ISSN 1611-1699 / eISSN 2029-4433

VILNIUS TECH
Vilnius Gediminas Technical University

JOURNAL of BUSINESS ECONOMICS & MANAGEMENT

2024
Volume 25
Issue 6
Pages 1202–1219

https://doi.org/10.3846/jbem.2024.22792

HOUSEHOLD ENERGY CONSUMPTION TENDENCIES: THE BALTIC STATES CONTEXT

Rasa GRIGOLIENĖ [1]✉, Deimena KIYAK [2], Ligita ŠIMANSKIENĖ [2], Daiva LABANAUSKAITĖ [2], Erika ŽUPERKIENĖ [2], Halyna MISHENINA [2]

[1]*Faculty of Marine Technology and Natural Sciences, Klaipėda University, Klaipėda, Lithuania*
[2]*Faculty of Social Sciences and Humanities, Klaipėda University, Klaipėda, Lithuania*

Article History:
- received 3 April 2024
- accepted 16 October 2024

Abstract. As energy resource prices are on the rise and the stability of energy supplies is increasingly challenged by the current geopolitical climate, it is essential to scrutinize the capability of households to adapt to the resulting circumstances by assessing the current and potential household energy supply and adapting solutions to energy consumption habits. The aim of the research is to study of the energy consumption behaviour of households in the Baltic States amidst a significant increase in prices. The research methods encompass the examination of literary sources, categorization, amalgamation, abstraction, and juxtaposition in the theoretical segment, as well as a case study focusing on energy consumers in Lithuania, Latvia, and Estonia. Notably, the study presents a unique analysis of the unprecedented scenario of substantial price hikes across all energy usage categories in the region. An examination of individual responses concerning energy consumption illustrates a notable escalation in household expenditures on electricity and heating. Households are endeavouring to curtail energy expenses through various conservation techniques. A correlation between income levels and household energy consumption is evident.

Keywords: household, energy prices, energy resources, energy consumption, energy consumers behaviour, sustainable energy, Baltic States.

JEL Classification: Q40, Q41, R11, L10.

✉Corresponding author. E-mail: ***rasa.grigoliene@ku.lt***

1. Introduction

Amidst economic expansion and escalating consumption, household energy usage is influenced by a multitude of factors, including per capita income, urbanization, climatic variations, household proliferation, evolving aspirations for enhanced living standards (resulting in increased comfort expectations), and the production of electrical appliances in domestic settings. In 2022, the Russian army's invasion of Ukraine triggered a significant surge in energy prices, coupled with heightened uncertainty regarding the availability of gas and electricity. This situation has fostered a more pessimistic outlook on household energy consumption. The increase in energy costs, particularly for electricity, has culminated in an energy crisis with profound long-term economic repercussions, including slow

Copyright © 2024 The Author(s). Published by Vilnius Gediminas Technical University

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

GDP growth and elevated inflation rates. The ramifications of increased energy prices on households are complex and have significant consequences. In the Baltic States, energy costs represent a considerable portion of consumer spending. The region faces high energy costs driven by significant demand, particularly due to cold climate conditions and low energy efficiency in housing inherited from the Soviet era. The rise in energy prices, alongside escalating food costs, contributed to a marked increase in overall consumer price inflation in 2022, resulting in a cost-of-living crisis and diminished purchasing power for many households. Notably, during the first nine months of 2022, consumer price increase in the Baltic States outpaced that of other EU countries significantly.

Shifts in the geopolitical landscape, which have triggered energy resource market price fluctuations and introduced fresh complexities in guaranteeing uninterrupted energy supply, prompt an examination of the evolving energy consumption patterns among households in the EU. Currently, there is a limited amount of research scrutinising the economic impact of the Russian invasion and the subsequent energy crisis on European nations (Hutter & Weber, 2022; McWilliams et al., 2022). The Baltic States are unique among EU countries, as they were formerly part of the Soviet Union prior to gaining independence (Bompard et al., 2017). These nations were deeply integrated into Soviet energy systems, with Russia serving as a crucial energy supplier prior to the invasion of Ukraine. Moreover, the economies of the Baltic States are characterized by their small size and high energy intensity, rendering them susceptible to fluctuations in energy prices and potential supply disruptions. The ongoing cost of living crisis has impacted households inconsistently, largely influenced by their energy consumption patterns; those residing in homes heated by gas, electricity, or solid fuels have been particularly adversely affected. It is also important to highlight that income and wealth inequality within the Baltic States exceeds that observed in neighbouring Northern European EU countries.

A primary factor contributing to the sluggish progress in domestic energy conservation is the deficiency in fundamental understanding of household energy consumption (Matsumoto et al., 2022). Studies indicate that households utilize various forms of energy in their day-to-day activities; nevertheless, the specific purposes for which each energy type is utilized remain unclear. Furthermore, the correlation between household attributes and energy usage has been inadequately investigated. Given the relatively elevated prevalence of energy poverty in the Baltic States (Estonia, Latvia, Lithuania), households in the Baltic States are particularly responsive to fluctuations in energy prices in the year 2022.

The aim of the research is to study of the energy consumption behaviour of households in the Baltic States amidst a significant increase in prices.

Considering the economic aspects of the energy crisis in the Baltic States, research focusing on the effects of this crisis on household energy consumption behaviour is both novel and highly pertinent. This study offers a distinctive analysis of the unprecedented increases in energy prices across all consumption categories within the region.

The article's structure is as follows: theoretical aspects of evolving energy consumption patterns are presented in the first part. The research methodology and purpose are explained in the second part. It includes questionnaire design technique, sample size determination, and data collection methodology. The results and findings of the study are presented in the third part. The following parts present conclusions, which include the conclusions and directions for further research.

2. Challenges of energy policy and household energy consumption, in the context of energy price fluctuations

2.1. Challenges to EU Energy Policy within the Framework of Sustainable Energy

The escalating reliance of European nations on energy imports, the issue of climate change, and the upsurge in energy costs are intensifying the discourse regarding the future of and alternatives in the energy sector, particularly within the political sphere.

A secure and dependable energy provision at fair and steady prices is paramount for achieving economic and social progress aligned with sustainability goals and should constitute an integral component of a thorough and cohesive energy policy. The aims of the energy sector are multifaceted, encompassing the minimization of costs and environmental impact, as well as the assurance of reliability and stability in energy supply. Experts advocate for the use of multi-criteria analysis or assessment in strategic decision-making within the energy sector. This approach allows decision-makers to evaluate the relative importance of various criteria – such as economic, environmental, and social factors – and identify the most appropriate solution considering all criteria (Cooremans & Schönenberger, 2019; Matuszewska et al., 2021).

The transformation of the global business landscape, particularly the political-economic context, has underscored the fundamental priorities of an energy policy: ensuring energy security, promoting energy sustainability, and enhancing energy consumption efficiency. According to expert reviewers from the World Bank, the key goals include directing attention toward underserved populations, hastening efficiency improvements, broadening the utilization of renewable energy, fostering an enabling environment, and amplifying international advocacy efforts. Enhancing energy efficiency stands out as the most effective approach to advancing the goals of sustainable, competitive energy and ensuring supply security.

In the context of these concerns, the European Commission defines the objectives of European energy supply as competitiveness; sustainability, reliability of supply (European Council, 2019).

To achieve objectives and successfully address the many challenges facing the EU, it is essential to establish closer connections and cooperation within the energy sector, to establish a consolidation of the energy sector and effective legal and regulatory frameworks, and to warrant their practical implementation.

As the European Green Deal policy evolves to encompass a broader scope, the focus is shifting towards not only short-term remedies but also the long-term approach to mitigating the impacts of climate change. This shift is underpinned by the argument that the first generation of the Green Deal policy is rooted in a "top-down" approach, while the second generation is characterized by a "bottom-up" principle (Samper et al., 2021). The primary distinction, as suggested by the authors, lies in the fact that the initial implementation of the Green Deal policy is primarily driven by institutions or the state, whereas the latter relies more on community-driven actions (Samper et al., 2021). It is worth noting that the Green Deal policy often integrates a combination of both approaches, as highlighted by various researchers in their studies (Mastini et al., 2021). Consequently, this further emphasizes the importance of involving households in promoting more sustainable energy consumption practices (Petrichenko et al., 2021).

In the pursuit of addressing energy security, competitiveness, and energy efficiency at the political level, the issue of energy poverty holds significant prominence. As the population

expands, associated social issues arise due to constraints on economic growth and escalating social conflicts. Uneven growth in household purchasing power leads to distinct consumption patterns, further driving the demand for economic goods, thereby widening the economic disparity among the population, and exacerbating overall poverty, including energy poverty. Energy poverty is characterized as a state in which individuals or households struggle to adequately heat their homes or access essential energy services at affordable rates (Carfora & Scandurra, 2024), making it challenging or impossible to maintain sufficient heating, as well as access other vital energy services such as lighting, transportation, or electricity for internet usage and other devices (Nacionalinis skurdo mažinimo organizacijų tinklas [NSMOT], 2021). According to experts, the primary determinants of energy poverty encompass low energy efficiency, high energy costs, and low income (Lekavičius, 2019).

At the political level, broad measures targeting increased revenue, reduction of general energy sector costs, and enhanced efficiency offer a multitude of solutions, with consideration to targeted measures for alleviating energy poverty being particularly noteworthy (Lekavičius, 2019). Efforts to alleviate energy poverty take into account the socio-economic profiles of households, such as providing heating cost assistance for low-income households and implementing support measures for specific housing types. Additionally, specific incentives may be directed toward particular energy types or residents in areas affected by escalating energy poverty.

The World Bank Group acknowledges that each country charts its course to achieve its energy goals, with each country's transition to a sustainable energy sector involving a distinct combination of resource opportunities and challenges, leading to varied emphasis on access, efficiency, and renewable energy (Tokarski et al., 2024). Every endeavor will be made to minimize the financial and environmental costs associated with expanding reliable energy supply. Importantly, the success of the transition in energy supply and consumption is shaped by the contributions of both businesses and households, underscoring the need for the latter to adapt to the evolving conditions of energy supply.

2.2. Theoretical framework of energy policy and household energy consumption studies

The EU's primary goal is to enhance the climate and create opportunities by advancing energy transformation, focusing on industries, transportation, and the construction sector (European Council, 2019). Within Europe, the residential housing sector accounts for approximately 30% of overall energy consumption (Chen et al., 2023). The energy consumption patterns of households, in conjunction with technological advancements, can significantly contribute to the transition towards a sustainable path for the European economy (European Commission, 2022). While consumer environmental awareness is crucial, it alone is inadequate for implementing the principles of sustainable development at the household level (Lin & Dong, 2023).

The rapid expansion of the economy and the resulting increase in household purchasing power and consumption have led to a rise in energy resource consumption, impacting not only industry but also households, with adverse effects on the environment and community relationships. This situation underscores the necessity of reshaping household consumption through the widespread adoption of the concept of sustainable development, which encompasses economic, social, and environmental aspects and integrates them into a cohesive whole. As consumer core values evolve and the three elements of coherence – economic, social, and environmental – are applied to the new consumer lifestyle, the focus shifts to the

fundamental tenet of sustainability: the capacity of society to meet present needs without compromising the ability of future generations to meet their own needs. To enact this principle, it is crucial for households to evaluate their actions' impact on society, the environment, and the economy (Bergquist et al., 2020). Everyone must contemplate whether their current lifestyle or livelihood affects future generations' ability to access clean air, water, or natural resources (Bibri & Krogstie, 2020; Chu et al., 2023).

As responsible household energy consumption increases, there is a growing implementation of more sustainable energy solutions. Sustainable energy can be described as energy sources that do not deplete over a timescale that is significant for humanity and, consequently, contribute to the sustainability of all life forms (Chu et al., 2023). Sustainable energy development pertains to the continual production and consumption of energy that ensures the long-term objectives of human development across social, economic, environmental, and institutional dimensions (Chu et al., 2020). The advancement of sustainable energy is crucial not only for ecological and environmental reasons but also for achieving energy independence. Utilizing local renewable resources represents one of the most effective approaches to accomplish this. Furthermore, the transition to renewable sources is inevitable in the context of sustainable development. Energy efficiency and the utilization of renewable resources stand as the two primary pillars of sustainable energy, carrying significance not only for industrial but also for household consumption (Marti & Puertas, 2022).

The shift of household energy consumption toward sustainable energy sources is an essential component of the European Green Deal policy. Emphasizing the transformative nature of the Green Deal policy, some authors argue that even a modest shift in the economic system toward a greener economy determines the choice between reform and revolution (Söderholm, 2020). Furthermore, the distinction between a gradual and a radical transformation has been explored, considering the Green Deal policy as part of ecological modernization and the environmental policy discourse (Spash, 2020). The authors conceptualize the environmental policy discourse based on the degree of gradual or radical change, as well as their incremental or transformative capacities.

As energy prices increase, household energy consumption is evolving, with a significant focus on enhancing household energy efficiency. Energy efficiency in household energy consumption can be interpreted in various ways. Experts examining energy efficiency from a social perspective place greater emphasis on energy savings as a prerequisite for improving household well-being, whereas the technological approach prioritizes resource conservation. The term "energy efficiency" is often used interchangeably with what could be defined as "energy conservation". Broadly, energy efficiency refers to the relationship between an activity or service and the energy used to carry it out. Since the definition of energy efficiency varies across different fields of activity, there is no universally accepted definition. Consequently, increased energy efficiency could mean either a reduction in energy costs to produce the same level of goods or services, or an increase in the level of goods or services using the same amount of energy resources (Rehman & Hasan, 2023). Essentially, energy efficiency is a process by which more is produced using less.

Prudent consumption should be considered in the context of contemporary building design and the optimization of energy-efficient electrical appliances in industrial settings (Griffiths, 2017). Each nation should implement investment regulations to promote energy conservation (Abdeldayem & Dulaimi, 2020).

A research study investigating the effectiveness of behaviour modification strategies in shaping energy consumption in family households revealed that individual feedback and

financial incentives with comparative feedback are successful in reducing energy usage. The study also found that comparative feedback is effective under specific circumstances, while general information alone is not effective. Furthermore, the study discusses the correlation between residents' attitudes and their levels of consumption (Gajdzik et al., 2024).

The researchers conducting the study on electricity consumption in dormitories aimed to determine the energy usage in unoccupied residences and arrived at the following conclusions (Anderson et al., 2015):

- Throughout the seasons, the average household consumed between 27.5% and 31.5% of total energy while unoccupied. The energy consumption in individual rooms varied from less than 4% to over 80%.
- Discrepancies in occupant behaviour and duration of unoccupancy account for the variations in energy consumption among the households.
- Additionally, the study revealed that there was no significant correlation between overall energy consumption and the proportion of energy used in unoccupied rooms for individual occupants. Both high and low energy users exhibited a similar pattern of electricity usage while away from home relative to their overall consumption.

Analysis of the relationship between the economic crisis and energy consumption in Greece revealed the following outcomes (Santamouris et al., 2013):

- A comparison of the 2010–11 winter with the harsher winter of 2011–12 demonstrated that residents consumed less energy during the latter due to the rapid economic downturn.
- Significant observations were made concerning household energy consumption, which was 37% lower than anticipated during the harsher winter of 2011–12.
- The application of cluster analysis yielded two distinct clusters: three-quarters of the households belonged to the lower-income group, residing in smaller spaces, earning half the income, and consuming more specific energy compared to the higher-income group, although still lower than expected based on the low temperatures of the second winter.
- One in three higher-income households and one in four lower-income households adopted some conservation measures after the first winter, while 2% of the higher-income households and 14% of the lower-income households fell below the fuel poverty threshold.

Steckel et al. (2022) conducted a study to evaluate the implications of elevated energy prices for households under diverse gas, oil, and coal price scenarios in the near future. The research involved an analysis of representative household expenditure data from 24 European Union countries, utilizing detailed microsimulation data. The findings revealed that the primary driver of additional costs in all countries is the upsurge in direct energy consumption expenses. Conversely, the rise in indirect energy utilization costs, stemming from increased prices for consumer goods, food, and services, was relatively minor. The study concluded that heightened energy prices have a disproportionate impact on low- and middle-income households across Europe. Furthermore, the limited energy tax rates and minimum VAT levels within the EU serve to mitigate the impact of reductions in consumer taxes. The researchers emphasized the imperative of curtailing access to fossil fuels in the medium term, advocating robust support for renewable energy production and energy efficiency across all sectors. The countries most severely affected were identified as Hungary, Romania, Italy, the Czech Republic, and Germany, while households in Denmark, Sweden, and France experienced comparatively lower impacts, accounting for approximately 10% of their total expenditure.

Fuerst et al. (2020) reported the regression findings from their survey, highlighting the significance of household socio-economic characteristics, such as household size, annual gross household income, primary employment status, and household composition/type, as stronger predictors of gas consumption for space heating compared to simple housing attributes, such as dwelling type and age, which consistently appeared insignificant. The study also indicated that the economic, occupational, and marital status of individuals influences their energy consumption behaviour, even when accounting for housing and household size.

The authors suggested that exploring households' awareness of their energy consumption habits and their knowledge of potential energy-saving measures could offer valuable avenues for further research.

Furthermore, Fuerst et al. (2020) underscored the limitations posed by the lack of detailed information on household incomes in analysing consumer energy consumption behaviour. They emphasized the pivotal role of providing suitable, energy-efficient housing for low-income households as a crucial measure in mitigating the risk of fuel poverty and energy expenditures.

A research study on Energy Consumption and Price Forecasting Through Data-Driven Analysis Methods indicates that in less economically developed regions, income levels continue to serve as the primary constraint on alterations in urban household energy consumption. Surprisingly, the anticipated accumulative effect of income levels on household energy consumption has not materialized during economic development in these less developed regions (Lianwei & Wen, 2021). Urbanization emerges as a pivotal factor in the analysis of household energy consumption, with distinct development patterns and processes gradually manifesting in scenario aspects such as the selection of urban household energy consumption and shifts in total consumption (Eurostat, 2022b).

Morgan and Trinh (2021) through a household survey conducted in eight Southeast Asian countries in 2021, revealed the substantial impact of COVID-19 on households, encompassing income, employment, and expenditures. Nearly half of the households surveyed encountered financial hardships as a result of the pandemic, leading to widespread reductions in consumption and household energy usage.

In a separate study by Aldulaimi et al. (2022), the findings underscored the necessity of increasing awareness, educating consumers, and transitioning the existing technological model to align with alternative energy sources, despite the accompanying additional costs. The study advocates for a focus on education and the cultivation of responsible consumer behaviours centered on sustainable energy practices as the most effective approach to expedite the journey towards sustainability (Aldulaimi et al., 2022).

Poniatowska-Jaksch (2021) conducted a survey focusing on changes in household energy consumption between 2008 and 2018 in Central and Eastern Europe (CEE), and established connections between the process of digitalization and developments in household energy usage. The study revealed that within the CEE countries, households represent a substantial portion of total energy consumption, accounting for approximately one-fifth of the total consumption in these nations by 2018. Notably, Estonia, the Czech Republic, and Lithuania were identified as the CEE countries with the highest per capita household energy consumption, surpassing 600 thousand tons (in oil equivalent – TOE) in 2018 (Poniatowska-Jaksch, 2021). Furthermore, it was noted that the group of countries with the highest energy consumption comprised those with the most advanced levels of socio-economic development among the CEE nations, while countries with lower energy consumption tended to exhibit relatively lower levels of development.

Moreover, Poniatowska-Jaksch (2021) revealed that the period from 2015 to 2020 witnessed a rise in household energy prices (euros per kilowatt excluding taxes and charges). The most substantial increases were observed in Lithuania (28.7%), as well as in the Czech Republic and Romania (14.6% and 11.4% respectively).

During the period of 2015–2020, the highest levels of energy prices were observed in 2018 for the Czech Republic, Slovenia, Latvia, and Estonia (ranging from 0.13 to 0.10 EUR), and in 2020 for the Czech Republic, Lithuania, Slovakia, Slovenia, and Romania (from 0.13 to 0.10 euro). Poniatowska-Jaksch (2021) offered significant insights from the study, suggesting that governments may need to consider providing subsidies to offset the rising energy costs for households, or alternatively, make investments in scientific and digital competencies as well as publicly available digital infrastructure.

2.3. Fluctuations in energy costs from 2018 to 2023

Wholesale energy prices in the EU experienced a significant surge in the latter half of 2021, largely attributed to the heightened global energy demand following the COVID-19 pandemic. This surge led to reduced supplies, particularly in the volume of liquefied natural gas (LNG) imports into Europe (European Commission, 2021). The combination of diminished gas supply, an extended heating season in 2020–2021, and unfavorable weather conditions for renewable energy generation further exacerbated the situation. Additionally, the escalating price of carbon dioxide added to the already volatile state of the market.

The household sector constitutes a significant portion of energy consumption across all energy resource sectors. As reported by Eurostat (2022b), in 2020, households, or the residential sector, represented 27.4% of final energy consumption, equivalent to 18.7% of gross inland energy consumption in the EU. Despite the ongoing efforts to transition to sustainable energy consumption, fossil fuels continued to hold a substantial share in EU household consumption in 2020. Specifically, natural gas accounted for 31.7% of EU final energy consumption in households, electricity for 24.8%, renewables and wastes for 20.3%, and oil and petroleum products for 12.3% (Eurostat, 2022b). Nevertheless, significant strides toward sustainability are evident in the statistical analysis of residential heating, which comprises the largest portion of energy consumption by households (62.8% of final energy consumption in the residential sector), and in the statistical analysis of renewables, which encompassed more than a quarter (26.8%) of EU households' space heating consumption (Eurostat, 2022b).

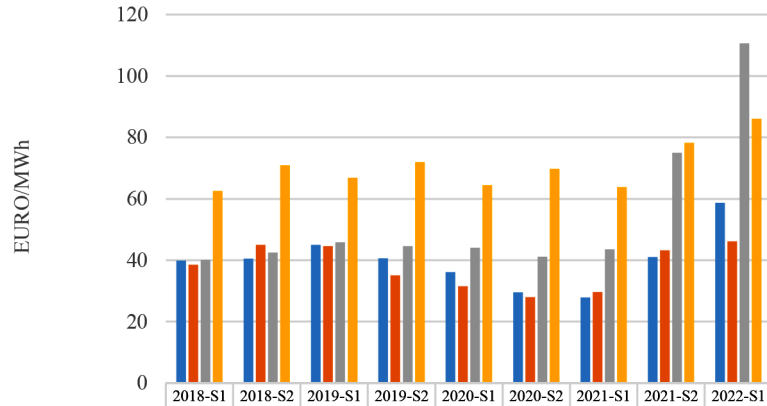
Following the Russian invasion of Ukraine on February 24, 2022, and the deliberate efforts of the Russian government to wield energy as a political tool, gas and electricity prices reached their peak in 2022. In recent years, electricity prices in Europe have surged to levels significantly surpassing those of previous decades. This trend is closely entwined with the higher cost of gas, which directly impacts the expense of electricity generated by gas-fired power plants. The escalation in prices gained momentum in the latter half of 2021, coinciding with the global economy's recovery following the relaxation of COVID-19-related restrictions. The subsequent Russian invasion of Ukraine further exacerbated the situation.

The surge in natural gas prices is posing a significant risk to the EU economy, potentially leading to sustained high inflation driven by elevated electricity prices. This trend undermines consumer purchasing power and contributes to mounting production costs.

Considering all factors and given the significant role of gas in the energy balance, retail prices have been notably affected, leading to an increased financial burden on households, especially the final consumers.

Following the commencement of the Russian invasion of Ukraine, Russia has utilized gas supplies as a tool to undermine the solidarity and energy security of the European Union. As a result, thirteen Member States have experienced direct impacts from partial or complete interruptions of gas supply, with five Member States no longer receiving any gas supplies from Russia. The share of EU imports from Russia's gas pipelines decreased from 41% in 2021 to 9% in September 2022, while liquefied natural gas (LNG) has emerged as the primary source of supply, constituting 32% of the total net gas imports into the EU. Furthermore, an additional investment of 210 billion euros is deemed necessary for the period leading up to 2027 to address the situation (European Commission, 2023; Barnes, 2022).

During the timeframe spanning from 2018 to 2022, the documented rise in gas prices within EU nations, totaling 37.5%, was notably lower than the corresponding increase in gas prices in Estonia, which reached 175.8%. In Lithuania, the gas price experienced a surge of 47.1%, whereas in Latvia, the increase amounted to 20% (Figure 1).

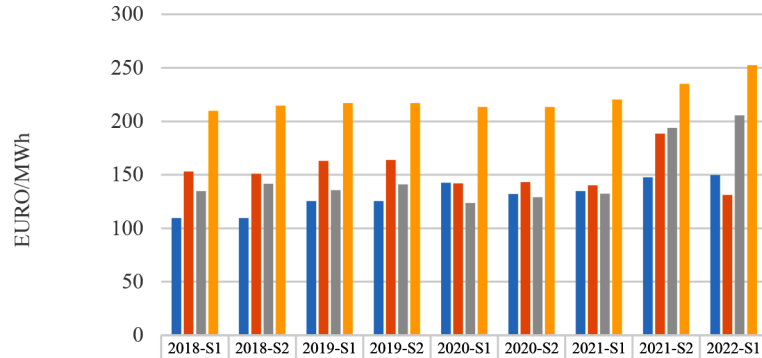


	2018-S1	2018-S2	2019-S1	2019-S2	2020-S1	2020-S2	2021-S1	2021-S2	2022-S1
Lithuania	40	41	45	41	36	30	28	41	59
Latvia	39	45	45	35	32	28	30	43	46
Estonia	40	43	46	45	44	41	44	75	111
European Union – 27 countries (from 2020)	63	71	67	72	65	70	64	78	86

Figure 1. Gas Prices for Household Consumers 2018–2022. Compiled by the authors using the data of Eurostat (2022c)

Meanwhile, electricity production in the EU has declined below average levels. Unprecedented summer temperatures have heightened the demand for cooling and elevated the strain on electricity production due to droughts and elevated water temperatures. Adverse weather conditions and their impact on water resources have contributed to energy shortages and rising energy prices, imposing a burden on consumers, businesses, industry, and impeding economic recovery. Additional pressures on the supply side of energy and food prices are exacerbating global inflationary trends, weakening household purchasing power and energy security. The lack of energy security globally, paired with volatile energy prices, has significantly impacted the EU's energy system, particularly in the Baltic states.

During the period from 2018 to 2022, the documented rise in electricity prices in EU Member States, totaling 20.1%, was notably lower than the corresponding increase in electricity prices in Estonia (52.1%) or Lithuania (36.5%). Conversely, in Latvia, the price of electricity experienced a decrease of 14.3% (Figure 2).



	2018-S1	2018-S2	2019-S1	2019-S2	2020-S1	2020-S2	2021-S1	2021-S2	2022-S1
Lithuania	110	110	126	125	143	132	135	148	150
Latvia	153	151	163	164	142	143	140	189	131
Estonia	135	142	136	141	124	129	132	194	206
European Union – 27 countries (from 2020)	210	215	217	217	213	213	220	235	253

Figure 2. Electricity prices for household consumers 2018–2022. Compiled by the authors using the data of Eurostat (2022a)

The ratio of wholesale to retail prices varies across different EU Member States and is contingent upon the regulatory framework and the composition of retail prices and energy equilibrium.

3. Methodology

Global events in 2022 have significantly impacted the energy market, with the Baltic States, whose electricity market is particularly susceptible to global fluctuations, being no exception (Zeng et al., 2017). Considering these dynamics, the authors conducted a comprehensive case study of a survey of energy consumers in the three Baltic states. A significant highlight of this study is the noteworthy finding of an outcome where energy prices have experienced a substantial increase across all usage categories. By categorizing households based on the number of occupants, the study aimed to achieve the following objectives:

- Gather individual feedback on energy consumption.
- Assess the influence of income levels on household energy consumption.
- Obtain insights on support for and the use of alternative energy sources.

To present the socio-demographic characteristics of the respondents, a percentage-graphical analysis was employed. For comparing households and different energy sources, key types of descriptive statistics such as measures of frequency, central tendency, dispersion, and position were utilized.

Empirical data were collected during the quantitative survey through an anonymous structured questionnaire. This survey method was chosen to gather comprehensive information on the subject under analysis, to discern changes in household energy consumption among the Baltic States' population, and to evaluate differences and similarities.

The survey comprised 15 questions and was developed based on an analysis of scientific literature pertaining to the influence and repercussions of global energy shifts on household energy requirements. The arrangement of questions is detailed in Table 1.

Table 1. Possible actions to overcome challenges

Category	Aim
Socio-demographic characteristics of the respondents	Classify the demographics and age of the respondents, the number of household occupants, the type of household property, and the country of residence.
Sources of household heating energy and method of electricity meter readings	Identify the main sources of household heating energy and frequent electricity meter readings.
Changes in household energy consumption	Determine changes in household energy consumption and measures to reduce energy consumption.

The target population is residents of the Baltic States. The sample size of the research study has been calculated using formula (Kardelis, 2016; Ryan, 2013):

$$n = \frac{t^2 \times N \times p \times (1-p)}{\Delta^2 \times N + t^2 \times p \times (1-p)}, \quad (1)$$

where n – sample size; N – population size; Δ – margin of error 5%; p – population proportion 50%; t – z-score. Here confidence level is 95%, and t = 1.96.

Based on Eurostat data (Eurostat, 2023), as of 1 January 2023, the population of the Baltic States was 6,106,171. Consequently, the sample size calculated using formula (1) is 385 respondents. The breakdown of the population by the respective country is illustrated in Figure 3.

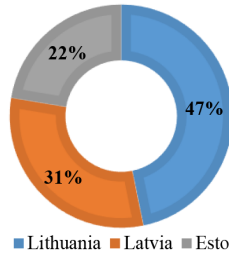


Figure 3. Population distribution across the Baltic States. Compiled by the authors using the data of Eurostat (Eurostat, 2023)

In determining the number of respondents from each country, the structural breakdown depicted in Figure 3 was adhered to, with a plan to interview 188 respondents from Lithuania, 123 from Latvia, and 89 from Estonia. The survey respondents were selected using the snowball sampling method (Naderifar et al., 2017), focusing on achieving the calculated sample size for each country, without deriving specific proportions for age categories within individual countries. Regarding age, respondents were randomly distributed.

The survey was conducted online during May to July 2023. The research was conducted in accordance with ethical principles. The research study faced several limitations related to the distribution of survey data. One limitation pertained to the lack of proportional representation across age categories within individual countries, while another limitation was the restriction to respondents with internet access. Given the shared climate and similar energy requirements among households in the researched area, the analysis focused on household energy consumption costs for room heating and electricity.

4. Results and findings

It is widely acknowledged that the response rate for traditional questionnaire surveys typically does not exceed 70% (Kardelis, 2016). Consequently, a large number of questionnaires were distributed to ensure a robust response. The research study successfully surveyed 422 respondents in accordance with the sample size proportions for each country (Figure 4). The sample size was determined using the commonly utilized standard margin of error of 5% ($\Delta = 0.05$). Upon the return of completed questionnaires, the actual margin of error was calculated to be 4.77%. Therefore, the study's sample is deemed representative, and the obtained results are considered valid. Statistical data analysis was performed using SPSS 26 and Microsoft Excel 2023 program packages; the chi-square (χ^2) criterion was applied. The difference in data was considered statistically significant when $p < 0.05$. The results of the study are presented below.

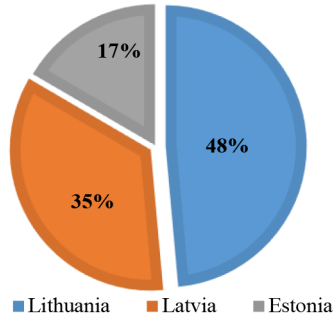


Figure 4. Distribution of respondents by country

The socio-demographic characteristics of the participants are outlined in Table 2.

Table 2. Socio-demographic characteristics

Variable	Range		
	Estonia	Latvia	Lithuania
Number of household occupants	Mean = 2.91 Median = 3 Mode = 3 SD = 1.31	Mean = 3 Median = 3 Mode = 4 SD = 1.52	Mean = 2.89 Median = 3 Mode = 2 SD = 1.21
Age of household occupant (respondent)	Mean = 44.27 Median = 45 Mode = 45 SD = 11.47	Mean = 50.45 Median = 49.5 Mode = 38 SD = 11.52	Mean = 45.19 Median = 45 Mode = 45 SD = 12.35
Type of housing unit:			
Block of flats / Apartment complex	35%	32%	51%
Detached house	43%	57%	40%
Terraced house / semi-detached house	22%	11%	9%
Dormitory	0	0	0
Other	0	0	0

Therefore, the typical participant in the study is 46.87 years old, with an average household size of 3 members. The respondent resides in an apartment block (49.69%) or in a detached house (46.42%). The study results indicate that demographic factors like household size, country of residence, and fluctuations in household income significantly influence household energy consumption patterns (Table 3 and Table 4).

Table 3. The sources of household heating energy and method of electricity meter readings

Category	Variable[1]	Range		
		Estonia	Latvia	Lithuania
Type of space heating equipment[1]	Centralized heating (city networks)	52%	34%	54%
	Autonomous gas heating	9%	41%	26%
	Autonomous electric heating	3%	7%	12%
	Autonomous heating with solid fuel	5%	10%	13%
	Autonomous heating using stove fuel	4%	4%	3%
	Autonomous heating with liquid fuel	1%	2%	2%
	Autonomous heating using renewable energy sources	16%	11%	12%
	Other	0	0	0
Type of electricity meter reading	Single rate meter	54%	51%	53%
	Dual rate meter	26%	31%	30%
	Smart meter	20%	18%	17%

Note: [1] Respondents could select a maximum of two sources.

Most households utilize centralized heating (city networks) or independent gas heating, with some employing independent heating systems that utilize alternative energy sources. Over 50% of respondents have single rate electricity meters, while only 18% use smart meters for electricity monitoring. On average, household energy expenditures have shown the most significant increase, comprising 10–20% of total expenses. While the income of most surveyed households has remained stable compared to the previous year, the substantial inflationary surge negates this stability, indicating a trend towards household impoverishment. Approximately 80% of household energy consumers allocate a larger portion of their income to energy expenses compared to the previous year (Table 4). To alleviate the impact of escalating energy prices on household budgets, consumers are proactively seeking to reduce energy costs through various measures; however, 11% of respondents neither take nor intend to take any measures to curtail household energy expenses (37%). Some respondents believe that there is potential for savings by using more energy-efficient electrical appliances (32%) and express an intention to adopt renewable energy sources (31%). A significant majority of respondents, nearly 74%, do not receive any state support aimed at reducing household energy costs.

The participants do not believe that renewable energy sources assist in reducing their household energy expenses and agree that government assistance is essential for households transitioning to renewable energy sources for domestic use. Household energy consumers assess their ability to adjust to fluctuations in energy resource prices more positively than their prospects of accessing alternative energy resources (a more pessimistic assessment).

Table 4. Changes in household energy consumption

Category	Variable	Range		
		Estonia	Latvia	Lithuania
Individual feedback regarding energy consumption	The average household expenditure on energy needs changed this year compared to last year.	Electricity – increased by 27% Heating – increased by 17%	Electricity – increased by 4% Heating – increased by 18%	Electricity – increased by 23% Heating – increased by 24%
	Intended energy cost reduction strategy.	Various strategies – 34% Purchase more economical electrical appliances – 30% Start using renewable energy sources – 20% Nothing – 16%	Various strategies – 37% Purchase more economical electrical appliances – 31% Start using renewable energy sources – 20% Nothing – 12%	Various strategies – 39% Purchase more economical electrical appliances – 33% Start using renewable energy sources – 22% Nothing – 6%
Effect of income levels on household energy consumption	Percentage of household income spent on energy	less than 10% – 29% 10% to 40% – 63% more than 40% – 8%	less than 10% – 35% 10% to 40% – 60% more than 40% – 5%	less than 10% – 39% 10% to 40% – 61% more than 40% – 0%
	Household income	Stable compared to last year – 59% Increased compared to last year – 21% Decreased compared to last year – 20%	Stable compared to last year – 52% Increased compared to last year – 32% Decreased compared to last year – 16%	Stable compared to last year – 63% Increased compared to last year – 35% Decreased compared to last year – 2%
	Proportion of household budget spent on energy costs	Smaller portion of incomes spent on energy needs compared to last year – 3% No change – 18% Larger share of income spent on energy needs compared to last year– 79%	Smaller portion of incomes spent on energy needs compared to last year – 4% No change – 22% Larger share of income spent on energy needs compared to last year– 74%	Smaller portion of incomes spent on energy needs compared to last year – 3% No change – 31% Larger share of income spent on energy needs compared to last year– 66%

The findings indicate that the introduction of financial incentives for households could result in a substantial decrease in energy consumption.

High gas and electricity prices have impacted the majority of households, albeit at different times and to varying extents. The price surge has had an impact across the board, but low- and low-middle-income households, which allocate a significantly larger portion of their income to energy expenses, have been particularly adversely affected. Income levels continue to serve as the primary constraining factor in alterations to the energy consumption of urban households.

5. Conclusions

Growing household energy consumption is determined by the overall economic growth and the resulting rise in the purchasing power and consumption of households. To ensure an environmentally friendly energy supply, and to increase the security of energy supply and the efficiency of energy production and consumption, an increasing number of energy policy measures are being taken to adjust household energy consumption habits by promoting the use of local, renewable, and waste energy sources.

Natural gas and electricity account for around 56% of the household energy demand in the EU. In Lithuania, the price of gas increased by 47.1%, while in Latvia the price of gas increased by 20%. In the period 2018–2022, the observed increase in electricity prices in EU countries, which reached 20.1%, was much lower than the rise of electricity prices over the same period in Estonia (52.1%) or Lithuania (36.5%). In Latvia, the price of electricity decreased by 14.3%.

An evaluation of household responses regarding energy consumption revealed a notable rise in spending on electricity and heating expenses. Households endeavoured to curtail energy usage through various conservation methods, such as turning off unused electrical appliances, reducing the use of electrical devices, dimming lighting, optimizing the use of electrical appliances during lower tariff periods, lowering room temperatures, transitioning to more cost-effective heating energy sources, utilizing computer-controlled heating schedules, and initiating the use of renewable energy sources. Nevertheless, approximately 10% of respondents did not implement any energy-saving measures, and nearly forty percent of respondents indicated that they have no clear strategy or immediate intention or means to do so.

The impact of income levels on household energy consumption is apparent. Forty percent of the surveyed households reported a surge in energy expenditure ranging from 10% to 20%, while 20% reported an increase of up to 30%. Moreover, over 70% of respondents did not receive any state assistance to offset household energy expenses, at least prior to the survey period. Consequently, it can be inferred that four-fifths of all households allocate a larger proportion of their income to energy requirements compared to the previous year.

Overall, households are more confident in their ability to cope with rising energy prices than in their ability to switch to alternative energy sources.

To alleviate the impact of rising energy prices on households, it is recommended to prioritize targeted support measures that can swiftly mitigate the effects on vulnerable groups. These measures should be easily reversible once the situation improves for these groups, without disrupting market dynamics or reducing incentives for transitioning to a decarbonized economy. In the medium term, policy efforts should focus on enhancing the EU's energy efficiency, reducing reliance on fossil fuels, and building resilience to energy price fluctuations, while ensuring that end-users have access to affordable and environmentally friendly energy. The 2022 State of the Energy Union Report also outlines additional measures aimed at lowering energy prices and ensuring supply security. These measures encompass the reduction of network tariffs and energy-related taxes, which are being implemented by Member States as crucial steps to alleviate the effects of elevated energy prices on end consumers. It is worth noting that in certain instances, these measures involve subsidies for fossil fuels, which could potentially impact the EU's objectives and commitments.

Energy poverty, encompassing various elements such as inadequate household incomes, soaring energy costs, poor residential energy efficiency, and the absence of digitalization in

energy consumption, is recognized as a multifaceted and escalating issue that impacts individuals' physical health, welfare, and social integration.

The results of the study can serve as a starting point for further research exploring the possibilities of using renewable energy to reduce household energy consumption and assessing how the shifting global political and economic climate, and government support measures affect these decisions. Establishing a correlation between energy consumption behaviours and sustainable energy practices may serve as a valuable aspect for future research. Further research opportunities could arise from exploring households' awareness of their energy consumption habits and their familiarity with potential energy-saving measures.

Author contributions

The authors of this article personally developed the work and are directly responsible for the contributions as follows: Conceptualization, D.K., R.G., L.S., D.L., E.Z.; methodology, R.G., D.K., L.S.; validation, L.S., R.G., D.L., E.Z.,; formal analysis, R.G., D.K., E.Z.; investigation, E.Z. and H.M., data curation, E.Z. and R.G.; writing – original draft preparation, D.K., R.G., L.S., D.L., E.Z., H.M.; writing – review and editing, D.K. and R.G.; visualization, R.G.; supervision, R.G. All authors have read and agreed to the published version of the manuscript.

Disclosure statement

Authors do not have any competing financial, professional, or personal interests from other parties.

References

Abdeldayem, M. M., & Al Dulaimi, S. H. (2020). Trends of global fintech education practices and the GCC perspective. *International Journal of Advanced Science and Technology*, *29*, 7150–7163. http://sersc.org/journals/index.php/IJAST/article/view/7577

Aldulaimi, S. H., Abdeldayem, M. M., Al-Sanjary, O. I., & Abdelhakim M. A. (2022). Paradigm of the Sustainability and energy saving strategies in GCC. In *ASU International Conference in Emerging Technologies for Sustainability and Intelligent Systems (ICETSIS)* (pp. 9–16). IEEE. https://doi.org/10.1109/ICETSIS55481.2022.9888837

Anderson, K., Song, K., Lee, S.H., Park, M. (2015). Energy consumption in households while unoccupied: Evidence from dormitories. *Energy and Buildings*, *87*(1), 335–341. https://doi.org/10.1016/j.enbuild.2014.11.062

Barnes, A. (2022). *EU Commission proposal for joint gas purchasing, price caps and collective allocation of gas: an assessment*. Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2022/12/EU-Commission-proposal-for-joint-gas-purchasing-price-caps-and-collective-allocation-of-gas-an-assessment-NG-176.pdf

Bergquist, P., Konisky, D. M., & Kotcher, J. (2020). Energy policy and public opinion: Patterns, trends and future directions. *Progress in Energy*, *2*, Article 032003. https://doi.org/10.1088/2516-1083/ab9592

Bibri, S. E., & Krogstie, J. (2020). Smart eco-city strategies and solutions for sustainability: The cases of Royal Seaport, Stockholm, and Western Harbor, Malmö, Sweden. *Urban Science*, *4*, Article 11. https://doi.org/10.3390/urbansci4010011

Bompard, E., Carpaneto, E., Huang, T., Pi, R. J., Fulli, G., Purvins, A., & Mutule, A. (2017). Electricity independence of the Baltic States: Present and future perspectives. *Sustainable Energy, Grids and Networks*, *10*, 55–64. https://doi.org/10.1016/j.segan.2017.03.003

Carfora, A., & Scandurra, G. (2024). Forecasting energy poverty in European Countries: The effect of increasing energy commodities prices. *Energies, 17*(5), Article 1224. https://doi.org/10.3390/en17051224

Chen, Y.-H., Li, Y.-Z., Jiang, H., & Huang, Z. (2023). Research on household energy demand patterns, data acquisition and influencing factors: A review. *Sustainable Cities and Society*, *99*, Article 104916. https://doi.org/10.1016/j.scs.2023.104916

Chu, W., Calise, F., Duić, N., Østergaard, P. A., Vicidomini, M., & Wang, Q. (2020). Recent advances in technology, strategy and application of sustainable energy systems. *Energies*, *13*, Article 5229. https://doi.org/10.3390/en13195229

Chu, W., Vicidomini, M., Calise, F., Duić, N., Østergaard, P. A., Wang, Q., & da Graça Carvalho, M. (2023). Review of hot topics in the Sustainable Development of Energy, Water, and Environment Systems Conference in 2022. *Energies*, *16*, Article 7897. https://doi.org/10.3390/en16237897

Cooremans, C., & Schönenberger, A. (2019). Energy management: A key driver of energy-efficiency investment? *Journal of Cleaner Production*, *203*, 264–275. https://doi.org/10.1016/j.jclepro.2019.04.333

Enerdata. (2023). *Global Energy Trends 2023*. https://www.enerdata.net/publications/reports-presentations/world-energy-trends.html

European Commission. (2021). *Tackling rising energy prices: A toolbox for action and support*. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52021DC0660

European Commission. (2022). *Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52022DC0547

European Commission. (2023). *Actions and measures on energy prices*. https://energy.ec.europa.eu/topics/markets-and-consumers/actions-and-measures-energy-prices_en#toolbox-of-measures

European Council. (2019). *European Green Deal policy*. https://www.consilium.europa.eu/en/policies/green-deal/

Eurostat. (2022a, September 9). *Electricity prices for household consumers.* https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_204_c/default/table?lang=en

Eurostat. (2023). *Population and population change statistics*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_and_population_change_statistics

Eurostat. (2022b). *Energy consumption in households*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households

Eurostat. (2022c, September 8). *Gas prices for Household Consumers*. https://ec.europa.eu/eurostat/databrowser/view/NRG_PC_202/default/table?lang=en&category=nrg.nrg_price.nrg_pc

Fuerst, F., Kavarnou, D., Singh, R., & Adan, H. (2020). Determinants of energy consumption and exposure to energy price risk: A UK study. *Z Immobilienökonomie*, *6*, 65–80. https://doi.org/10.1365/s41056-019-00027-y

Gajdzik, B., Wolniak, R., Nagaj, R., Žuromskaitė-Nagaj, B., & Grebski, W. W. (2024). The influence of the global energy crisis on energy efficiency: A comprehensive analysis. *Energies*, *17*, Article 947. https://doi.org/10.3390/en17040947

Griffiths, S. (2017). Renewable energy policy trends and recommendations for GCC countries. *Energy Transitions*, *1*(1), 1–15. https://doi.org/10.1007/s41825-017-0003-6

Hutter, C., & Weber, E. (2022). *Russia-Ukraine war: Short-run production and labour market effects of the energy crisis* (IAB Discussion Paper 10). Institute for Employment Research of the Federal Employment Agency, Nürnberg. https://doi.org/10.1016/j.enpol.2023.113802

Kardelis, K. (2016). *Mokslinių tyrimų metodologija ir metodai*. MELC.

Lekavičius, V. (2019). *Energijos nepriteklius (energetinis skurdas).* Lietuvos energetikos institutas. https://lsta.lt/wp-content/uploads/2019/02/Lekavicius_Energetinis_skurdas_20190130_papildytas.pdf

Lianwei, Z., & Wen, X. (2021). Urban household energy consumption forecasting based on energy price impact mechanism. *Frontiers*, *9*, Article 802697. https://doi.org/10.3389/fenrg.2021.802697

Lin, C.-C., & Dong, C.-M. (2023). Exploring consumers' purchase intention on energy-efficient home appliances: Integrating the theory of planned behavior, perceived value theory, and environmental awareness. *Energies, 16*, Article 2669. https://doi.org/10.3390/en16062669

Marti, L., & Puertas, R. (2022). Sustainable energy development analysis: Energy Trilemma. *Sustainable Technology and Entrepreneurship*, *1*(1), Article 100007. https://doi.org/10.1016/j.stae.2022.100007

Mastini, R., Kallis, G., & Hickel, J. (2021). A green new deal without growth? *Ecological Economics*, *179*, Article 106832. https://doi.org/10.1016/j.ecolecon.2020.106832

Matsumoto, S., Mizobuchi, K., & Manag, S. (2022). Household energy consumption. *Environmental Economics and Policy Studies*, *24*, 1–5. https://doi.org/10.1007/s10018-021-00331-9

Matuszewska-Janica, A., Żebrowska-Suchodolska, D., & Mazur-Dudzińska, A. (2021). The situation of households on the energy market in the European Union: Consumption, prices, and renewable energy. *Energies*, *14*(19), Article 6364. https://doi.org/10.3390/en14196364

McWilliams, B., Sgaravatti, G., & Zachmann, G. (2022). *Can Europe survive painlessly without Russian gas?*. Bruegel Datasets. https://www.bruegel.org/blog-post/can-europe-survive-painlessly-without-russian-gas

Morgan, P. J., & Trinh, L. Q. (2021). *Impacts of COVID-19 on households in ASEAN countries and their implications for human capital development* (ADBI Working Paper 1226). Asian Development Bank Institute, Tokyo. https://www.adb.org/publications/impacts-covid-19-households-asean-countries

Nacionalinis skurdo mažinimo organizacijų tinklas. (2021). *Skurdas ir socialinė atskirtis*. NSMOT. https://www.eapn.eu/wp-content/uploads/2021/10/eapn-Leidinys-PW-Lithuania-Final-5258.pdf

Naderifar, M., Goli, H., & Ghaljaei, F. (2017). Snowball sampling: A purposeful method of sampling in qualitative research. *Strides in Development of Medical Education*, *14*(3), 1–6. https://doi.org/10.5812/sdme.67670

Petrichenko, L., Petrichenko, R., Sauhats, A., Baltputnis, K., & Broka, Z. (2021). Modelling the future of the Baltic energy systems: A Greena scenario. *Latvian Journal of Physics and Technical Sciences*, *3*, 47–65. https://doi.org/10.2478/lpts-2021-0016

Poniatowska-Jaksch, M. (2021). Energy consumption in Central and Eastern Europe (CEE) households in the platform economics. *Energies*, *14*, Article 1002. https://doi.org/10.3390/en14041002

Rehman, H. u., & Hasan, A. (2023). Energy flexibility and towards resilience in new and old residential houses in cold climates: A techno-economic analysis. *Energies*, *16*, Article 5506. https://doi.org/10.3390/en16145506

Ryan, Th. P. (2013). *Sample size determination and power*. John Wiley &Sons.

Samper, J. A., Schockling, A., & Islar, M. (2021). Climate politics in green deals: Exposing the political frontiers of the European Green Deal. *Politics and Governance*, *9*(2), 8–16. https://doi.org/10.17645/pag.v9i2.3853

Santamouris, M., Paravantis; J. A., Foundac; D., Kolokotsa; D., Michalakakoue, P., Papadopoulos, A. M., Kontoulis, N., Tzavali, A., Stigka, E. K., Ioannidis, Z., Mehilli, A., Matthiessen, A., & Servou, E. (2013). Financial crisis and energy consumption: A household survey in Greece. *Energy and Build*ings, *65*, 477–487. https://doi.org/10.1016/j.enbuild.2013.06.024

Söderholm, P. (2020). The green economy transition: the challenges of technological change for sustainability. *Sustainable Earth*, *3*, Article 6. https://doi.org/10.1186/s42055-020-00029-y

Spash, C. (2020). A tale of three paradigms: Realising the revolutionary potential of ecological economics. *Ecological Economics*, *169*, Article 106518. https://doi.org/10.1016/j.ecolecon.2019.106518

Steckel, J. C., Missbach, L., Ohlendorf, N., Feindt, S., & Kalkuhl, M. (2022). *Effects of the energy price crisis on European households. Socio-political challenges and policy options*. Mercator Research Institute on Global Commons and Climate Change (MCC) gGmbH, Berlin, Germany.

Tokarski, S., Magdziarczyk, M., & Smoliński, A. (2024). An analysis of risks and challenges to the Polish power industry in the year 2024. *Energies, 17*(5), Article 1044. https://doi.org/10.3390/en17051044

Zeng, S., Streimikiene, D., & Baležentis, T. (2017). Review of and comparative assessment of energy security in Baltic States. *Renewable and Sustainable Energy Reviews*, *76*, 185–192. https://doi.org/10.1016/j.rser.2017.03.037