Attitudes (PCA – 1st principal component)	0.0	1.2	-2.756	2.656	0.69	–
Caring for the environment is not a priority in my life (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	2.895	1.1	1	5	–	0.49***
Everything I do to help the environment must be in line with my lifestyle (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	2.513	1.0	1	5	–	0.69***
I don't think much about energy conservation (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	3.152	1.3	1	5	–	0.81***
Locus of control (PCA – 1st principal component)	0.0	1.2	-2.777	2.192	0.61	–
I find it difficult to change my habits to conserve energy (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	3.145	1.2	1	5	–	0.85***
I can cut my energy consumption fairly easily (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	3.316	1.1	1	5	–	0.85***
Knowledge (PCA – 1st principal component)	0.0	1.2	-2.657	3.377	0.59	–
I don't know how much energy my house uses (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	2.152	1.5	1	5	–	0.79***
I need more information on how to conserve energy in my home (Likert's scale) (1 – Absolutely agree, …, 5 – Absolutely disagree)	3.447	1.0	1	5	–	0.69***
I know how I can save electricity and heat (Likert's scale) (1 – Absolutely disagree, …, 5 – Absolutely agree)	2.867	1.1	1	5	–	0.65***

Source: compiled by the author.

*** Significant at 0.1% level.

In accordance with the analysis, the following variables were obtained. The variable **"Need for personal comfort"** characterizes the degree to which energy conservation affects the perceived comfort of the respondents. To assess this variable, 3 items were used, which included the questions: "I don't conserve energy because my quality of life will decrease", "Energy conservation means I live less comfortably", "I don't conserve energy because it takes too much time and effort" according to approaches of previous research (Seligman et al, 1978; Becker et al, 1981). Cronbach's alpha is 0.81, which indicates a good level of consistency of respondents' answers. The higher the value of the obtained variable, the stronger the feeling that the required level of comfort prevents the respondent from energy conservation.

The **"Cost-Benefit ratio"** variable was measured with two items that included: "I won't help nature if it requires additional expenses from me", "Helping nature is worth it if it saves money" according to same previous research (Seligman et al, 1978; Becker et al, 1981). Considering that Cronbach's alpha is 0.14, the pooled questions did not form a reliable scale, so based on external validity, we decided to use the latter statement as the only measure. The higher the value of the variable, the higher the degree to which saving money and avoiding additional costs is important to the respondent when conserving energy. Additionally, the variable was centered and scaled to reduce the spread of values and avoid possible outliers.

The **"Normative social influence"** variable was measured using two questions including: "If the government did more to deal with climate change, I would do more too", "If the business did more to deal with climate change, I would do more too" based on the approach of previous research (Abrahamse, Steg, 2011; Chen et al, 2017; Trotta, 2018). Cronbach's alpha is equal to 0.79, which indicates a good consistency of respondents' answers. The higher the value of the obtained variable, the stronger the respondent's energy behavior is determined by external causes and the behavior of other people and organizations.

The variable **"Personal norms"** was measured using three questions that assessed the respondents' sense of moral obligation to protect the environment and conserve energy. Questions included: "I feel guilty if my actions harm the environment", "It worries me a lot when I see how people waste heat and electricity", "I conserve energy, no matter what other people do" according to the previous studies (Abrahamse, Steg, 2009; Chen et al, 2017). Cronbach's alpha turned out to be equal to 0.58, which indicates a poor but acceptable consistency of respondents' answers. A higher value of the resulting variable indicates a stronger sense of moral obligation to protect the environment and conserve energy, demonstrated by the respondent.

The **"Beliefs"** variable was measured using three items, including the questions: "I believe that all people should conserve energy to handle climate change", "I don't believe my lifestyle is contributing to climate change", "I believe the effects of climate change are too far in the future to really bother me" based on the approach of previous studies (Abrahamse, Steg, 2011; Chen et al, 2017). Cronbach's alpha equal to 0.7 indicates the consistency of respondents' answers. The higher the value of the resulting variable, the higher the degree to which the respondent believes that there is a climate change problem and the need for energy conservation to overcome this problem.

Variable **"Attitudes"** expresses the extent to which the respondent demonstrates energy-conserving behavior in daily activities. Attitudes towards energy conservation were measured by the extent to which the respondent agreed with the following sentences, including: "Caring for the environment is not a priority in my life", "Everything I do to help the environment must be in line with my lifestyle ", "I don 't think much about energy conservation", according to approaches taken in previous studies (Abrahamse, Steg, 2009; Chen et al, 2017). Cronbach's alpha is 0.69, which indicates an acceptable level of consistency of respondents' answers. The higher the value of the obtained variable, the more positive the respondent's attitude to energy conservation.

The variable **"Locus of control"** characterizes the degree to which respondents feel able to conserve energy at home and is measured using two questions according to previous studies (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011). These questions included: "I find it difficult to change my habits to conserve energy", "I can cut my energy consumption fairly easily". Cronbach's alpha is 0.61, which indicates an acceptable level of consistency of respondents' answers. A higher value of the obtained variable indicates that the respondent feels more capable of energy-conserving behavior.

The **"Knowledge"** variable was obtained by evaluating 3 items, which include: "I don't know how much energy my house uses", "I need more information on how to conserve energy in my home", "I know how I can conserve electricity and heat." The Cronbach's alpha of answers to this group of questions is 0.59, which indicates an acceptable level of consistency of respondents' answers. The higher the value of the obtained variable, the higher the degree to which the respondent knows the amount of energy consumed in the house, and how to conserve energy.

Socio-demographic factors

To assess the socio-demographic characteristics of the respondents and to form the relevant factors, we use questions in which respondents were asked to provide information about themselves (questions 37-46 of the questionnaire). Socio-demographic factors included numerical variables such as **age** (number of full years), **household size** (number of family members), and **number of children** (under 18 years old). Discrete variables were also obtained which included **education** (depending on the level: 1 - school, 2 – college, 3 - higher education and 4 - PhD), **material status** (respondent's assessment of the financial situation of his family, from 1 or "Very difficult" to 5 or "Very good") and family **income** per month (7 items reflecting income levels from lower to higher). Obtained binary variables included **gender** (0 – female, 1 – male) and **marital status** (0 – not married, 1 – married), and also nominal variables were used for the analysis such as **district of residence** (17 of 18 districts of St. Petersburg excluding the Kronstadtsky district) and **employment status** (different levels reflecting the sphere of respondents' employment). The results of the calculation of socio-demographic factors are presented in the Table 6.

Table 6 Descriptive statistics of socio-demographic factors.

Variables	N	Mean (%)	Std Dev	Min	Max
Age (continuous variable)	421	37.7	14.8	18.0	93.0
Gender (0 – female, 1 – male)	421	38.5%	0.5	0	1
Marital status (0 – single, 1 – married)	421	53.4%	0.5	0	1
Household size (continuous variable)	421	2.67	1.4	1	13
Number of children (continuous variable)	421	0.58	0.9	0	4
Education (discrete variable)	421	2.93	0.51	1	4
1 – school education	12	3%	–	–	–
2 – college education	35	8%	–	–	–
3 – higher education	346	82%	–	–	–
4 – PhD	28	7%	–	–	–
Material status (discrete variable)	421	3.19	0.8	0	5
1 – very poor	12	3%	–	–	–
2 – poor	43	10%	–	–	–
3 – moderate	230	55%	–	–	–
4 – good	124	29%	–	–	–
5 – very good	12	3%	–	–	–
Monthly income (discrete variable)	421	2.69	1.4	1	7
1 – >40,000 rubles	81	19%	–	–	–
2 – 40,000-80,000 rubles	153	36%	–	–	–
3 – 80,000-120,000 rubles	80	19%	–	–	–
4 – 120,000-160,000 rubles	69	17%	–	–	–
5 – 160,000-200,000 rubles	9	2%	–	–	–
6 – 200,000-300,000 rubles	20	5%	–	–	–
7 – >300,000 rubles	9	2%	–	–	–
District of living (nominal variable)	421	–	–	–	–
Admiralteisky (0 – no, 1 – yes)	8	2%	0.14	0	1
Vasileostrovskiy (0 – no, 1 – yes)	17	4%	0.20	0	1
Vyborgsky (0 – no, 1 – yes)	33	8%	0.27	0	1
Kalininsky (0 – no, 1 – yes)	32	8%	0.27	0	1

Variables	N	Mean (%)	Std Dev	Min	Max
Kirovsky (0 – no, 1 – yes)	3	1%	0.08	0	1
Kolpinsky (0 – no, 1 – yes)	4	1%	0.10	0	1
Krasnogvardeisky (0 – no, 1 – yes)	38	9%	0.29	0	1
Krasnoselsky (0 – no, 1 – yes)	15	4%	0.19	0	1
Kronstadtsky (0 – no, 1 – yes)	0	–	–	–	–
Kurortniy (0 – no, 1 – yes)	8	2%	0.14	0	1
Moskovsky (0 – no, 1 – yes)	22	5%	0.22	0	1
Nevsky (0 – no, 1 – yes)	107	25%	0.44	0	1
Petrogradsky (0 – no, 1 – yes)	22	5%	0.22	0	1
Petrodvortsoviy (0 – no, 1 – yes)	13	3%	0.17	0	1
Primorsky (0 – no, 1 – yes)	74	18%	0.38	0	1
Pushkinsky (0 – no, 1 – yes)	12	3%	0.17	0	1
Frunzensky (0 – no, 1 – yes)	8	2%	0.14	0	1
Centralniy (0 – no, 1 – yes)	5	1%	0.11	0	1
Employment status (nominal variable)	421	–	–	–	–
Entrepreneur, business owner (0 – no, 1 – yes)	43	10%	0.30	0	1
Commercial company worker (0 – no, 1 – yes)	176	42%	0.49	0	1
Social worker (0 – no, 1 – yes)	74	18%	0.38	0	1
Civil servant (0 – no, 1 – yes)	6	1%	0.12	0	1
Freelancer / self-employed (0 – no, 1 – yes)	11	3%	0.16	0	1
Pensioner (0 – no, 1 – yes)	33	8%	0.27	0	1
Student (full-time) (0 – no, 1 – yes)	49	12%	0.32	0	1
Temporarily unemployed (0 – no, 1 – yes)	10	2%	0.15	0	1
Housewife / maternity leave (0 – no, 1 – yes)	19	5%	0.21	0	1

Source: compiled by the author.

Dwelling factors

Dwelling characteristics include factors of living conditions that can influence household energy conservation and energy efficiency. Among the variables considered in the literature, binary variables were included: **homeownership status** (0 – rental, 1 – owned), **payment of utility bills** (0 – if others pay, 1 – if the respondent pays by himself), characteristics of the **heating system** (0 – central heating system, 1 – autonomous heating system, including house commonly owned boiler, individual gas and electric heating boilers in apartments and private houses), as well as the **presence of meters** and the **presence of thermostats** to control the heating temperature in dwelling (0 – absent, 1 – present). In addition, we include continuous and discrete variables such as the **number of rooms** (in quantitative terms), the **age of the house** (based on the pictures with typical serial houses chosen by the respondents as the most similar to their place of residence), the **area of the house** and the **duration of residence** in the current dwelling. The results of the calculation of dwelling factors are presented in the Table 7.

Table 7 Descriptive statistics of dwelling factors.

Variables	N	Mean (%)	Std Dev	Min	Max
House ownership (0 – tenant, 1 – owner)	421	79.1%	0.41	0	1
Bill payment (0 – another person, 1 – myself)	421	73.4%	0.44	0	1
Number of bedrooms (continuous variable)	421	1.922	0.96	1	10
House age (discrete variable)	421	3.174	1.63	1	7
1 – Up to 5 years	9	2%	–	–	–
2 – 5-14 years old	194	46%	–	–	–
3 – 15-24 years old	111	27%	–	–	–
4 – 25-34 years old	24	6%	–	–	–
5 – 35-49 years old	27	6%	–	–	–
6 – 50-64 years old	18	4%	–	–	–
7 – 65 years and over	38	9%	–	–	–
House area (discrete variable)	421	2.879	1.36	1	7
1 – Up to 32 sq.m	48	12%	–	–	–
2 – 32-51 sq.m	165	39%	–	–	–
3 – 52-71 sq.m	80	19%	–	–	–
4 – 72-91 sq.m	68	16%	–	–	–
5 – 92-111 sq.m	43	10%	–	–	–
6 – 112-172 sq.m	12	3%	–	–	–
7 – More than 172 sq.m	5	1%	–	–	–
Living period (full years) (discrete variable)	421	1.684	0.83	1	4
1 – Up to 5 years	209	50%	–	–	–
2 – 5-12 years	158	37%	–	–	–
3 – 13-24 years	32	8%	–	–	–
4 – More than 24 years	22	5%	–	–	–

Variables	N	Mean (%)	Std Dev	Min	Max
House heating system (0 – central, 1 – autonomous)	421	13.8%	0.35	0	1
House meters presence (0 – no, 1 – yes)	421	88.6%	0.32	0	1
Thermostat presence (0 – no, 1 – yes)	421	81.0%	0.39	0	1

Source: compiled by the author.

Purchasing factors

In addition to the classic factors that are highlighted in the literature as stimulating energy conservation, for questions that involve a rational decision concerning the purchase or investment in energy efficiency retrofits, we provided the answer options with the reasons for the decision. In this context, we asked respondents to name the main reasons they bought energy-efficient appliances or installed energy-efficient retrofits, or the reasons by which respondents would buy these appliances or adopt these retrofits if they have not already done this. The results of the analysis of the factors of making a purchase are presented in the Table 8.

Table 8 Purchasing factors of energy conservation.

Variables	N	Mean (%)	Std Dev	Min	Max
Reasons for energy efficient appliances purchase:					
Reason: economy (0 – no, 1 – yes)	421	64.85%	0.48	0	1
Reason: environment (0 – no, 1 – yes)	421	26.84%	0.44	0	1
Reason: quality (0 – no, 1 – yes)	421	38.72%	0.49	0	1
Reason: friends (0 – no, 1 – yes)	421	0.48%	0.07	0	1
Reason: comfort (0 – no, 1 – yes)	421	13.06%	0.34	0	1
Reasons for energy efficient retrofits installation:					
Reason: economy (0 – no, 1 – yes)	421	37.29%	0.48	0	1
Reason: easiness (0 – no, 1 – yes)	421	25.89%	0.44	0	1
Reason: environment (0 – no, 1 – yes)	421	7.13%	0.26	0	1
Reason: initiative (0 – no, 1 – yes)	421	34.44%	0.48	0	1
Reason: support (0 – no, 1 – yes)	421	26.60%	0.44	0	1
Reason: friends (0 – no, 1 – yes)	421	6.65%	0.25	0	1
Reason: comfort (0 – no, 1 – yes)	421	33.02%	0.47	0	1

Source: compiled by the author.

To identify factors potentially influencing the purchase of energy efficient appliances, respondents were asked to indicate the reasons why they bought them, as well as the reasons that could influence the decision to purchase an energy efficient appliance if the respondent has not bought them yet (question 16 of questionnaire). As a result, the following variables were formed from the reasons chosen by the respondents: **“Reason: economy”** – this allows (would allow) saving on utility bills; **“Reason: environment”** – this helps (would help) the environment, reduces (would reduce) carbon dioxide emissions; **“Reason: quality”** – energy efficient appliances are (would be) better than alternatives; **“Reason: friends”** – this is what my neighbors or friends do (would do); **“Reason: comfort”** – they make (would make) the house more comfortable.

Similarly, factors potentially influencing the installation of energy efficient retrofits were identified. Respondents were asked to indicate the reasons why energy efficiency retrofits were made, as well as the reasons that could affect the installation of them if it has not yet been made (questions 21-22 of the questionnaire). As a result, the following variables were formed: **“Reason: economy”** – this allows (would allow) saving on utility bills; **“Reason: easiness”** – it was (would be) easy or quick to do; **“Reason: environment”** – it helps (would help) the environment, reduces (would reduce) carbon dioxide emissions; **“Reason: initiative”** – this was (would be) done not on my initiative; **“Reason: support”** – financial support for the work was (would be) allocated; **“Reason: friends”** – neighbors or people who live nearby did (would do) it; **“Reason: comfort”** – this make (would make) the house warmer and more comfortable.

In the following sections, the obtained variables characterizing the reasons for making a purchase will be used to build models for purchasing energy-efficient appliances and installing energy-efficient retrofits. As a result of the application of these variables, it is expected to highlight differences in the factors or reasons for making an efficiency decision between buyers and non-buyers of energy efficient measures, interpret the differences and form recommendations for better involvement of people who do not buy energy efficient measures.

2.2 Results of empirical study

The next step after collecting and processing the data was the construction of econometric models that explain the stimulating factors of energy-conserving behaviors, in accordance with formulas 2-6 in Section 2.1.1.

2.2.1 Curtailment behavior model

The model of curtailment behavior, which is presented in the Table 9, was built by considering the influence of various groups of factors, including psychological, socio-demographic and dwelling, on the dependent variable **"Curtailment behavior"** in accordance with formula (2), presented in Section 2.1.1. To study the dependent variable, a hierarchical approach was used, presented in some previous studies (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011; Chen et al, 2017), which allows to consider the isolated influence of various groups of factors. At the same time, the quality of the obtained models is evaluated using the coefficient of determination (R^2), which shows what part of the variation of the dependent variable can be explained by the selected set of factors. The parameters of the obtained regression equations are estimated using the ordinary least squares (OLS) method, which is based on minimizing the sum of squared deviations of the values of the constructed functions from the actual values, which allows to find an equation that best corresponds to the actual values (Das, 2019). The OLS method is based on a set of prerequisites, to verify which statistical tests that characterize the quality of the constructed model are necessarily carried out.

Table 9 Parameters of the curtailment behavior model.

Parameters	Model 1: Psychological factors		Model 2: Dwelling factors		Model 3: Socio-demographic factors		Model 4: Complete	
	β	t	β	t	β	t	β	t
Intercept	0.00	0.00	-0.35$^{\bullet}$	-1.86	-0.42	-1.22	-0.36	-1.26
Cost-Benefit ratio	0.11*	1.98					0.16**	3.02
Personal norms	0.32***	7.10					0.30***	6.98
Attitudes	0.19***	3.66					0.27***	5.53
Locus of control	0.31***	6.26					0.26***	5.66
Knowledge	0.13**	2.73					0.13**	2.90
Number of bedrooms			-0.16*	-2.45			-0.20***	-3.52
House heating system			0.38*	2.03			0.54***	3.53
Thermostat presence			0.75***	4.70			0.68***	5.10
Age					-0.00	-0.16	-0.01*	-2.41
Gender					-0.30*	-2.28	-0.17$^{\bullet}$	-1.64
Marital status					0.44**	2.89	0.33**	2.69
Household size					-0.16*	-2.53	-0.09$^{\bullet}$	-1.82
Number of children					0.24*	2.57	0.24**	3.19
Material status					0.19*	2.26	0.15*	2.24
R^2	32.3%		7.3%		7.1%		45.2%	
F	39.7***		11.0***		5.25***		24.01***	
BIC	1305.57		1425.91		1445.17		1270.41	

Source: compiled by the author.

$^{\bullet}$ Significant at 10% level.

* Significant at 5% level.

** Significant at 1% level.

*** Significant at 0.1% level.

As a result of modeling and studying the influence of various groups of factors on curtailment behavior, a complete model was obtained (Model 4). Basic statistical tests of linear regression were carried out for the model. According to the Shapiro-Wilk normality test, the residuals are normally distributed (p.v. = 19.0%), the Breusch-Pagan test signals that the residuals are homoscedastic (p.v. = 6%), the Breusch-Godfrey test demonstrates that there is no autocorrelation of the residuals (p.v. = 13 %). In addition, Ramsey's RESET test was carried out, according to which the mathematical specification of the model is correct, and variance-inflation factors were calculated, according to which there is no problem of multicollinearity of the model regressors.

The results of statistical tests allow us to conclude that the parameters (coefficients) of the model are best linear unbiased estimators (BLUE) and correspond to the properties of consistency, unbiasedness and efficiency. The resulting model was able to explain more than 45% of the variance of the curtailment behavior variable, which is not enough to make reliable predictions, but enough to draw conclusions about the statistical significance of the factors included in the model. In addition, the obtained coefficient of determination overcomes many previous studies, which allows us to conclude that it is difficult to explain energy-conserving behavior in terms of rational factors (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011; Chen et al, 2017; Trotta, 2018). Behavior can often be carried out without explicit reasons, intuitively or out of habit, which makes it inexplicable from the point of view of rational factors.

Based on the analysis of the coefficients of the model, the following conclusions can be drawn:

1. The curtailment behavior of households is explained mainly by psychological factors. **"Cost-Benefit ratio"**, **"Personal norms"**, **"Attitudes"**, **"Locus of control"** and **"Knowledge"** act as statistically significant psychological factors. People who believe that energy conservation is justified if it saves money are more inclined to conserve energy. The stimulating factor is the direct saving of money, which is achieved through daily actions **(Cost-Benefit ratio)**. Also, people who demonstrate personal norms for energy conservation are actually more inclined to curtailment behavior **(Personal norms)**. A positive attitude towards energy conservation **(Attitudes)** and knowledge about energy consumption and energy conservation at home **(Knowledge)** also have a positive effect on the intensity of households' curtailment behavior. Therefore, in the case of this study, the actions of respondents are not characterized by the presence of the problem of attitudes-actions gap and knowledge-action gap, which were obtained in some other studies (Barr et al, 2005; Abrahamse et al, 2005). It is also worth noting the positive impact of the perceived level of control on energy conservation: people who demonstrate a higher level of control over their actions are more prone to energy conservation and are thriftier than others **(Locus of control)**.

2. At the same time, with regard to psychological factors, the variables **“Need for personal comfort”**, **“Normative social influence”** and **“Beliefs”** did not affect the curtailment behavior within the constructed model. This may be due to the fact that people do not perceive daily intuitive actions as a threat to their comfort **(Need for personal comfort)**. Also, the respondents do not focus on external circumstances in the process of energy conservation – it does not matter to them whether friends, neighbors, the state or business contribute to energy conservation, and does not affect their own curtailment behavior **(Normative social influence)**. At the same time, people's beliefs about climate change have nothing to do with their activities in relation to curtailment behavior **(Beliefs)**. It is necessary to carry out educational work with the population in order to better translate people's beliefs into actions and create a strong association of energy conservation as one of the tools for solving the problem of climate change.

3. From the point of view of other groups of factors, it can be concluded that curtailment behavior is poorly influenced by dwelling factors and socio-demographic factors. From a dwelling perspective, the greater the **number of bedrooms** in a dwelling, the lower the intensity of energy conservation, which is explained by higher difficulty in controlling a larger number of household appliances and switches, what is consistent with the results of previous studies (Santin, 2011). Also, a larger number of rooms in the house may indirectly signal the material status of the respondent, and respectively, reflect the lower relevance of energy conservation for those who lives in larger houses. The configuration of the heat supply system **(House heating system)** also showed its influence on curtailment behavior within the model under consideration. For people with an individual heating system, curtailment behavior is more typical since people feel themselves responsible for reducing energy consumption and receive bills only for their consumption. In this regard, the decentralization of heat supply systems, for example, equipping apartment buildings with individual heat points with weather-dependent automatics, can also influence the behavior of residents towards stimulating energy conservation. In addition, the presence of a thermostat or other means to regulate or adjust the temperature of the heating in the house is a significant factor **(Thermostat presence)**. The presence of a statistically significant relationship means that people tend to use thermostats when they are available and pay attention to additional opportunities to reduce energy consumption in the house.

4. At the same time, it turned out unexpectedly that such factors as **“Bill payment”** and **“House meters presence”** do not have a statistically significant effect on curtailment behavior. According to some early studies, it was expected that the fact of self-paying utility bills and the presence of meters indirectly affect people's awareness of the amount of energy consumed in the house (Santin, 2011; Calvillo et al, 2016). Thus, the respondents would have to respond to the quantities obtained from billing documents and meters in order to seek to reduce them and

conserve energy. However, in today's conditions, given that the actions of paying bills occur unconsciously, people are not inclined to respond to the quantitative values of energy consumed if they are at an intuitively acceptable level. In this regard, consumer response is more sensitive to tariff changes, which are kept relatively low in Russia for political reasons.

5. From the perspective of socio-demographic factors, statistically significant factors were obtained, such as **"Age"**, **"Gender"**, **"Marital status"**, **"Household size"**, **"Number of children"** and **"Material status"**. According to the obtained model, **age** has a negative influence on curtailment behavior. This result is in line with some past research and suggests that as people age, they become less mindful of curtailment behavior and value their comfort more than the necessity to conserve energy (Poortinga et al, 2003). Similarly, with some of the results obtained in previous studies (Zelezny et al, 2000), women were more prone to curtailment behavior than men **(Gender)**. Also, **marital status** has a positive impact on curtailment behavior, which is demonstrated in a change in habits and everyday behavior for people who are married. This finding is also in line with results of previous studies, which conclude that families are becoming more frugal than singles, and that habits and behaviors acquired in marriage persist even after divorce (Trotta, 2018). The same applies to the **number of children** in the family, which have a positive effect on curtailment behavior. The more children under 18 years old are in the family, the less income per family member is, so the issues of energy conservation become more relevant for the household, as well as educational practices and demonstrating a positive example of using appliances for children. At the same time, the **number of household members** negatively affects curtailment behavior. The more members the household has, the less the personal responsibility of each member for energy conservation is felt, therefore, larger households are less inclined to curtailment behavior than smaller. With regard to **material status**, the higher people evaluate their financial situation, the more inclined they are to curtailment behavior according to constructed model. This contradicts the results of some previous research which suggested that lower incomes and poorer financial status are incentives for curtailment behavior (Trotta, 2018). It can be assumed that less wealthy households are less focused on optimizing energy consumption in the home and pay more attention to basic needs, which prevents their curtailment behavior.

6. Also, unexpectedly, it turned out that **household income** and the **level of education** of people do not have a statistically significant effect on curtailment behavior. The lack of influence of **household income** can be explained by the fact that many other factors indirectly take into account the level of household wellbeing, and that both low-income and high-income households are involved in curtailment behavior. In this context, the level of income is not able to explain the difference in the behavior of different households, thus a more detailed study of the behavior of households with different income levels, distributed by quantile groups, is needed. As for the **level**

of education, a statistically significant effect is not achieved due to the fact that people with less than a higher education are underrepresented in the sample, therefore, the features of their behavior cannot be analyzed within the constructed model. This assumption acts as a limitation of the study and should be properly addressed in future studies.

2.2.2 Model for energy-efficient appliances purchase

As a result of considering various combinations of factors and their influence on the dependent variable **"Purchase of energy-efficient appliances"**, a logit model was built, which is presented in the Table 10. Due to the mathematical properties of the logit specification of the model, the set of statistical tests for its quality is limited to tests for the individual and group significance of the coefficients and the calculation of the pseudo-coefficient of determination to assess the quality of the model fit. The resulting model presents statistically significant factors that influence whether respondents buy an energy-efficient appliance and are able to explain 52% of the variance of this dependent variable.

Table 10 Parameters of the energy-efficient appliances purchase model.

Parameter	Energy efficient appliances purchase		
	β	z-value	Effect (%)
Intercept	-3.70^{***}	-5.50	-46.1%
Need for personal comfort	0.53^{***}	3.53	6.6%
Beliefs	0.70^{***}	3.60	8.7%
Knowledge	0.45^{**}	3.14	5.6%
Number of bedrooms	$0.37^{\cdot}$	1.85	4.6%
House meters	2.24^{***}	4.62	43.7%
Gender	1.13^{***}	3.35	13.0%
Marital status	1.53^{***}	4.32	20.2%
Reason: efficiency label	4.32^{***}	7.45	52.1%
Reason: economy	1.99^{***}	5.24	30.4%
Reason: environment	-2.37^{***}	-4.95	-40.9%
Pseudo-R^2	52%		

Source: compiled by the author.

$^{\cdot}$ Significant at 10% level.

* Significant at 5% level.

** Significant at 1% level.

*** Significant at 0.1% level.

As a result of studying the coefficients and marginal effects of the model, the following conclusions were drawn:

1. Among the psychological factors, those that have an influence on dependent variable were identified: **“Need for personal comfort”**, **“Beliefs”** and **“Knowledge”**. At the time of purchase of energy efficient appliances, people's beliefs that energy conservation poses a threat to their personal comfort can be translated into the choice of an energy-efficient appliance (if the **“Need for personal comfort”** variable increases by 1, the probability of purchasing an energy-efficient appliance increases by 6.6%). In the same way, people's beliefs about the problem of climate change and the need for energy conservation and energy efficiency as tools to overcome climate change can influence the decision to buy energy-efficient appliance (with an increase in the **“Beliefs”** variable by 1, the probability of buying an energy-efficient device increases by 8.7%). The level of people's knowledge about energy conservation and about the amount of energy consumed in their home also contributes to the fact of choosing an energy-efficient appliance (if the **“Knowledge”** variable increases by 1, the probability of buying an energy-efficient appliance increases by 5.6%).

2. As for dwelling factors, the resulting model shows the influence of the variables **“Number of bedrooms”** and **“House meters presence”**. At the same time, as in previously obtained studies (Santin, 2011), it is noted that a larger number of rooms in a dwelling requires or creates opportunities for placing a larger number of appliances, respectively, increases the likelihood that at least one of them will be energy efficient (with an increase in the **number of bedrooms** in a dwelling by 1, the probability of buying an energy-efficient appliance increases by 4.6%). Also, as a significant parameter we have the **presence of utility meters** in housing. In the case of meters, people get the opportunity to control their energy consumption, to get accurate results of the energy spent over a certain period. In addition, they start paying bills only for their energy consumption, which is measured and recorded by the meter, so they get more incentives to buy energy efficient appliances and reduce energy consumption (**with a meter**, the probability of buying an energy efficient appliance increases by 43.7%).

3. From the point of view of socio-demographic factors, it is worth noting that indicators of **gender** and **marital status** were included in both the curtailment behavior model and the model of purchasing energy-efficient appliances. And if the **marital status** has retained its direction of influence (married people are 20.2% more likely to buy an energy-efficient appliance), then the coefficient for the **gender** variable has changed its sign. This means that, in contrast to the curtailment behavior, buying energy-efficient appliances is more common for men (men are 13% more likely to buy an energy-efficient appliance).

4. As regards the reasons for purchasing energy efficient appliances, their relatively high influence on the purchase of an energy efficient appliance is noted. This suggests that purchasing behavior is more rational than curtailment behavior, as rational reasons weigh heavily in the

decision to purchase an energy-efficient appliance. As significant reasons, buyers of energy-efficient appliances noted the presence of **energy efficiency labels** on appliances, and possibility to **save money** (if these factors are chosen, the probability of buying an energy-efficient appliance increases by 52.1% and 30.4%, respectively). Accordingly, for people who buy energy efficient appliances, information about possible savings and the presence of an energy efficiency label is important and can influence the repeated purchase of an energy efficient appliance. As for **non-buyers** of energy-efficient appliances, they noted the possibility to **help the environment** by reducing the greenhouse gas emissions as a significant purchase factor (when choosing this factor, the probability of purchasing an energy-efficient appliance decreases by 40.9%). This means that purchasing of an energy-efficient appliance is not associated with helping the environment by people. In this case, to correct the situation, it is possible to conduct an information campaign on the environmental benefits of energy-efficient appliances, as well as to include in the energy efficiency label an estimated reduction in greenhouse gas emissions resulting from replacing old appliance with an energy-efficient one. These measures can influence non-buyers of energy efficient appliances and encourage them towards the decision to buy it.

5. As for the other factors related to the reasons for purchasing an energy-efficient appliance, namely the **quality of the appliance**, the fact that **neighbors or friends bought** such an appliance, and the **comfort** associated with the appliance, they did not show statistical significance. Very few respondents chose neighbors as a possible reason for the purchase, which indicates that people are not guided by others when buying appliances. At the same time, in relation to the quality and comfort of using energy-efficient household appliances, there is currently no single position of respondents. **Buyers** of energy efficient appliances notice their quality, while **non-buyers** notice quality as a possible reason for buying. Therefore, it is necessary to improve the positioning of energy-efficient appliances as higher quality and more comfortable for use at home.

2.2.3 Model for installation of energy efficient retrofits

To determine the factors stimulating the installation of energy efficient retrofits, a model was built in accordance with formulas (5) and (6) presented in Section 2.1.1. The dependent variable is the **"Energy efficient retrofits"** means the fact of the installation of an energy efficient retrofit noted by the respondents. Psychological, socio-demographic, and dwelling factors, as well as factors indicating the reasons for making these retrofits obtained in Section 2.1.3, were included as independent variables in the model. The final model, including all statistically significant factors, is presented in the Table 11.

Table 11 Parameters of the energy-efficient retrofits installation model.

Parameter	Energy efficient retrofits installation		
	β	z-value	Effect (%)
Intercept	-7.27***	-6.77	-36.5%
Cost-Benefit ratio	-1.23***	-4.76	-6.1%
Normative social influence	-0.36*	-2.08	-1.6%
Beliefs	0.53**	2.76	2.9%
Locus of control	-0.45*	-2.26	-2.1%
House age	0.82***	5.43	3.9%
House area	0.35*	2.14	1.8%
Living period	0.88**	3.21	4.5%
House heating system	2.09**	2.96	18.3%
Gender	1.09*	2.27	6.1%
Reason: economy	-2.33***	-3.72	-11.0%
Reason: easiness	-2.46**	-2.66	-8.8%
Reason: initiative	2.71***	4.16	22.0%
Reason: support	-5.20***	-4.12	-16.2%
Reason: friends	2.73***	3.37	35.5%
Reason: comfort	4.39***	6.16	46.2%
Pseudo-R^2			69.2%

Source: compiled by the author.

* Significant at 5% level.

** Significant at 1% level.

*** Significant at 0.1% level.

Similar to the model for purchasing energy-efficient appliances, this logit model also has a limited set of statistical tests to assess the quality of the model. The calculated pseudo-coefficient of determination indicates that 69% of the variance of the dependent variable is explained by this set of factors. As a result of studying the coefficients and marginal effects of the independent variable, the following conclusions were drawn:

1. Psychological factors are less able to influence the installation of energy efficient retrofits as compared to previous models. This means that such a decision is based on rational factors and reasons to a greater extent. Variables **"Cost-Benefit ratio"**, **"Normative social influence"**, **"Locus of control"** have a negative sign, so they negatively influence the installation of energy-efficient retrofits. The **"Cost-Benefit ratio"** variable, which characterizes the degree to which a person evaluates the material benefits of conserving energy negatively affects the dependent variable (if the **"Cost-Benefit ratio"** variable increases by 1, the probability of installing an energy-efficient retrofit decreases by 6.1%). People who are not willing to spend additional money without receiving respective material benefits are a less desirable audience for

incentivizing the installation of energy efficient retrofits. The **"Normative social influence"** variable, which characterizes the degree to which a person's energy conservation and energy efficiency depends on the actions of others, also has a negative impact on the dependent variable (if the **"Normative social influence"** variable increases by 1, the probability of installing an energy-efficient retrofit decreases by 1.6%). People who install energy efficient improvements are primarily guided by their own needs and are not subject to normative social influence from others. The variable **"Locus of control"**, which characterizes the degree to which a person controls his actions and is able to act to conserve energy, also has a negative impact on the dependent variable (if the **"Locus of control"** variable increases by 1, the probability of installing an energy-efficient retrofit decreases by 2.1%). People who install energy efficient retrofits do not tend to control their actions in order to conserve energy as part of curtailment behavior. However, they contribute to energy efficiency by investing in energy-efficient retrofits. On the contrary, the **"Beliefs"** variable, which expresses the degree to which a person is convinced of the importance of the climate change problem and the need to conserve energy, has a positive effect on the installation of energy-efficient retrofits (if the **"Beliefs"** variable increases by 1, the probability of making an energy-efficient retrofit increases by 2.9%). This suggests that people who are convinced of the problem of climate change are a more attractive audience for involvement in programs to stimulate the installation of energy-efficient retrofits.

2. Compared to previous models, in the model of factors that stimulate the installation of energy-efficient retrofits, dwelling factors play a larger role. The literature also confirms the conclusion that the installation of energy-efficient retrofits is a rational decision, which is explained mostly by objective factors, and not by the psychological profile of a person (Trotta, 2018). As expected, the older the house, the more likely a person is to install an energy-efficient retrofit (if the **age of the house** increases by one category (see variable levels in Paragraph 2.1.3), the probability of installing an energy-efficient retrofit increases by 3.9%). The same is true for large houses - the larger the area of the house is, the greater is the chance that a person will install an energy-efficient retrofit (with an increase in the **area of the house** by one category (see variable levels in Paragraph 2.1.3), the probability of installing an energy-efficient retrofit increases by 1.8%). A significant factor influencing the installation of energy-efficient retrofits is the period of residence (with an increase in the **living period** by one category (see variable levels in Paragraph 2.1.3), the probability of installing an energy-efficient retrofit increases by 4.5%). For this reason, people who live longer in their home are more likely to invest in it. Finally, the parameter of the **house heating system** can also influence the decision to install energy-efficient retrofits (if there is an individual or autonomous heating system (see Paragraph 2.1.3 for explanations), the probability of installing an energy-efficient retrofit increases by 18.3%). This is because people

feel more responsible for their own energy supply and therefore more likely to take steps to optimize their energy consumption.

3. From the point of view of socio-demographic factors, only the **"Gender"** variable acts as a significant one. As in the previous model, men were more likely to make decisions about installing energy-efficient retrofits (for men, the probability of installing energy-efficient retrofit increases by 6.1%). This result may indicate a greater propensity for the male population to tackle technically complex issues, such as choosing an energy-efficient appliances or retrofits to install in the home according to various parameters.

4. Just as in the case of the model of purchasing energy-efficient appliances, the factors that characterize the reasons for installation of energy-efficient retrofit have a significant influence. All variables from this list turned out to be statistically significant and influencing the dependent variable excepting the **"Reason: environment"** variable. In reality, energy-efficient retrofits are not associated with helping the environment, either among people who install these retrofits or among people who do not. This once again emphasizes the importance of calculating the marginal effects on greenhouse gas emissions from the implementation of various retrofits and then informing the potential audience. Considering that quite a lot of people have positive beliefs about helping the environment, it is necessary to additionally stimulate their investments in energy efficiency with a sense of satisfaction from the implementation of some energy-efficient retrofit.

5. As for the other factors characterizing the reasons for installing energy-efficient retrofits, they were divided into two groups according to the direction of influence. The first group of factors includes **"Reason: economy"**, **"Reason: easiness"** and **"Reason: support"**, which stress out possible money savings, ease of installation and financial support as determinants for installing retrofits (if these reasons are indicated, the likelihood that a person installed energy-efficient retrofits, decreases by 11%, 8.8% and 16.2% respectively). As a result, we can conclude that for people who have not installed energy-efficient retrofits, potential energy cost savings, ease of improvement, and financial support may be significant factors in stimulating the decision to install. **Savings** from energy-efficient retrofits are not always obvious, so it is necessary to help the population, through external identification the potential for energy-efficient improvements and proposition them for implementation to residents. The same applies to the **easiness of implementation** of energy-efficient improvements, since not all of them are obvious and known to people. In order to help people it is necessary to select a list of the simplest retrofits that can be implemented on their own, as well as to simplify the solution of the problem for residents by delegating the authority to carry out work to a specialized organization. **Financial support** can be provided through the provision of vouchers that give the right to purchase works or services for the installation of energy-efficient retrofits. In this context, the development of the institution of

energy service contracts as a tool for improving the energy efficiency of the residential sector also seems reasonable. Currently, energy service contracts are actively used in the public sector, and in the residential sector they are just beginning to develop and popularize.

6. The second group of factors characterizing the reasons for the implementation of energy-efficient retrofits includes **“Reason: initiative”**, **“Reason: friends”**, **“Reason: comfort”**, which characterize such stimulating factors as the initiative to install retrofits from outside, the fact of installation of energy-efficient retrofits among friends and neighbors and increase comfort and warmth in the home. If these factors are indicated the likelihood that a person has installed energy-efficient retrofits increases by 22%, 35.5% and 46.2%, respectively. We can once again ensure that the **initiative** coming from the outside makes it easier for people to make decisions, so it is necessary to strive for the proactive involvement of the population in the installation of energy efficient retrofits. It can also be concluded that there is a **“word of mouth”** effect in the installation of energy-efficient retrofits. In this way, the experience gained as part of the retrofit installation is transferred to the closest friends and neighbors, which will positively affect the speed of dissemination of best practices. Finally, the **comfort** gained through the installation of energy-efficient retrofits is the underlying reason and fundamental factor in the implementation of this activity. A more in-depth study of possible retrofits and their impact on the level of perceived comfort is needed in order to specifically offer possible options to people with different living parameters and financial possibilities.

2.2.4 Consumer profiles based on cluster analysis

The cluster analysis was carried out in accordance with the methodology presented in Section 2.1.1. Variables **“Curtailment behavior”**, **“Energy efficient appliances”**, **“Energy efficient retrofits”** characterizing all types of energy saving behavior considered in this study were chosen for grouping. Such a grouping makes it possible to obtain all possible combinations of different types of energy behavior that are characteristic of different types of users, describe the portraits of these user groups, as well as interpret their preferences and form recommendations for stimulating energy conservation and energy efficiency among the resulting groups.

Using Gower distance as a distance metric, a dissimilarity matrix was calculated, or in other words, a mathematical expression of how far the points in the data differ from each other. Subsequently, the specified dissimilarity matrix is used to group the closest points, depending on the chosen agglomerative clustering method. Agglomerative clustering allows to obtain more balanced groups, which are individually quite homogeneous and at the same time differ from each other. Ward linkages was used as a cluster merging method. The resulting dendrogram, which is a graphical representation of the constructed clusters, is shown in the Figure 4.

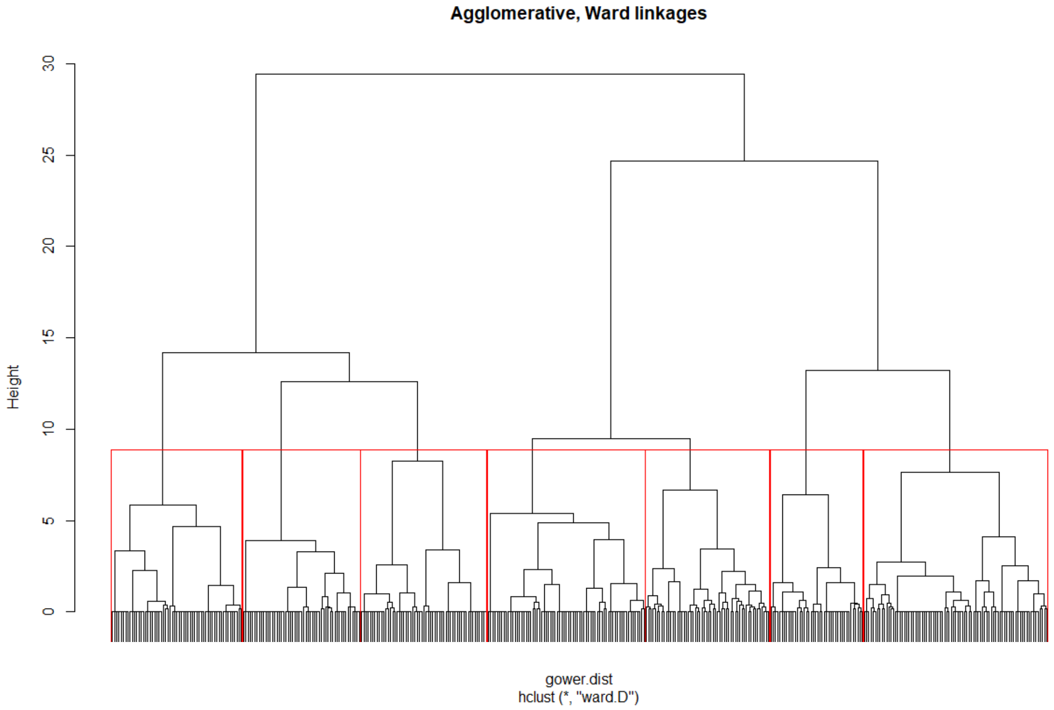

Figure 4 Dendrogram of clusters by energy behaviors

Source: compiled by the author.

To analyze and select the number of clusters, additional calculations were made, and graphs were built. As statistical methods for deciding on the number of clusters, the "Elbow" method and the "Silhouettes" method are traditionally used (Kaufman, Rousseeuw, 1990). The calculated statistics for the obtained clusters, which were used for the analysis, are presented in the Table 12.

The Elbow method relies on the **Within Cluster Sum of Squares** (or error sum of squares) statistics, which is a measure of cluster density and is defined as the sum of squared distances between cluster objects and its center (Kaufman, Rousseeuw, 1990). This indicator is calculated for each variant of the number of clusters and is presented in the Table 12 as the **“within.cluster.ss”** parameter. The lower the **Within Cluster Sum of Squares**, the more compact the clusters are, which means the better the result of the cluster analysis. The decision heuristic for the Elbow method is usually referred to as the point at which the decline in **Within Cluster Sum of Squares** slows down, so further increase in the number of clusters is not rational (Kaufman, Rousseeuw, 1990). The constructed graph of the "Elbow" method is shown in the Figure 5.

In the same way, within the Silhouettes method, for each number of possible clusters, a measure of how similar an object is to its cluster compared to other clusters (**"avg.silwidth"** in the Table 12) was calculated (Kaufman, Rousseeuw, 1990). The higher the value of the calculated statistics, the better the points match their own clusters and the worse they match neighboring clusters, respectively, the better the clustering configuration. The constructed graph of the "Silhouettes" method is shown in the Figure 6.

Table 12 Clustering statistics on energy behaviors.

Parameter	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Test 11	Test 12	Test 13	Test 14
cluster.number	2	3	4	5	6	7	8	9	10	11	12	13	14	15
n	421	421	421	421	421	421	421	421	421	421	421	421	421	421
within.cluster.ss	73.05	59.06	53.14	46.94	42.26	38.34	35.70	32.91	29.72	27.38	25.73	24.23	22.96	22.03
avg.silwidth	0.19	0.23	0.21	0.23	0.26	0.29	0.29	0.30	0.33	0.34	0.36	0.36	0.37	0.38
Cluster-1 size	169	169	110	110	57	57	28	28	28	28	28	28	28	28
Cluster-2 size	252	127	127	127	127	56	56	56	37	37	37	37	37	37
Cluster-3 size	0	125	125	83	83	83	83	49	19	19	19	19	19	19
Cluster-4 size	0	0	59	42	42	42	29	29	49	49	49	49	49	49
Cluster-5 size	0	0	0	59	53	53	42	42	29	29	29	29	29	29
Cluster-6 size	0	0	0	0	59	71	53	53	42	24	24	24	24	24
Cluster-7 size	0	0	0	0	0	59	71	34	53	18	18	18	18	18
Cluster-8 size	0	0	0	0	0	0	59	71	34	53	53	53	53	53
Cluster-9 size	0	0	0	0	0	0	0	59	71	34	34	34	34	34
Cluster-10 size	0	0	0	0	0	0	0	0	59	71	71	62	34	34
Cluster-11 size	0	0	0	0	0	0	0	0	0	59	26	26	26	26
Cluster-12 size	0	0	0	0	0	0	0	0	0	0	33	33	28	28
Cluster-13 size	0	0	0	0	0	0	0	0	0	0	0	9	33	16
Cluster-14 size	0	0	0	0	0	0	0	0	0	0	0	0	9	17
Cluster-15 size	0	0	0	0	0	0	0	0	0	0	0	0	0	9

Source: compiled by the author.

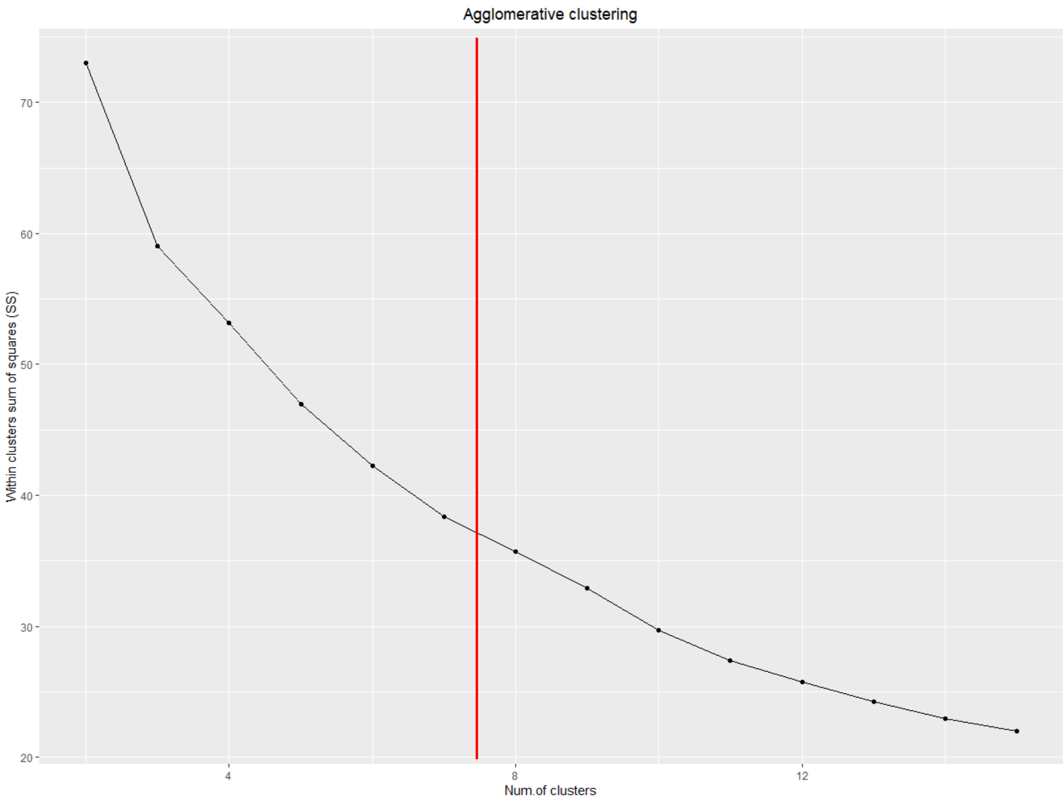

Figure 5 Application of the Elbow method to determine the number of clusters.

Source: compiled by the author.

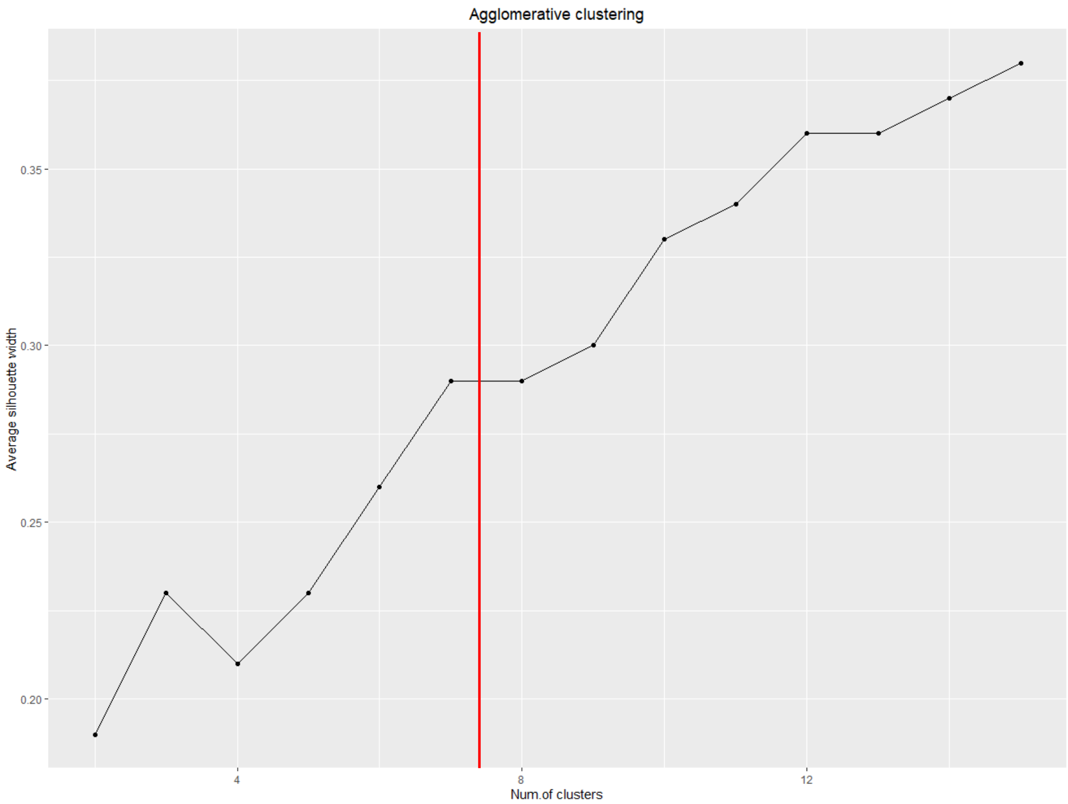

Figure 6 Application of the Silhouettes method to determine the number of clusters.

Source: compiled by the author.

As a result of the analysis of both methods, 7 clusters were determined as the optimal number of clusters, which are further used to describe user profiles in relation to energy conservation and energy efficiency. The selected number of clusters makes it possible to ensure a sufficiently high compactness of the resulting clusters, as well as a high degree of their difference from each other, while maintaining a sufficiently large size and representativeness of the clusters.

Received 7 user profiles differ in frequency, intensity and types of energy behaviors. A more detailed description of the portraits makes it possible to better understand their characteristics, the degree of activity in relation to various types of energy behaviors, as well as the factors that can stimulate the energy conservation and energy efficiency of various groups. The results of the description of user portraits are presented in the Table 13.

In terms of involvement in various types of energy behaviors, users were divided into groups, 4 of which are actively buying energy-efficient appliances and 2 of which have installed energy-efficient retrofits in their homes. Users are also divided according to the level of intensity of curtailment behavior into groups, 2 of which are relatively curtailment, 1 is wasteful, and 4 have an average or above average intensity of curtailment behavior. To compare the performance of user groups according to the models constructed in Sections 2.2.1-2.2.3, an average value was calculated for each variable. Additionally, for continuous variables, the difference between the mean and the minimum value was taken, and then divided by the range of the variable to determine how high or low the group mean of the variable was on the PCA-built scales.

Table 13 Descriptive statistics of identified consumer profiles.

Parameter	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**	**Cluster 7**
Cluster size, %	14%	13%	20%	10%	13%	17%	14%
Energy conservation and efficiency variables							
Energy efficient appliances	93%	41%	11%	7%	98%	99%	100%
Energy efficient retrofits	0%	93%	18%	14%	2%	96%	0%
Curtailment behavior	62%	55%	75%	24%	51%	55%	76%
Psychological factors							
Need for personal comfort	39%	35%	26%	51%	25%	42%	46%
Cost-Benefit ratio	32%	31%	53%	39%	44%	27%	46%
Normative social influence	74%	60%	63%	57%	46%	51%	54%
Personal norms	65%	61%	66%	46%	64%	65%	54%
Beliefs	66%	63%	76%	45%	61%	65%	47%
Attitudes	55%	49%	59%	28%	59%	46%	52%
Locus of control	52%	56%	70%	36%	66%	50%	52%
Knowledge	38%	43%	41%	29%	46%	52%	54%
Dwelling factors							
House age	27.4	31.3	21.0	33.1	15.0	23.0	19.5
House area	56.6	77.6	50.2	59.1	68.3	59.2	55.4
Living period	5.1	7.8	3.6	8.0	6.1	12.8	6.6
House heating system	4%	21%	17%	0%	2%	39%	2%
House meters presence	98%	84%	90%	57%	98%	97%	85%
Thermostat presence	93%	79%	87%	45%	98%	70%	86%

Parameter	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Socio-demographic factors							
Age	36.6	33.1	34.3	31.7	42.8	43.6	40.5
Gender	49%	38%	20%	45%	30%	48%	46%
Marital status	37%	43%	28%	26%	87%	76%	78%
Household size	2.5	2.0	2.7	2.6	3.1	3.1	3.3
Presence of children	37%	21%	24%	31%	30%	52%	53%
Reasons for energy efficient appliances purchase:							
Reason: efficiency label	28%	27%	7%	0%	75%	89%	78%
Reason: economy	72%	52%	51%	52%	75%	77%	75%
Reason: environment	18%	39%	40%	12%	13%	39%	14%
Reason: quality	37%	27%	33%	79%	36%	39%	34%
Reason: comfort	5%	34%	24%	14%	6%	4%	2%
Reasons for energy efficient retrofits installation:							
Reason: economy	93%	14%	31%	40%	38%	20%	32%
Reason: easiness	60%	5%	14%	69%	42%	0%	15%
Reason: initiative	18%	50%	36%	26%	25%	28%	56%
Reason: support	47%	4%	13%	55%	47%	1%	39%
Reason: friends	2%	2%	2%	12%	0%	17%	12%
Reason: comfort	4%	59%	45%	17%	21%	55%	17%

Source: compiled by the author.

The first category of users (Cluster 1) is the **"Intuitive savers"**, who buy and use energy-efficient appliances, have an above average intensity of curtailment behavior, but do not install energy-efficient retrofits. This group is characterized by the presence of high **personal norms** for environmental protection and energy conservation, and a generally positive **attitude** towards energy conservation. However, energy conservation of this group is limited by the relatively low level of **knowledge** about energy conservation and the amount of energy used in the home. This group tends to buy energy-efficient appliances because they consider them to be of higher quality and more economical, and also because of their **beliefs**. The installation of energy-efficient retrofits for this group may be facilitated by their **beliefs** as well as their relative willingness to bear the cost for energy conservation and efficiency **(Cost-Benefit ratio)**. Purchasing factors of retrofit installation include saving money on energy **(Reason: economy)**, easiness of installation **(Reason: easiness)**, and outside financial support **(Reason: support)**. However, this group lives in their home for a relatively short time, which may preclude their decision to install an energy-efficient retrofit **(Living period)** and live in homes with central heating **(Autonomous heating system)**, which may limit the technical ability to install energy-efficient retrofits.

The second group of users (Cluster 2), **"Non-permanent energy savers"**, is different in that almost every representative reported installing an energy-efficient retrofit, although curtailment behavior and purchase of energy-efficient appliances are less common. However, the installation of energy-efficient retrofits mostly was influenced by the initiative of others **(Reason: initiative)** or the need to improve comfort **(Reason: comfort)**, given that, on average, they live in relatively old houses. Thus, the efficiency behavior of this group is temporary and is aimed at solving a certain problem that arises due to the **high age of the house** or the operation of an **autonomous heating system** at home. At the same time, users of this group are not characterized by curtailment behavior or the purchase of energy-efficient appliances. Factors that may encourage this group to buy energy-efficient appliances are **saving money**, **helping the environment** by reducing greenhouse gas emissions, and making the home more **comfortable** with a new appliance. With regard to curtailment behavior, this group is characterized by the existence of **personal norms** in relation to helping nature and energy conservation, but there is also the potential for developing a level of **knowledge** and **attitudes** towards energy conservation so that their values would better translate into everyday actions. In order to encourage energy conservation among this group of users, it is necessary to increase the frequency of implementation of currently intermittent energy efficiency actions. To do this, it is worth promoting the identified parameters of energy-efficient appliances, as well as improving the level of **knowledge** and **attitude** towards energy conservation through additional information and education.

The third group of users (Cluster 3) **"Thrifty housewives"** is characterized by a high intensity of curtailment behavior in the absence of facts of buying energy-efficient appliances and installing energy-efficient retrofits. This group has the highest propensity for curtailment behavior, according to their **personal norms**, **beliefs** and **attitudes** towards energy conservation, and also associates curtailment behavior with **reducing energy costs**. The incentives for buying energy-efficient appliances are **saving money** and **helping the environment**, while the incentives for installing energy-efficient retrofits are **increasing the warmth and comfort** in the home and the **initiative of others**. At the same time, their high **beliefs** and generally suitable living conditions **(House heating system, House meters presence)** can encourage the purchase of energy-efficient appliances and the installation of energy-efficient retrofits. However, the shortest average duration of residence in their homes **(Living period)** and the technical complexity of these issues for women **(Gender)** should be singled out as the main obstacles to stimulate their efficiency behavior.

The fourth group (Cluster 4) is **"Energy wasters"**, who are characterized by the lowest intensity of energy conservation and do not practice any type of efficiency behaviors. They do not have **knowledge** about energy conservation, **personal norms** for nature protection and energy conservation, and do not control their actions that consume energy in the house **(Locus of control)**. They do not buy energy-efficient appliances and do not make energy-efficient retrofits because they do not understand the reasons for this and how to solve the technical issues of choice. The main factor that stimulates the purchase of energy-efficient appliances is the **quality** of the appliance, a feature that needs to be promoted among uninformed consumers. The key factors for installing energy-efficient retrofits in this group are the **easiness of installation** and **financial support** from the state. Thus, the main measures to stimulate energy conservation of this group should be raising awareness and cultivating a positive attitude towards energy conservation, inspiring beliefs on the need of energy conservation that contribute to the environment protection. Another dimension of the incentive policy can be to make it as easy as possible for the resident to solve the problem by delegating authority to others and by providing support.

A distinctive feature of the fifth group (Cluster 5) **"Unconscious energy wasters"** is the purchase of energy-efficient appliances in the absence of the installation of energy-efficient retrofits, as well as the below than average intensity of curtailment behavior compared to other groups. At the same time, respondents demonstrate relatively high **personal norms** in relation to environmental protection and energy conservation, a positive **attitude** towards energy conservation and the ability to control their behavior **(Locus of control)**, but often get lost in everyday automatic actions, such as leaving lights or appliances on when they leave. At the same time, non-automatic actions that require decision-making are almost always carried out in good faith. The same is true for the purchase of energy-efficient appliances, which are bought by almost all representatives of this group, focusing on the **energy efficiency label** and potential **savings**. Factors that may encourage the installation of energy-efficient retrofits include **financial support**, the **economic feasibility** of the improvement, and **easiness of implementation**. At the same time, taking into account the characteristics of this group, they are able to independently make retrofits if the necessary assistance is allocated. It is necessary to carefully encourage this group to install retrofits, as among the groups considered, on average, they live in the newest homes **(House age)**, which may not require the most of retrofits. As regards the promotion of curtailment behavior, the favorable factors would be an increase in the level of **knowledge** about energy conservation and an improvement in **attitudes** towards energy saving, given that the group has the lowest degree to which comfort prevents energy conservation **(Need for personal comfort)**.

The sixth group (Cluster 6), **"Modernizers - lovers of comfort"** are distinguished by the fact that they are fully involved in efficiency behavior, that is, they buy energy-efficient appliances and install energy-efficient retrofits. However, they have an average level of curtailment behavior, meaning that they sometimes or often perform daily activities that contribute to energy conservation. They almost always buy energy-efficient appliances because they **save money**, **help nature** by reducing greenhouse gas emissions and are better than alternatives **(Reason: quality)**, and they always look for **energy efficiency labels** when buying. The main factor that influenced their installation of energy-efficient retrofits is the increase in **warmth and comfort** in the home. Also, this group, to a greater extent than the rest, highlights the experience of friends and neighbors in installing retrofits **(Reason: friends)** as a significant factor. Thus, this group is characterized by the “word of mouth” effect, when successful experience is transferred between people on their own, without additional promotion. The stimulation strategy for this category of consumers comes down to retaining them and stimulating repeat purchases and installations. Energy-efficient appliances can be promoted among this group through the characteristics of **energy saving**, **quality** and durability, as well as a positive effect on the **environment**. To incentivize the installation of new retrofits, a broad list of retrofits and their impact on home comfort should be identified and proposed for their consideration. Stimulation of curtailment behavior among members of this group is limited, since they have relatively low economic incentives to change their daily behavior. Taking advantage of the relatively high level of **knowledge** and **personal norms** of this group, it is possible to continue to develop a positive **attitude** towards energy conservation and to increase the degree to which users control their daily behavior **(Locus of control)** through information and education.

The seventh group (Cluster 7) **“Frugal families with children”** differs in that they have a relatively high intensity of curtailment behavior and buy energy-efficient appliances, but do not install energy-efficient retrofits. Factors stimulating their curtailment behavior are a high desire to **save money** by energy conservation and high level of **knowledge** in the field of energy conservation compared to other groups. Additionally, curtailment behavior is stimulated by their **marital status** and the **presence of children**, which reduces income per family member and increases the demand for energy conservation. In particular, having children stimulates energy conservation through the educational aspect and the need to show children a good example of how to use appliances correctly and not waste energy. Representatives of this group note **saving money** and **quality** as significant factors in the purchase of energy-efficient appliances, while the benchmark for them is the **energy efficiency label** on the product. A factor that could stimulate the installation of energy-efficient retrofits in the house is an **initiative from outside**, despite the fact that representatives of this group themselves do not see the point in installing them. It is necessary to consider that they live in relatively young housing **(House age)** and for a short time **(Living period)**, while the reluctance to spend additional money for energy conservation and energy efficiency **(Cost-Benefit ratio)** also hinders the installation of energy-efficient retrofits. For this group of users, it is recommended to carefully approach the proposal of energy-efficient retrofits, concentrating on the **cheapest** and **fastest payback** measures. At the same time, it is also recommended to develop a positive **attitude** towards energy conservation through the economic benefits of its implementation.

2.3 Policy recommendations

As a result of building models of energy-conserving behaviors of households and studying their parameters, as well as constructing and interpreting of consumer profiles, general conclusions and recommendations can be drawn on the formation of a policy to stimulate energy conservation and efficiency of households.

As part of the study of the model of curtailment behavior, it can be concluded that it is influenced mainly by psychological factors. In order to encourage frugal daily behavior of households, certain efforts should be made increasing the general level of knowledge of the population in energy conservation issues, fostering positive beliefs and attitudes towards energy conservation. Population informing can be provided both by municipalities and specialized government authorities. When developing and planning activities, it is necessary to focus on the effect that provided information has on the level of knowledge and beliefs of the population, how it is aimed at increasing the perceived level of control over energy conservation, and to what extent reveals the economic benefits of energy conservation and energy efficiency. It is necessary to abandon template forms for presenting information and ensure that it is accessible to all age categories, including the elderly people, who may find it more difficult to understand complex issues of energy conservation and efficiency.

Special attention in terms of stimulating curtailment behavior deserves the technical equipment of residential buildings with metering devices and thermostats to control the heating temperature, as well as the possible decentralization of electricity and heat supplying systems. These measures allow people to feel more responsible for their energy consumption and make energy conservation more desirable, in contrast to the case of passive consumption, when households unconsciously and uncontrollably consume all the energy provided to them.

An additional direction for stimulating curtailment behavior among the population can be the creation and implementation of specialized educational courses in schools, which will allow to develop useful qualities in the younger generation. Additional school courses aimed at protecting nature and energy conservation are as relevant as the recently actively introduced financial literacy and modern technology courses. Considering that families with children are more prone to energy conservation, it can be concluded that the use of special school courses for children can involve their parents and indirectly stimulate energy conservation among the older generation.

Among other things, proper communication can influence efficiency behavior in the form of buying energy-efficient appliances and installing energy-efficient retrofits. The research has shown the role of knowledge and beliefs in decisions to make a purchase or install a retrofit, therefore, the recommended information campaign should also cover these areas. In addition, it is necessary to ensure that public awareness is targeted at both men and women, who have shown less propensity to purchase energy-efficient appliances and install energy-efficient retrofits than men. Also, in the process of informing, the correct positioning of energy-efficient equipment among the population deserves special attention, since rational reasons are fundamental factors in making efficiency decisions.

As for the purchase of energy-efficient appliances, the current positioning only signals economical motives for their purchase. Energy-efficient appliances need to be promoted as a means to reduce greenhouse gas emissions in order to attract non-buyers of energy-efficient appliances but would make a purchase to protect nature. An additional factor confirming the necessity to position the environmental friendliness of energy-efficient appliances is the growing role of the energy efficiency label in the choice of electrical appliances. In addition to the standard set of information, which is regulated by the legislation, it is recommended to indicate the potential environmental impact of the products sold, using the example of how RZD does it when selling tickets for passenger trains. In this context, information about the annual reduction in greenhouse gas emissions achieved by using an energy-efficient appliance may encourage pro-environmental people to purchase this appliance. It is also necessary to disclose the quality characteristics of energy-efficient appliances, promoting their durability and reliability, in order to attract conservative buyers who do not trust innovation and prefer older appliances.

Regarding the positioning of energy-efficient retrofits, it is worth paying close attention to the promotion of those characteristics that are not currently associated with them. Doubts about the energy and money savings that can be achieved, as well as about the difficulty of implementation often prevent people from installing retrofits. It is necessary to form a list of quickly paid back retrofits that are accessible to the majority of the population and that can have a significant effect on efficiency behavior. Considering that people mostly are unaware of improvements that can be successfully implemented in their homes, offering a wide range of options can stimulate the activity of households in adapting these retrofits. The issue of providing financial support for the installation of retrofits deserves special attention, which is essential for people who did not install improvements. It is recommended to develop and implement a voucher program for the installation of energy-efficient retrofits, which will remove the risks and uncertainty from the residents and stimulate their efficiency behavior. This measure will allow many people to improve the quality of their living conditions, as well as, in the long run, save money needed for larger repairs or renovations due to deteriorating housing. The pilot launch of this program will not require significant funding and may involve interested territorial development institutions, such as VEB.RF, DOM.RF or the Territorial Development Fund, whose activities are related to the goals of the proposed initiative.

In order to stimulate the repeating installation of retrofits by people who are already involved in these activities, it is necessary to draw up a list of activities that contribute to improving the comfort of housing and promote it among people who have experience in installing retrofits. Considering the revealed presence of the "Word of mouth" effect in the installation of energy-efficient retrofits, we positively assess the likelihood of the residents' communities being involved in the installation of retrofits and the possibility of stimulating the efficiency behavior among groups of people.

Also, according to the analysis, when implementing measures to stimulate the installation of energy-efficient retrofits, it is necessary to take into account the technical parameters of housing, since the recommended improvements will vary depending on the age, size, condition and configuration of dwellings. For this reason, being proactive about engaging households should be combined with targeting, focusing firstly on people who live in a dwelling for a long time and are more likely to install energy-efficient retrofits.

In this context, based on the obtained consumer profiles, it is possible to form targeted proposals to stimulate energy conservation and energy efficiency among different categories of the population. Considering that "Energy wasters" make up only 10% of the population, it can be concluded that the energy consumption pattern in St. Petersburg is relatively frugal with significant potential for improvement. Mostly this can be explained from a historical perspective and by mentality parameters, but it is important to continue to encourage energy-conserving behaviors depending on the preferences and characteristics of the identified profiles. Therefore, for the targeting and effectiveness of the proposed activities, it is recommended to implement new formats of interaction between the state and the population that contribute to the collection of data on the population, the correct classification of preferences and requests, and the formation of popular and useful activities. For this purpose, a platform of residents can be implemented, which will unite communities involved in improving the quality of living conditions, protecting the environment and conserving energy.

2.4 Research limitations and directions for future research

At the end of this study, it is worth paying special attention to the limitations associated with the achieved results. First, it should be taken into account that the questionnaire answers were collected on a voluntary basis without the involvement of a professional commercial organization. The research of young scientists is often self-initiated and is not able to attract financial support in the form of grants, which will allow to form a representative sample of respondents and ensure the absence of selection bias. In this case, we obtained a distribution structure of respondents close to the general population. However, the study highlights the problem that the following categories of the population are overrepresented in the sample: people with higher education, young people 20-35 years old, and women. This bias is primarily due to the propensity of the individuals to take part in surveys in the framework of sociological research, in particular using online forms for survey. In addition, most of the districts of St. Petersburg were not sufficiently covered within the framework of the study, and respondents from the Kronstadtsky district were completely absent. This is due to the fact that the target audience of the survey were users of social networks in the communities of residential complexes, which are most common in areas with high population density. For this reason, the respondents of the Nevsky and Primorsky districts are overrepresented in the sample, since they are the most frequent audience of the respective communities in social networks.

A possible way to solve the problem could be to apply a stratified sample to the data obtained in order to get the structure of data which corresponds to the distribution of the general population according to the main socio-demographic parameters. However, in the case of this study, this approach was not justified due to a significant reduction in sample size and a corresponding increase in the sample margin error. A high margin error in the case of a small sample causes the questionable quality of the results obtained, since in reality they can differ significantly from the actual values.

Nevertheless, within the framework of this study, a methodology was formed and groups of factors that influence household energy conservation and energy efficiency were identified. The large sample size (421 respondents) allows us to conclude that the results obtained are statistically significant, although there may be a bias in the quantification of the measured impact.

In this regard, as part of further research, the methodology presented in this paper can be used to study smaller areas with a less heterogeneous structure of respondents in terms of socio-demographic and dwelling characteristics. It is also allowed to apply this methodology on a representative sample formed by professional organization in case of further development of science in this area and obtaining the possibility of grant funding.

Another problem that is typical for many studies in the field of household energy behavior is the subjectivity of respondents' assessments of most of the parameters considered. The study is based on the respondents' self-assessment of the characteristics of their behavior, its frequency and intensity, and not on real measurements. For this reason, respondents could overestimate or underestimate certain aspects of their behavior, as well as their knowledge and beliefs in relation to climate change and energy conservation, the ability to control behavior, and their attitude towards energy conservation in general (Semenza et al, 2008). Thus, the study does not reflect the actual energy consumption of households, as well as their ability to reduce energy consumption in physical terms.

Future research should aim to overcome this limitation by involving fewer respondents in providing actual data on energy consumption in order to apply the identified factors to this dependent variable, based on some previous studies (Santin, 2011; Abrahamse, Steg, 2011). It is possible that variables may change their statistical significance, direction, and size of influence when tested with variables that reflect actual household consumption and conservation achieved as a result of certain actions.

Finally, the last limitation of the study is the chosen design in the form of an observational study, which allows to judge only the presence of a correlation between the phenomena under study, but not causal relationships between phenomena. As part of further research, it is planned to use an experimental design, when the behavior of respondents is studied for a certain time, and the identified effects are tested using a control group. Based on some previous research, a longitudinal study is needed to uncover the causal relationships that arise in the process of energy consumption and energy conservation by households (Abrahamse, Steg, 2009; Abrahamse, Steg, 2011).

CONCLUSION

In recent decades, the problem of climate change has become especially acute in the form of an increase in temperature and concentration of greenhouse gases in the atmosphere. The problems of climate change are an object of global general concern among international community and lead to irreversible consequences for anthropogenic and natural systems, affecting the population, infrastructure and climate-dependent sectors of the economy, leading to the degradation of ecosystems.

Most carbon dioxide emissions are concentrated in cities and have a steady upward trend due to the accelerated pace of urbanization and the growth of agglomerations. At the same time, the residential sector is one of the largest sources of greenhouse gas emissions into the atmosphere and is of particular concern due to deteriorating equipment of residential buildings and energy-wasting behavior of households.

Considering the limited financial resources and the impossibility of a full-scale introduction of energy efficient technologies in the residential sector, the stimulation of sustainable behavior of households in relation to energy consumption and conservation deserves special attention. In this regard, the attention of researchers is focused on the question of what factors can affect the frequency and intensity of energy-conserving behavior of households and provide effective changes in household behavior.

As part of the study, the main types of energy behavior were revealed, including curtailment and efficiency behaviors, which are associated with different levels of financial and behavioral costs and depend on various factors. In addition, a review of the literature made it possible to identify the factors influencing the energy conservation and energy efficiency of households, classify them and systematize their contribution to energy behavior in the theoretical framework used in this study.

As a result of the econometric analysis of the constructed models, it was determined that curtailment behavior mostly depends on the psychological profiles of people, which are characterized by their level of knowledge, beliefs, perceived control over actions, and attitudes towards energy conservation. On the contrary, efficiency behavior is more objective and relies primarily on rational reasons and factors for making a purchase. Based on the conclusions about the statistical significance of the factors included in the model, the direction and strength of their influence on various types of energy behavior were assessed.

In addition, the study identified seven main household profiles according to the degree of involvement in various types of energy behavior. The interpretation of the profiles made it possible to formulate the main preferences and requests of user groups, as well as their psychological, socio-demographic and dwelling characteristics, on the basis of which recommendations were made to stimulate energy conservation and energy efficiency for each of the user groups.

Based on the results of the empirical analysis, the goal of this work was achieved. Based on the constructed models, recommendations were made for the authorities of St. Petersburg, resource-supplying organizations and institutions of territorial development on involving the population in energy-conserving activities. These recommendations focus on informing the population, conducting educational activities in the field of energy conservation and efficiency, positioning certain characteristics of energy-efficient products and organizing new forms of interaction between the state and society, the purpose of which is to stimulate energy conservation and energy efficiency of households.

The results of this work and the approaches used in the econometric analysis can be applied in the field of scientific research on household energy behavior and pro-environmental behavior, which determine the theoretical contribution of this work. The recommendations formed on the basis of the empirical analysis reflect the practical significance of this work and set the direction for the work of St. Petersburg authorities, resource-supplying organizations and territorial development institutions to stimulate household energy conservation and energy efficiency.

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APPENDIX 1 QUESTUONNAIRE FOR ST. PETERSBURG RESIDENTS

Энергосбережение и энергоэффективность в жилых домах

Здравствуйте! В рамках исследования, проводимого в Санкт-Петербургском государственном университете, мы изучаем пути повышения энергоэффективности жилых домов города Санкт-Петербурга. Для этого нам нужна Ваша помощь. Пожалуйста, ответьте на вопросы анкеты, это займет у Вас не более 10 минут.

Раздел 1

Ваше место постоянного проживания

В данном разделе мы хотим узнать характеристики места Вашего постоянного проживания, для чего просим Вас ответить на несколько вопросов.

1. Выберите, что лучше всего соответствует месту Вашего постоянного проживания. Один вариант ответа.

- Живу в собственном доме
- Живу в арендованном доме
- Живу в своей квартире в доме, в котором не более 4-х квартир
- Снимаю квартиру в доме, в котором не более 4-х квартир
- Живу в своей квартире в многоквартирном доме
- Снимаю квартиру в многоквартирном доме
- Живу в своей комнате в коммунальной квартире / общежитии
- Снимаю комнату в коммунальной квартире / общежитии
- Другое

2. Укажите, пожалуйста, кто оплачивает счета за коммунальные услуги в Вашем доме. Один вариант ответа.

- Я
- Один из моих членов семьи (сожителей) / Партнер
- Арендодатель
- Другое

3. Сколько жилых комнат в Вашем доме, не считая кухню и подсобные помещения? (впишите число).

4. Какой вариант наиболее точно описывает материал, из которого изготовлен Ваш дом? Один вариант ответа. (Показывать, если в Вопросе 1 выбраны пункты 1-4)

- Кирпичный
- Блочный (пенобетонный, арболитовый и др.)
- Деревянный
- Другое

5. Какой возраст у Вашего дома? Один вариант ответа. (Показывать, если в Вопросе 1 выбраны пункты 1-4)

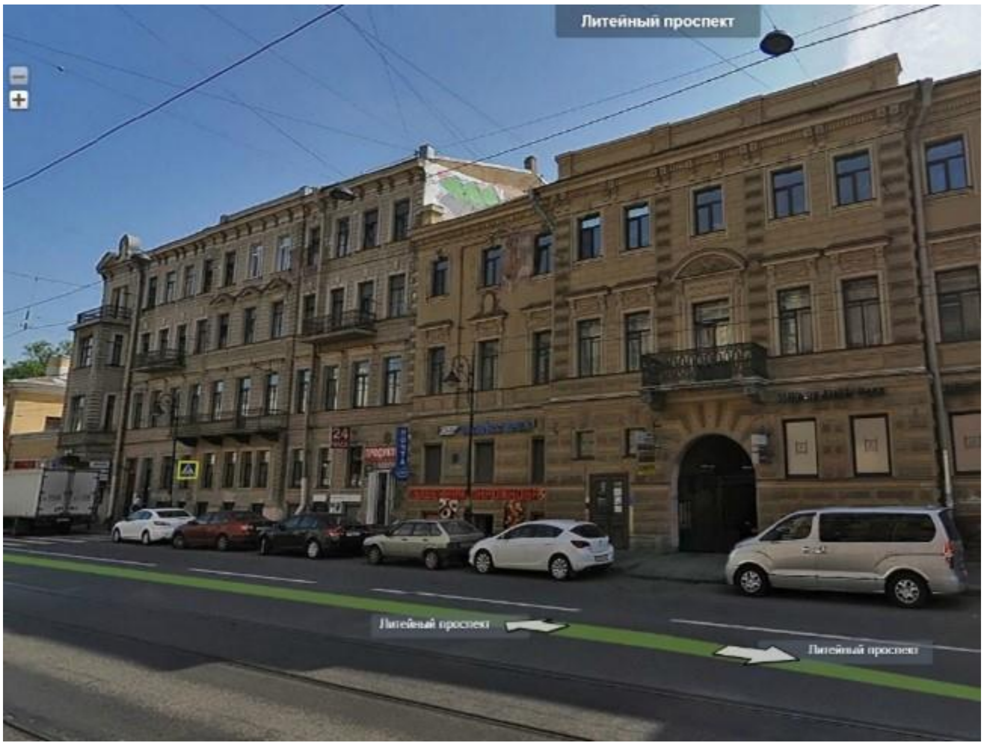
- До 5 лет
- 5-14 лет
- 15-24 года
- 25-34 года
- 35-44 года
- 45-54 года
- 55-64 года
- 65 и более лет

6. Знаете ли Вы класс энергоэффективности Вашего дома? Один вариант ответа.

- A - A++
- B - B++
- C
- D
- E
- F
- G
- Не знаю

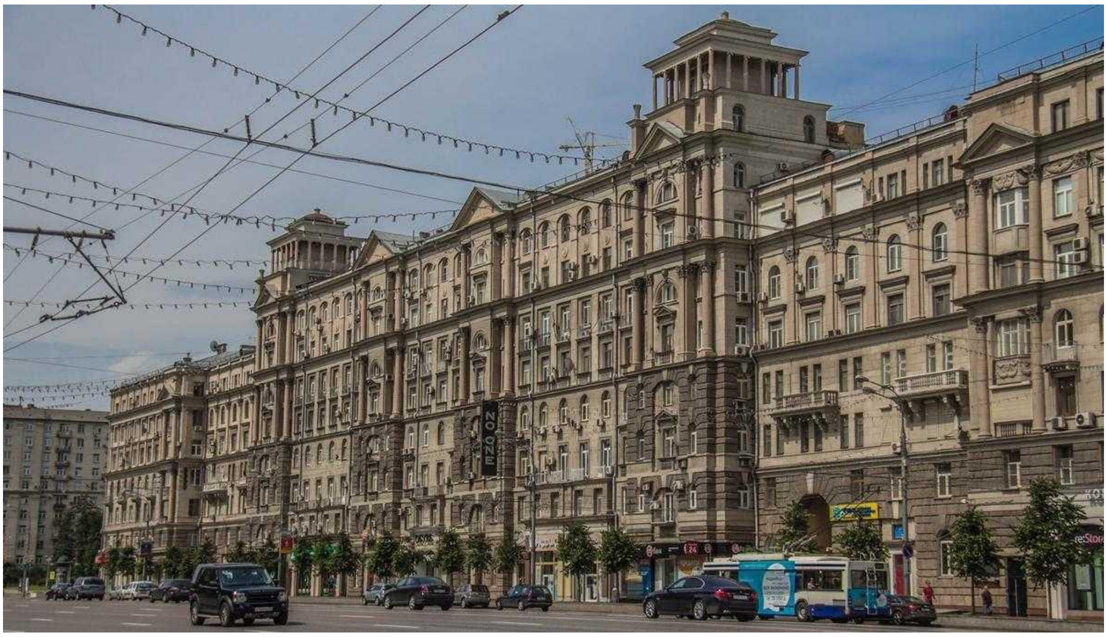
7. Выберите вариант из представленных ниже, наиболее похожий на дом, в котором Вы проживаете: Один вариант ответа. (Показывать, если в Вопросе 1 выбраны пункты 5-8)

- Дореволюционный без капремонта



- Дореволюционный с капремонтом

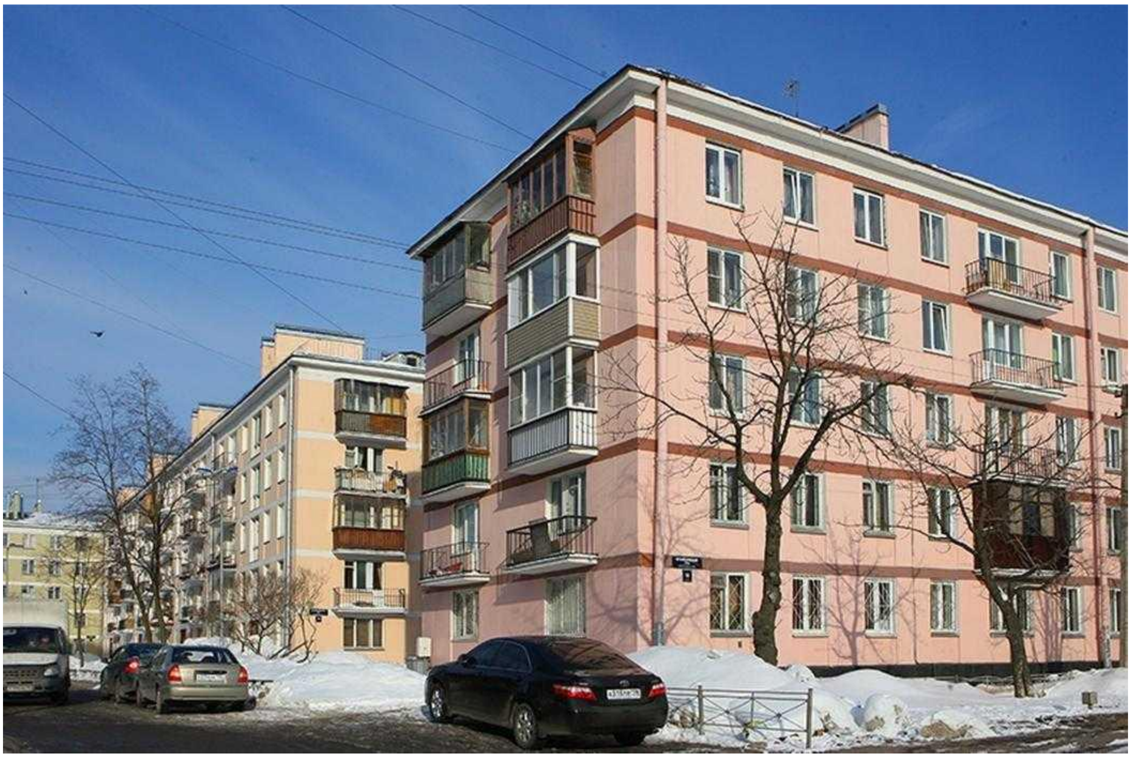
- Сталинский



- Сталинский: Конструктивизм

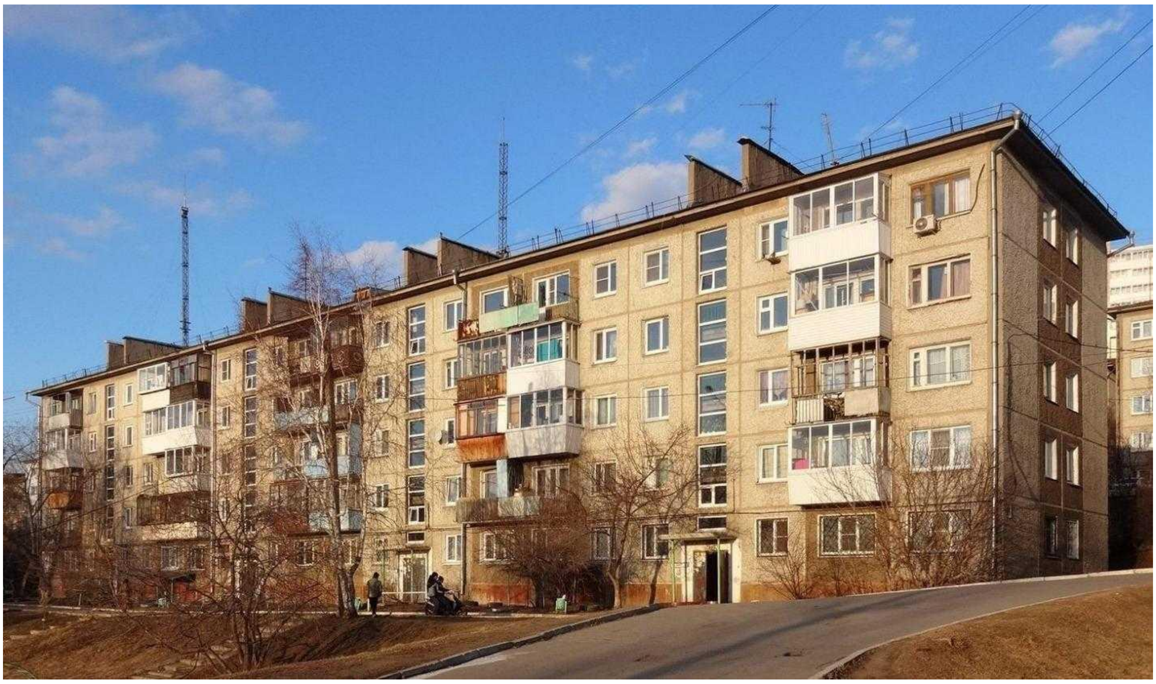
- Немецкие коттеджи

- Хрущевский: 527-528 серии



- Хрущевский: 507 серия

- Хрущевский: 335 серия



- Хрущевский: серия ГИ

- Хрущевский: серия ОД

- Хрущевский: кирпичный

- Брежневский: 600-я серия

- Брежневский: 504-я серия

- Брежневский: 606-я серия

- 137-я серия

- 121-я серия

● Брежневский: кирпичный

● Серия 90ЛО

- Серия 1.090.1 Оптима

- Серия Контакт-СП

- Современные панельные

- Современные кирпичные

- Кирпично-монолитные

- Другое

8. Укажите общую площадь помещений в вашем доме / квартире (впишите число).

- Введите ответ

9. Укажите, пожалуйста, сколько полных лет Вы проживаете в указанном доме / квартире (впишите число).

- Введите ответ

10. Какой из следующих вариантов больше всего соответствует системе отопления в Вашем доме? Один вариант ответа.

- Центральное
- Автономное (крышная, встроенно-пристроенная котельная; котельная во дворе)
- Индивидуальное (собственный газовый котел в квартире/доме)
- Индивидуальное (собственный электрический котел в квартире/доме)
- Печное
- Другое

11. Есть ли у Вас терморегулирующие клапаны, для регулировки температуры в помещении (включения/выключения отопления)? Один вариант ответа.

- Да, устанавливал сам
- Да, был встроен изначально
- Нет

Раздел 2

Электрические бытовые приборы

В этом разделе мы просим Вас указать краткую характеристику бытовых приборов, находящихся в Вашем доме, ответив на несколько вопросов.

12. Для каждого представленного электроприбора, укажите, пожалуйста, класс энергоэффективности, если он есть в Вашем доме / квартире. Если электроприбора нет в Вашем доме / квартире, то отметьте вариант "Нет прибора". Шкала Ликерта.

	Нет прибора	A - A++	B	Другой класс	Нет класса	Не знаю класс
Холодильник	●	●	●	●	●	●
Морозильная камера	●	●	●	●	●	●
Стиральная машина	●	●	●	●	●	●
Стирально-сушильная машина	●	●	●	●	●	●
Сушильная машина	●	●	●	●	●	●
Посудомоечная машина	●	●	●	●	●	●
Кондиционер	●	●	●	●	●	●
Электроплита	●	●	●	●	●	●

Духовой шкаф	●	●	●	●	●	●
Телевизор	●	●	●	●	●	●
Персональный компьютер	●	●	●	●	●	●

13. Как Вы обычно выбираете бытовые приборы для покупки? Несколько вариантов ответа.

- Выбираю сам
- Выбирает супруг (супруга) или партнер
- Выбирает другой член моей семьи (сожитель)
- Выбираю по совету друзей / знакомых
- Выбираю по рекомендации в интернете
- Выбираю по рекомендации консультанта в магазине
- Другое

14. Выберите, какие из перечисленных бытовых приборов Вы покупали за последние 5 лет? Несколько вариантов выбора.

- Холодильник
- Морозильная камера
- Стиральная машина
- Стирально-сушильная машина
- Сушильная машина
- Посудомоечная машина
- Кондиционер
- Электроплита
- Духовой шкаф
- Телевизор
- Персональный компьютер
- Никакие из перечисленных

15. Когда Вы выбираете бытовые приборы, ориентируетесь ли Вы на высший показатель энергоэффективности (A - A++)? Один вариант ответа.

- Да
- Нет

16. Назовите основные причины, по которым Вы покупаете (или могли бы купить) энергоэффективные бытовые приборы. Несколько вариантов выбора.

- Это позволяет (позволило бы) экономить на счетах за электроэнергию
- Это помогает (помогало бы) окружающей среде (снижает (снизило бы) выбросы углекислого газа)
- Энергоэффективные приборы более качественные (был бы более качественными), чем альтернативы
- Знаю (знал бы), что так делают мои соседи / знакомые
- Они делают (делали бы) дом уютнее / комфортнее
- Другое

Раздел 3

Потребление и экономия энергии

В данном разделе представлены некоторые действия, влияющие на потребление энергии. По каждому скажите, что характерно для Вас лично в данный момент. Помните, что нет правильных или неправильных ответов — нас просто интересует то, что Вы лично делаете в данный момент.

17. Отметьте, пожалуйста, какое поведение наиболее характерно для Вас. Шкала Ликерта.

	Никогда	Редко	Иногда	Часто	Всегда
Кипятить чайник только с тем количеством воды, которое Вам нужно	●	●	●	●	●

Намеренно сокращать потребление электричества (не использовать лишний раз электроприборы)	●	●	●	●	●
Покупать энергоэффективные (класса «А» или выше) приборы	●	●	●	●	●
Использовать энергосберегающие лампочки для освещения помещений в своем доме / квартире	●	●	●	●	●
Использовать светильники с датчиками движения для освещения помещений в своем доме / квартире	●	●	●	●	●

18. Отметьте, пожалуйста, какое поведение наиболее характерно для Вас. Шкала Ликерта.

	Никогда	Редко	Иногда	Часто	Всегда
Стирать одежду при температуре 40 градусов или ниже	●	●	●	●	●
Намеренно стремиться сократить потребление горячей и (или)	●	●	●	●	●

холодной воды дома / в квартире					
Выключать отопление, когда надолго выхожу из дома	•	•	•	•	•
Оставлять включенными телевизор или компьютер в режиме ожидания на длительное время	•	•	•	•	•
Оставлять свет включенным, когда никого нет в помещении	•	•	•	•	•

Раздел 4

Энергоэффективные усовершенствования домов / квартир

В данном разделе представлены некоторые улучшения, которые могут быть применены к домам и квартирам с целью сокращения потребления энергии. Отметьте, пожалуйста, те варианты ответа, которые наиболее характерны для Вашего опыта в установке и эксплуатации подобных улучшений в Вашем доме.

19. Устанавливались ли для Вашего дома / квартиры какие-либо из представленных или других улучшений для сокращения потребления энергии (Вами или другими лицами)?

1. Теплоизоляция наружных стен, крыши или пола (подвала)
2. Установка индивидуального (квартирного) электрического или газового котла
3. Установка теплоотражающих экранов за отопительными приборами
4. Замена отопительных радиаторов (батарей) на новые
5. Замена старых окон на стеклопакеты
6. Замена окон на энергоэффективные стеклопакеты, обладающие повышенным термическим сопротивлением

7. Другие улучшения здания / помещения

Один вариант ответа.

- Да
- Нет

20. Отметьте, пожалуйста, какие улучшения устанавливались. Несколько вариантов выбора. (Показывать, если в Вопросе 19 выбран пункт 1)

- Теплоизоляция наружных стен
- Теплоизоляция крыши (чердака)
- Утепление пола (подвала)
- Установка индивидуального (квартирного) электрического котла
- Установка индивидуального (квартирного) газового котла
- Установка теплоотражающих экранов за отопительными приборами
- Замена отопительных радиаторов (батарей) на новые
- Замена старых окон на стеклопакеты
- Замена окон на энергоэффективные стеклопакеты, обладающие повышенным термическим сопротивлением
- Другое

21. По каким причинам были сделаны указанные улучшения? Несколько вариантов выбора. (Показывать, есть в Вопросе 19 выбран пункт 1)

- Это экономит деньги
- Я знал, что это легко / быстро сделать
- Это помогает окружающей среде (снижает выбросы углекислого газа)
- Это было сделано не по моей инициативе (в процессе реновации или капитального ремонта)
- Была получена финансовая поддержка на работы
- Видел / знал, что это сделали другие люди
- Делает дом теплее/приятнее
- Другое

22. По каким причинам Вы могли бы сделать одно из вышеуказанных улучшений? Несколько вариантов выбора. (Показывать, есть в Вопросе 19 выбран пункт 2)

- Это позволило бы экономить деньги
- Это было бы легко сделать / установить

- Это помогало бы окружающей среде (снизило бы выбросы углекислого газа)
- Это было бы сделано не по моей инициативе (в процессе реновации или капитального ремонта)
- Если была бы выделена финансовая поддержка на работы
- Если бы это сделали соседи / люди, которые живут рядом
- Если это сделало бы дом теплее / приятнее
- Другое

Раздел 5

Отношение к энергосбережению и проэкологическому поведению

В данном разделе представлены суждения, относящиеся к сбережению энергии и полезным для окружающей среды действиям. Укажите, пожалуйста, насколько Вы согласны со следующими утверждениями. Помните, что нет правильных или неправильных ответов — нас просто интересует Ваша личная точка зрения.

23. Укажите, пожалуйста, насколько вы согласны или не согласны со следующими утверждениями: Шкала Ликерта.

	Абсолютно не согласен	Скорее не согласен	Трудно сказать, согласен или не согласен	Скорее согласен	Абсолютно согласен
Помогать природе стоит в том случае, если это экономит деньги	●	●	●	●	●
Я могу довольно легко сократить потребление энергии	●	●	●	●	●
Я не сокращу потребление энергии, так как это требует слишком много времени и сил	●	●	●	●	●

Я сокращаю потребление энергии, независимо от того, что делают другие люди	●	●	●	●	●
Если бы правительство делало больше для борьбы с изменением климата, я бы тоже делал больше	●	●	●	●	●
Изменение климата не поддается контролю — с этим ничего нельзя сделать	●	●	●	●	●
Забота об окружающей среде не является приоритетом в моей жизни	●	●	●	●	●
Мне нужно больше информации о том, как сберегать энергию в своем доме	●	●	●	●	●
Мне трудно изменить свои привычки, чтобы сократить потребление энергии	●	●	●	●	●
Меня очень беспокоит, когда я вижу, как люди тратят тепло- и электроэнергию впустую	●	●	●	●	●
Я не верю, что мое повседневное поведение и образ жизни способствуют изменению климата	●	●	●	●	●
Я считаю, что все люди должны сокращать потребление энергии для борьбы с изменением климата	●	●	●	●	●

24. Укажите, пожалуйста, насколько вы согласны или не согласны со следующими утверждениями: Шкала Ликерта.

	Абсолютно не согласен	Скорее не согласен	Трудно сказать, согласен или не согласен	Скорее согласен	Абсолютно согласен
Я знаю, как я могу экономить электро- и теплоэнергию	●	●	●	●	●
Я не уменьшу потребление энергии, потому что качество моей жизни снизится	●	●	●	●	●
Я чувствую вину, если мои действия наносят вред окружающей среде	●	●	●	●	●
Если бы бизнес делал больше для борьбы с изменением климата, я бы тоже сделал больше	●	●	●	●	●
Последствия изменения климата слишком далеко в будущем, чтобы меня действительно беспокоить	●	●	●	●	●
Все, что я делаю, чтобы помочь окружающей среде, должно соответствовать моему привычному образу жизни	●	●	●	●	●
Я не знаю, сколько электричества расходуется в моем доме	●	●	●	●	●

Энергосбережение означает, что мне придется жить менее комфортно	●	●	●	●	●
Мне не стоит делать что-то, чтобы помочь окружающей среде, если другие не делают того же	●	●	●	●	●
Я не особенно задумываюсь об экономии энергии в своем доме	●	●	●	●	●
Я не буду помогать природе, если это потребует от меня дополнительных расходов	●	●	●	●	●

Раздел 6

Персональные характеристики

В последнем разделе мы просим Вас ответить на несколько вопросов о Вас. Хотим поблагодарить Вас за участие в опросе - Ваш вклад очень важен для целей нашей исследовательской работы!

25. Сколько Вам полных лет? (впишите число). Однострочный текст.
- Введите ответ

26. Вы: Один вариант ответа.
- Мужчина
- Женщина

27. Выберите район Санкт-Петербурга, в котором Вы живете. Один вариант ответа.
- Адмиралтейский
- Василеостровский
- Выборгский
- Калининский
- Кировский

- Колпинский
- Красногвардейский
- Красносельский
- Кронштадтский
- Курортный
- Московский
- Невский
- Петроградский
- Петродворцовый
- Приморский
- Пушкинский
- Фрунзенский
- Центральный
- Другое

28. Ваш род занятий? Один вариант ответа.

- Предприниматель, владелец бизнеса
- Руководитель компании, топ-менеджер
- Руководитель среднего звена в компании
- Специалист компании
- Рабочий
- Сфера обслуживания (продавец, парикмахер и пр.)
- Представитель творческих профессий (фотограф, художник и пр.)
- Работаю в социальной сфере (образование, здравоохранение, культура и спорт, социальные услуги населению)
- Госслужащий (органы власти, военная служба)
- Фрилансер/самозанятый
- Пенсионер
- Студент (дневного отделения) или учащийся
- Временно не работаю безработный/ ищу работу
- Домохозяйка
- Декретный отпуск
- Другое

29. Укажите, пожалуйста, уровень Вашего образования. Один вариант ответа.

- Не закончил среднюю школу
- Среднее общее (закончил школу)
- Среднее профессиональное (закончил техникум / колледж)
- Незаконченное среднее профессиональное (учусь в техникуме / колледже)
- Высшее (закончил бакалавриат / специалитет)
- Незаконченное высшее (учусь в бакалавриате / специалитете)
- Учёная степень

30. Ваше семейное положение? Один вариант ответа.

- Состою в браке (в т.ч. незарегистрированном)
- Не состою в браке (в разводе)
- Не состою в браке (вдова/вдовец)
- Никогда не состоял в браке

31. Сколько человек проживает вместе с Вами постоянно, считая Вас? (впишите число). Однострочный текст.

- Введите ответ

32. Сколько среди них несовершеннолетних детей в возрасте до 18 лет? (впишите число). Однострочный текст.

- Введите ответ

33. Охарактеризуйте, пожалуйста, материальное положение Вашей семьи. Один вариант ответа.

- Очень тяжелое, так как хватает только на еду
- Тяжелое, так как хватает на еду и одежду
- Умеренное, так как хватает на еду, одежду, ежедневные нужды и отпуск раз в году
- Хорошее, так как хватает на еду, одежду, ежедневные нужды, покупку автомобиля и отпуск раз в году
- Очень хорошее, так как хватает на всё, вплоть до покупки одежды и автомобилей класса “премиум” и дорогостоящего отдыха на престижных курортах несколько раз в году

34. Как бы Вы оценили средний доход в месяц Вашей семьи? Один вариант ответа.

- До 40 тысяч рублей в месяц
- 41-60 тысяч рублей в месяц
- 61-80 тысяч рублей в месяц
- 81-100 тысяч рублей в месяц
- 101-120 тысяч рублей в месяц
- 121-140 тысяч рублей в месяц
- 141-160 тысяч рублей в месяц
- 161-200 тысяч рублей в месяц
- 201-300 тысяч рублей в месяц
- более 300 тысяч рублей в месяц