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How to support sustainable energy consumption in households?

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Abstract
Households are responsible for almost 30% of final energy consumption in the EU. Therefore, sustainable energy consumption in households can provide a lot of benefits for energy savings, use of renewables and GHG emission reduction. Environmental awareness plays an important role in promoting sustainable energy consumption in households, fostering low carbon energy transition, and creating a carbon-neutral society in the EU by 2050. Though the use of renewables and energy efficiency improvements in households are increasing in the EU, the low environmental awareness about the benefits of sustainable energy consumption, especially in vulnerable households receiving state support, might be an important barrier to creating a carbon-neutral society in the EU. The paper analyses the main scientific literature showing the linkages between environmental awareness and sustainable energy consumption in households and presents the results of an empirical study conducted in Lithuanian households. The study identified the main barriers to sustainable energy consumption in households and assessed state policies targeting sustainable energy consumption in households.

Keywords
Environmental awareness; Households; Sustainable energy consumption.

Introduction

The residential sector was responsible for almost 30% of final energy consumption in the EU in 2020 and has a huge GHG emission reduction potential which is not yet realized. Energy use efficiency improvements and the use of renewable energy sources in households are one of the main climate change mitigation measures linked to sustainable energy consumption (Stankuniene et al., 2020).

There is no agreement between scientists on the relationship between knowledge, attitudes and behaviour (Kollmuss, Agyeman, 2002; Diekmann, Preisendörfer, 2003; Frederiks et al., 2015; Ramos et al., 2016; Paço, Lavrador, 2017; Enzler et al., 2019; Brounen et al., 2020; Never et al., 2022;). A few studies' results stressed the weak link developed among (the pairs of) knowledge, behaviour, and attitudes. Other studies showed the existence of a direct relationship between knowledge and attitudes and behaviour, signifying the primary linkage of domestic energy consumption with total energy consumption, thus, utmost counting for it (the energy consumption). The urbanization rate development and the domestic energy consumption are strongly interrelated since an increase in the urbanization rate can cause an increase in domestic energy consumption; nevertheless, energy consumption structures are highly differentiating among urban and rural residents (Istudor et al., 2021; Liu et al., 2021).

In the relevant literature, it was also argued that subjective factors can play an important role in energy consumption reduction, not environmental awareness alone (Li et al., 2021). Such a household's subjective attitude significantly influences purchasing decisions towards more energy-efficient products and shapes solid pro-environmental attributes (Li et al., 2021). In the relevant literature, policymakers stressed a concern regarding the discordance reported between energy-related behaviours and consumers' personal values. While pro-environmental or green attitudes are obviously widespread, today's consumerism is commonly characterized by the purchase of non-green alternatives. Two behavioural types of energy consumption are a) those that emphasize beliefs, attitudes, and values, and b) those that also consider contextual factors and social norms (Brown and Sovacool, 2018). Such types of energy consumption can support reliable decisions to be made while identifying and addressing the key factors that impede or foster the target behaviours in particular populations, as well as rigorously evaluating programs towards plausible opportunities for improvement. In this respect, energy consumption implies a wide spectrum of decision-making stakeholders, including households, boards of directors, commercial buying units, and governmental bodies (Brown and Sovacool, 2018).

The aim is to close the research gap on the link between knowledge, attitudes and behaviour. The paper analyses knowledge and attitudes and environmental behaviour linked to household energy consumption based on a case study conducted in Lithuania. For this purpose representative survey of Lithuanian households was conducted first time in 2020 to reveal the overall environmental knowledge of respondents as well as their attitudes towards sustainable energy consumption and their actual behaviours and drivers with regards to energy savings, use of renewables and GHG emission reduction.

The methodology is presented in the second part of the article below; section 3 provides results of a systematic literature review; section 4 analyses the case study results in Lithuanian households; the fifth section discusses major findings, and the sixth section concludes.

Methods and data

The systematic literature review was carried out in order to consolidate the literature on environmental awareness and sustainable energy consumption in households. The reasoning behind the adopted framework of this study has resided in the fact that the joint appreciation of environmental awareness campaigns and technology choices toward end-use energy consumption behaviour has gained an ongoing scientific interest (Nguene et al., 2011). In this research context, energy savings through more energy-efficient end-use technology can be achieved at specific research frameworks such as the SOCIO-MARKAL. Such a framework was not confined to technical and economic considerations, but it was a model that integrated technological, economic and behavioural contributions to the environment (Nguene et al., 2011). Besides, this research study considered technological improvements on the demand side, behavioural changes in carbon dioxide emissions lowering, as well as rational use of energy encouragement. This model simulated the possible contribution of environmental awareness campaigns towards behavioural changes in energy consumption and technology switch in an examined city of Switzerland through the ANSWER and IEA platforms in the field of low consumption lighting technologies (Nguene et al., 2011).

From a sociological context, private consumers have expressed vivid interest in utilizing flexible ways of energy, thus, being self-motivated to be (co-)owners of renewable energy production facilities (Roth et al., 2021). Subsequently, behavioural changes can be driven by (co-)ownership in different types of renewables installation, mainly solar, wind, or bioenergy. Within the group of (co-)owners of solar installation, the choice

between self-consumption and sale of the produced energy had been attributed to the consumers' behaviour to become demand flexible (Roth et al., 2021).

Literature review on environmental awareness, governmental policies and renovation measures taken into household contexts

Towards visualizing household energy use and developing sustainable energy systems, it is also crucial to note the determining role of political goals targeted at reducing total energy consumption and using energy more efficiently while further addressing climate changes in their community. To achieve this, energy users should be encouraged to transform their behaviour and start reflecting on their energy use. In the relevant literature, such an energy use visualization should contain methods like information tools, keeping time diaries and using the "power-aware cord" (Löfström and Palm, 2008). In this context, a combination of such methods could be proven useful to draw attention to household energy use and the possibilities for energy reduction. Therefore, the primary goal of combining the data gained from different governmental methods is the design and the applicability of those strategies that are better suited to people's (consumerism and energy-friendly) behaviour (Löfström and Palm, 2008).

In the relevant literature, the uptake of environmentally sustainable housing appreciated "sustainability" not so much as a technological problem but as an institutional one, while theories of innovation should focus on innovation diffusion through chains of production. Therefore, the dis-aggregation critique and innovation involvement in the building sector should be closely determined by the non-know-how of new technologies, a lack of legislation and pricing, and unclear communication patterns (Crabtree and Hes, 2009). These key determinants could also generate uneven adoption of environmentally sustainable materials and processes within the Lithuanian household areas/urban zones. Regarding the renovation history in the household sector of Lithuania, a research attempt was reported as part of the Large Analysis and Review of European housing and health Status (LARES), under which the WHO collected data in eight European cities between 2001 and 2002 (Milstead and Miles, 2011). In this study, data were related to home-"do-it-yourself (DIY)" activities in Vilnius, Lithuania, where housing was privatized following the collapse of Communism. It was shown that DIY activities prevail among households regardless of socioeconomic status. However, residents were resilient to engage in DIY activities, while DIY activity was not associated with the condition of buildings and open spaces between buildings. Citizens' perceptions of neighbourhood quality were important in explaining the DIY activity, implying that DIY activity was no greater in, or near, the gentrifying city centre than elsewhere (Milstead and Miles, 2011), and in this context, our study can precisely explain and reflect the drivers and the barriers developed in the Lithuanian household sector, since then (two decades later).

Within an urban context, environmental awareness is also related to the consequences of a neighbourhood environmental service provision system that fails to pay sufficient attention to territorial differences in "need" for such services. Therefore, it is vital for researchers to understand better how high levels of social need and a failure within environmental service providers to compensate for these levels of need, combine and interact to deepen the environmental problems encountered in many deprived neighbourhoods (Hastings, 2009).

Environmental awareness and consumers' behaviour on housing, pricing, and renovation, can also be affected by the increase in frequency and severity of natural disasters, such as flood events in the UK, thus highlighting the impact of such calamities, like flooding, on the value of a property. While past studies showed a considerable variety of impacts, from no impact to discounts of more than 40 per cent of the property price, transactional measurements have also to be attempted in the national property markets through reliable available data, aiming at improving the available evidence base.

In this respect, the temporariness and no effect of flood designation can drive policy implications with regard to the perceptions and behaviours of property-household stakeholders (Lamond et al., 2010). To better understand the governmental and housing markets' responses to the increased frequency and severity of natural disasters expected with global climate change, the utilization of a framework to analyze a variety of alternative scenarios and their implications for housing prices and government intervention has been proposed (Pryce et al., 2011). In such a way, a plausible framework for analyzing housing price responses to flood frequency and severity, based on findings of behavioural economics and the sociology of risk, can emphasize myopic and amnesiac perceptions of risk towards the built-household environment (Pryce et al., 2011).

The social dimension of achieving sustainable energy consumption in households can be closely considered in alignment with poor housing and poor health; thus, strong evidence on the health impact of housing interventions towards sustainability to be developed, indicating that changes in dwelling type can influence key-psychosocial processes such as control, with consequent impacts on wellbeing (Gibson et al., 2011). Housing and health issues can also vary over time and between populations since the elderly population is increasing worldwide, but only limited information exists about housing conditions: changes over time, as well as linkages among health, safety, and thermal comfort, especially among the elderly (Pekkonen et al., 2018). Satisfaction

with the dwelling, maintenance, indoor air quality (IAQ), perceived safety, general health, and sleeping difficulties were variables associated with the outcomes (Pekkonen et al., 2018). The increase in wellbeing among building owners is also perceived as increasing housing satisfaction among household occupants (Pekkonen et al., 2018).

Therefore, it can be inferred that environmental awareness cannot be simply linked to energy and sustainability but also to enhance our understanding of the mechanisms linking housing change with improved wellbeing (Gibson et al., 2011). Another consideration of the social dimension of the household sector examined refers to the fact that most prognoses of older adults in the housing market are based on average housing preferences and average housing market behaviour of all persons in a certain age cohort. Subsequently, the linkage between age and housing is prone to changes for successive cohorts due to sociocultural and socioeconomic dynamics. Therefore, from a social viewpoint, it is crucial for future research to precisely determine housing preference estimates by recognizing the growing differentiation among older adults. This heterogeneity can be approached by differentiating older adults on their lifestyles (operationalized as values), using latent class analysis as a clustering technique. Such an analysis can classify older adults into distinct segments on the basis of their viewpoints, motivations and attitudes, being helpful in formulating contemporary housing policy (de Jong et al., 2018).

The environmental dimension of achieving sustainable energy consumption in households can be closely considered in alignment with an ambitious zero-carbon target for all new housing, especially among EU member state countries. This primary target can be associated with policies that emerged from discourses of environmental policy innovation through the interaction between pressure group politics and the technical analyses that accompany governments' consultation exercises. While regional and local variations in housing and property markets are likely to influence the ease of zero-carbon development, research conceptualization can be affected by the interrelated fields of "science and technology literature" as well as "literature on policy implementation" (Goodchild and Walshaw, 2011). Another environmental-related study for setting targets for reducing carbon dioxide emissions of the building stocks classified two contrasting propositions for reducing emissions from the housing stock, both based on modelling studies: One proposition was based on extensive stock management, including increased demolition rates, rigorous energy-efficiency measures, embedded renewable energy generation, and a supportive population. The other proposition was based on the multiplication of more modest improvements in all the aforementioned areas together with the decarbonization of the central electricity supply. Both these propositions demonstrated the complex interactions that commonly occur between embedded energy conversion technologies and the energy supply infrastructure, while future research can support monitoring campaigns to properly plan decarbonizing strategies and impacts assessment (Lomas, 2009).

The finance-economic dimension of achieving sustainable energy consumption in households was also assessed in the relevant literature in terms of the life cycle costs (LCC), life cycle energy (LCE) and carbon dioxide emissions impacts of filling the housing gap with different building materials and technologies, while maintaining reasonable standards of indoor temperature and humidity. The main variables assessed are a) different climatic conditions and b) residential behavioural patterns, using urban and rural housing archetypes, by jointly considering conventional and low-cost materials and energy-savings measures (Mastrucci and Rao, 2019).

In another finance-economic-related study, it was stressed that the development and the application of an integrated approach can capture complex interactions with regard to housing performance, energy, communal spaces and wellbeing, thus, better addressing the research constraints of narrow financial focus, adverse incentives, and inadequate handling of knowledge, skills, communication and feedback gaps (Eker et al., 2018). The dynamics created by these relationships can be interpreted by simulation modelling, along with a diverse group of stakeholders, proposing that monitoring is a key aspect of improving the housing stock's performance besides energy efficiency (Eker et al., 2018).

The multidimensional characteristics of the finance-economic contribution of achieving sustainable energy consumption in households were also analyzed by the integration of the green building with the largest low-income housing production programme and the innovativeness of US states' housing agencies (Yeganeh et al., 2021). The method of this study contained the deployment of a panel data and regression analysis to quantify associations between state-level characteristics and the adoption of green building criteria into the Low-Income Housing Tax Credit (LIHTC) programme. It was argued that housing agencies can increasingly adopt green building criteria, and most can identify co-benefits from energy-efficient buildings and smart growth. The LIHTC programme can be significantly associated with the states' internal factors, such as public housing agencies' motivations and resources, and external factors like regional policy diffusion from other states (Yeganeh et al., 2021).

The energy consumption in the form of electricity in households is highly linked to the behaviour of the inhabitants. Timely feedback on the user's household energy consumption and energy-saving advisory is a key aspect of energy-saving (Nguyen et al., 2014). The existing literature also investigated the association of environmental awareness with pro-environmental behaviours by combining theory and empirical evidence (Li et

al., 2021). The relevant research was modelled to incorporate environmental awareness agents to understand better the decision-making processes under a number of hypotheses derived from the theoretical framework in the Chinese context. Government should play a more active role in raising public awareness of sustainable development (Li et al., 2021).

Behavioural strategies of occupant energy conservation are proven essential to counter the effect of growing energy demand. Indicative occupant energy interventions, such as subsidies' offering to promote energy saving, entail continuous financial investments, which are particularly challenging to subsidy providers, i.e. national energy agencies. Besides, cost-effective interventions are proven vital in promoting household energy conservation in the long term; thus, in the relevant literature, the promising strategy of the Household Energy Saving Option (HESO) was proposed and validated in order to moderate the financial burden of energy policy providers (Xu et al., 2021). The effectiveness of HESO on household energy reduction for a hundred households in Singapore encouraged home electricity conservation based on the Difference-in-Difference (DID) analysis (Xu et al., 2021).

Similarly, in a residential-based study, the difference in differences (DID) analysis was deployed in order to study the impact of urban metro systems on transportation energy consumption in China(Yu et al., 2020). The research outcomes of this study disclosed that after the opening of the local/regional city subway, then, the per capita traffic energy consumption decreased, indicating that subways can reduce energy consumption in urban areas. Moreover, a "U" relationship exists between metro operation intensity and per capita traffic energy consumption (Yu et al., 2020). Further research can focus on how the metro system can reduce the distance travelled by cars by replacing the use of traditional automobile transportation, thus reducing transportation energy consumption(Yu et al., 2020).

Among the most recent and relevant empirical studies is the proposition of a deep neural network-based supervised learning algorithm that is capable of classifying household appliances from energy consumption data (Ukil et al., 2020). In this methodological context, the deep residual networks (ResNet) enabled learning of the residual functions and made a more robust trained model by transforming the representation learning problem into a residual learning problem. This was an empirical study on publicly available relevant datasets from the UCR time-series archive and demonstrated a substantially improved and consistent performance over baseline algorithms and state-of-the-art methods (Ukil et al., 2020).

Another empirical study introduced the concept of a mobile application that displayed real-time energy consumption information in a household. The research objective was to build up a conscious energy awareness amongst the users, to encourage energy savings and to make the user avoid using excessive energy during the energy peaks. The testifying and usability of the relevant empirical techniques were developed through visualization, gamification and social networking (Nguyen et al., 2014).

It is also noteworthy that the development of strategic energy planning is certainly determined by human-induced factors along with unavoidable challenges and uncertainties that escalate when the target society is not fully known to the decision-maker; thus, s/he creates performance gaps between the expected and actual outcomes of sustainability targets. Therefore, it is critical for relevant research to be devoted to the role of socioeconomic and behavioural dimensions in residential energy consumption patterns among densely-populated regions as those high hosting proportions of migrant communities with diverse cultural and ethnic traits through machine learning approaches(Ghofrani et al., 2014).

The ultimate goal is the identification of linkages between critical factors that influence human-building interactions, thus, supporting a better discerning of the energy behaviour of locals and migrants. Case scenarios of a simulation analysis determined the ways of residential energy consumption under different human indoor thermal comfort preferences, thus demonstrating how socioeconomic and behavioural contributors to residential energy consumption were the impact of human factors at a high level in regions with imbalanced demographics and societies in transition (Ghofrani et al., 2014).

Another viewpoint of energy consumerism is the consideration of its habitual physiognomy. Indeed, habits - not fully conscious forms of behaviour - it is an important entity as it contradicts the rational choice theory. Habits are valued as "counter-intentional", which is especially important in the energy sector since habits may explain the "efficiency paradox" regarding the continued increase of energy consumption despite the rising environmental awareness among the population. In this context, strategic policies are targeted to reduce energy consumption and specifically address habits' performance context (Marechal, 2010). The empirical analysis of Marechal (2010) suggested that individuals do not consider the need to change existing habits as an obstacle, even though this is contradicted implicitly in the responses received from the survey respondent. This "unconsciousness" feature of habits can be accounted for when energy designing measures (Marechal, 2010).

In another empirical study, it was demonstrated that many factors can determine the energy consumption at household and industrial sectors, including climate conditions, household and building characteristics, and occupant behaviour (Feng et al., 2016), as well as population factors, efficiency factor, and economy factor (being proven as the main aspect of the increasing energy consumption in household departments, comparing to the other factors of population and efficiency (Rus et al., 2020). However, the extent to which each factor is

actually contributing to the total energy consumption has remained unclear, especially in developing countries such as China. Results reveal that occupant behaviour is the most important parameter of cooling energy use, compared with household characteristics and urban geometry (Feng et al., 2016).

Lithuanian case study

The representative survey of Lithuanian households was performed by Vilmorus in November-December of 2020 in the framework of a scientific project financed by the Research Council of Lithuania. The aim of this survey was to evaluate the environmental awareness of Lithuanian households and their perceptions of climate change mitigation measures related to energy consumption in households. The sample size of 1008 Lithuanian households 18 and older was surveyed by Vilmorus face-to-face. The sampling method applied- probabilistic selection. The households were surveyed at their homes in all Lithuanian regions.

The questions linked to sustainable energy consumption were grouped into transportation, electricity and heat consumption and other sustainable consumption patterns.

The following sustainable energy consumption linked questions were applied in the transportation area:

1.Do you use biodiesel or bioethanol in your car?
2.Do you apply responsible driving techniques?
3.Do you try to use as much as possible public transport, walking and/or other ecological transport modes?
4.Do you share your car with other households?
5.Do you drive a new hybrid or electric car?
6.Do you want to buy a new hybrid or electric car?
7.Do you encounter financial difficulties buying a new hybrid or electric car?

The following sustainable energy consumption linked questions were applied in the electricity and heat consumption area:

1. Do you use energy-efficient light bulbs at your house?
2. Do you prioritize energy-efficient appliances during your buying process?
3. Do you use renewables in your house?
4. Would you like to use renewables for heating, hot water, conditioning, electricity generation etc.?
5. Do you have possibilities (necessary infrastructure) to install renewables at your house?
6. Do you think that your house needs energy renovation?
7. Do you consider energy renovation of your home?
8. Do you feel the lack of financial resources for a house renovation?
9. Do you feel the lack of financial resources for buying effective electric appliances?
10. Do you feel the lack of financial resources for renewable energy technologies installation?
11. Do you think that you lack knowledge about energy renovation possibilities available?

The following questions were applied to other sustainable consumption patterns area:

1. Do you apply priority for Lithuanian goods then you are buying food etc. in order to reduce environmental pressure due to long distances of transportation?
2. Do you prioritize energy-efficient appliances during your buying process?
3. Do you sort the communal waste?
4. Do you limit meat consumption due to environmental reasons?
5. Do you take into account the packing of goods during the buying process and try to limit packing waste?
6. Do you agree to limit your energy and other consumption due to climate change mitigation?
7. Are you saving energy, water etc., in your house?

There were several questions in the questionnaire linked to awareness about state policies and their assessments

1. Do you think that state policies support sustainable consumption patterns?
2. Do you think that state support for energy renovation is enough to motivate you to make a decision on the renovation?
3. Will the existence of a responsible institution for all organizational issues linked to your house's energy renovation positively impact your decision to renovate the house?
4. Do you think that information about state support for sustainable energy consumption measures is easy to obtain?

The results of the survey are generalized in Tables 1-4 below.

In Table 1, the distribution of respondents according to answers to sustainable energy consumption questions linked to transportation is provided:

Tab. 1. The distribution of households according to sustainable energy consumption behavior in transport, %

Number of question	Questions	Yes	No	No answer	Total
1	Do you use biodiesel or bioethanol in your car?	12.1	87.7	0.2	100%
2	Do you apply responsible driving techniques?	43.9	55.2	0.9	100%
3	Do you try to use as much as possible public transport, walking and/or other ecological transport modes?	17.2	82.6	0.2	100%
4	Do you share your car with other households?	19.2	80.7	0.2	100%
5	Do you drive a new hybrid or electric car?	5.5%	94.4%	0.1%	100%
6	Do you want to buy a new hybrid or electric car?	62.1%	36.5%	1.4%	100%
7	Do you encounter financial difficulties in buying a new hybrid or electric car?	74.9%	20.5%	4.6%	100%

Information provided in Table 1 shows that the majority of Lithuanian households surveyed do not use biodiesel or bioethanol in their private car, and 94.4% of respondents use electric or hybrid vehicles. 62% of respondents would like to buy a new hybrid or electric car, but just 20.5% of all respondents do not face any financial obstacles to do this.

Most Lithuanian households do not attempt to use more public transport or other ecological or environmentally friendly ways of transportation like walking or bicycle driving. Also, 80.7% of Lithuanian households do not share their private cars with other households. More than half of respondents apply responsible driving techniques like speed limit etc.

Therefore, financial barriers seem an important barrier to households' use of hybrid and electric cars. However, Lithuanian households do not implement simple energy saving and GHG emission reduction measures linked to transportation like switching to public transport driving or other environmentally friendly modes of transportation, car sharing or responsible driving.

In Table 2, the distribution of respondents according to sustainable energy consumption behaviour in households is summarized.

Tab. 2. The distribution of respondents according to sustainable electricity and heat consumption behaviour in households

Number of question	Questions	Yes	No	No answer	Total
1	Do you use energy-efficient light bulbs at your house?	88.1	11.2	0.7	100%
2	Do you prioritize energy-efficient appliances during your buying process?	81.4	18.3	0.3	100%
3	Do you use renewables in your house?	9.9	89.1	1.0	100%
4	Would you like to use renewables for heating, hot water, conditioning, electricity generation etc.?	62.5	34.1	3.4	100%
5	Do you have possibilities (necessary infrastructure) to install renewables at your house?	81.4	16.6	2.0	100%
6	Do you think that your house needs energy renovation?	52.5	43.4	4.2	100%
7	Do you consider energy renovation of your home?	36.8	58.5	4.7	100%
8	Do you feel the lack of financial resources for a house renovation?	60.8	32.0	7.1	100%

9	Do you feel the lack of financial resources to buy effective electric appliances?	57.8	38.8	3.4	100%
10	Do you feel the lack of financial resources for renewable energy technologies installation?	60.5	30.7	8.8	100%
11.	Do you think that you lack knowledge about energy renovation possibilities available?	54.0	41.0	5.1	100%

Information provided in Table 2 shows that the majority of Lithuanian households use energy-efficient light bulbs (88.1%) and favour energy-efficient appliances (81.4%) in their homes, although a large proportion (57.8%) identified that they encounter financial difficulties in buying energy-efficient appliances.

Just 9.9% of respondents use renewable energy technologies in their houses. The major barriers are the lack of infrastructure to use renewables (81.4%) and financial barriers (60.5%) to installing renewable energy technologies in their homes.

More than half of respondents (52.5%) indicated the need for energy renovation for their homes, and 60.8% of respondents indicated that they lack financial resources for energy renovation of their houses. Also, more than half of respondents claimed they lack information and knowledge about energy renovation possibilities, and 58.5% of respondents did not even consider energy renovation options.

In Table 3, the distribution of Lithuanian households according to other sustainable consumption patterns was provided.

Tab. 3. The distribution of respondents according to other sustainable consumption patterns

Number of question	Questions	Yes	No	No answer	Total
1	Do you apply priority for Lithuanian goods then you are buying food etc. in order to reduce environmental pressure due to long distances of transportation?	43.1	56.5	0.4	100%
3	Do you sort the communal waste?	84.1	15.2	0.7	100%
4	Do you limit meat consumption due to environmental reasons?	40.1	59.4	0.5	100%
5	Do you take into account the packing of goods during the buying process and try to limit packing waste?	47.7	51.5	0.8	100%
6	Do you agree to limit your energy and other consumption due to climate change mitigation?	46.4	53.5	0.1	100%
7	Are you saving energy, water etc., in your house?	78.4	21.0	0.6	100%

The information shown in Table 3 shows that less than half of Lithuanian households favor Lithuanian goods during the buying process and pay more attention to the price of goods. Also, just 40% of Lithuanian households limit their meat consumption due to climate change mitigation reasons. A quite similar share of respondents (47.7%) take into account the packing of goods during their buying decisions. Also, 46.4% of respondents agree to limit their consumption of energy, water and other resources due to environmental reasons though 78.4% of Lithuanian residents are saving energy and water. However, it is obvious that financial issues are more important for shaping the sustainable consumption behaviour of households as energy and water prices have increased in recent years.

Tab. 4. Evaluation of state policies supporting sustainable consumption and behaviour in households

Number of question	Questions	Yes	No	No answer	Total
1	Do you think that state policies support sustainable consumption patterns?	37.6	58.6	3.8	100%

2	Do you think that state support for energy renovation is enough to motivate you to make a decision on the renovation?	18.9	72.2	8.8	100%
3	Will the existence of a responsible institution for all organizational issues linked to your house's energy renovation positively impact your decision to renovate the house?	32.5	60.1	7.3	100%
4	Do you think that state support for renewable energy microgeneration technologies is enough to motivate you to make a decision installation of these technologies?	60.5	30.7	8.8	100%
5	Do you think that information about state support for sustainable energy consumption measures is easy to obtain?	33.9	50.9	15.2	100%

As shown in Table 4, more respondents (58.6%) are critical of state policies and measures supporting sustainable energy consumption in households. More than 70% of respondents think that state support for energy renovation and renewable energy sources is not enough to make a decision on the renovation or installation of renewable energy technologies. In addition, the survey revealed that according to more than 50% of respondents' information about support measures for sustainable energy consumption in households, it is difficult to obtain.

The survey showed that according to Lithuanian households, the existence of responsible institutions for all organizational issues linked to energy renovation would have a positive impact just on 30% of households' decision to renovate their houses. Therefore, though institutional barriers were found to be very important for hampering successful energy renovation in households, the financial barriers still dominate in the Lithuanian household sector.

Discussion of results

The systematic analysis provided that boosting renewables in households are among the most important ways to reduce GHG emissions in the residential sector and to achieve a low carbon energy transition and carbon-neutral society by 2050. Such ways of achieving carbon neutrality are proposed by the PV systems and wind turbines as on-site renewable power technologies (Krarti and Aldubyan, 2021). The main mechanism of interrelating GHG emissions with the residential sector and low carbon energy transition is attributed to the sharp growth of household activities that has been recently attributed to the lock-down in the COVID-19 pandemic and the abiding increase of household energy use caused by high energy consuming appliances (Ukil et al., 2020; Kyriakopoulos, 2021). Subsequently, high energy consumption causes a fast pace of air pollution and carbon footprint. This carbon footprint is mainly the case of greenhouse gases (GHGs) emitted while burning fossil fuels for energy production. In this context, one plausible approach to lowering the carbon footprint is the investigation of ways under which citizen behavioural patterns' are linked to household appliances (Ukil et al., 2020).

Indeed, efficient building design options for energy management greenhouse-gas (GHG) emissions reduction should be associated with a building life-cycle; they are always highly challenging to construction/sustainable development designers. Optimization models for developing strategies are directed to both building's energy consumption reduction and GHG emissions reduction (Tam et al., 2018), while the simulation of different types of software to assess environmental, sustainability, and financial aspects in a life-cycle of a system, it remains a dilemma to all construction development designers. Another constraint in the progress of sustainable development, especially in developed and industrialized areas, is that designers can utilize various green building rating tools to minimize environmental footprint while increasing the efficiency of building operation throughout their lifetime (Tam et al., 2018). Subsequently, a contemporary design of the built environment should involve the building's life-cycle assessment (LCA), calculation of life-cycle energy consumption, life-cycle cost, and life-cycle GHG emissions (Tam et al., 2018).

It was certainly shown that although the total domestic energy consumption and urbanization rate are generally increasing, the current situation and changing trends in domestic energy consumption of densely populated areas have to be systematically examined through field investigation, survey questionnaire, actual situation analysis, horizontal survey data, statistical yearbook panel data, time-series econometric models. All these methodological tools could better comprehend the relationship developed between the urbanization rate and total domestic energy consumption (Liu et al., 2021).

Major fields have been reviewed, including building envelope design, comprehensive optimization of several areas simultaneously, and configuration and control of building energy consumption (Krarti and Aldubyan, 2021). These research outcomes can assist researchers in choosing which program is the best suitable for their study on sustainable assessment. Towards a sustainable assessment, it is also noteworthy that the cost-effectiveness of carbon-neutral communities can be significantly improved, including a reduction of capitals cost

by more than 50% when electrical loads for the communities can be lowered through energy efficiency actions on individual housing units (Krarti and Aldubyan, 2021).

In another building-based analysis, an energy audit can be conceptualized in order to both identify energy use among different services and to offer energy conservation opportunities (Darshan et al., 2022). The integration of renewable energy sources in a building is attributed to cost-saving due to energy-efficient appliances, thus, necessitating patterns' analysis of energy usage at residential units and various measures of cost-saving and energy consumption reduction. Therefore, in the relevant literature, case studies can analyze ways of making buildings energy-efficient through energy per unit consumption reduction while further observing the increments in costs. Auditing calculations two-folded benefited occupants: a) to reduce the building's carbon footprint and b) to offer cost savings in the long run (Darshan et al., 2022).

The case study performed in Lithuania revealed the low environmental awareness of the Lithuanian population and showed that the main drivers of sustainable energy consumption in Lithuanian households were economic motives instead of an environmental ones. It is in agreement with other scientific literature indicating that environmental awareness alone does not necessarily reduce energy consumption due to the existence of other important factors (Li et al., 2021). The Lithuanian case study results align with other studies (Brown and Sovacool, 2018), showing that policies and measures providing credible and targeted information can foster targeted, sustainable behaviours. The results of studies (Seetharaman Moorthy et al., 2019; Reddy, Painuly, 2004) stressing the importance of economic motives can also be acknowledged as the Lithuanian case study identified the dominating financial barriers to sustainable energy consumption in households.

Conclusions and policy implications

The aforementioned systematic literature review was performed to identify that environmental awareness is an important factor driving sustainable energy consumption in households. However, environmental awareness alone does not necessarily provide for sustainable energy consumption in households as other economic, institutional and other factors play an important role in this multifaceted socio-environmental field.

Though the Lithuanian case study identified major financial barriers to using new, hybrid and electric cars, Lithuanian households do not implement simple energy saving and GHG emission reduction measures which do not require any additional spending in transportation areas like switching to a public or using environmentally friendly modes of transportation, car sharing or responsible driving.

More than 80% of Lithuanian households use energy-efficient light bulbs and favour energy-efficient appliances during buying, though more than half of households surveyed are facing financial problems from buying energy-efficient appliances.

A survey revealed that less than 10% of households are using renewable energy technologies, and they identified that this is due to a lack of infrastructure to use renewables (81.4%) and financial barriers (60.5%) to installing renewable energy technologies in their homes.

Though more than 50% of respondents specified the need for energy renovation for their houses, the majority of respondents answered that the lack of financial resources and shortage of information and knowledge about energy renovation possibilities hampers energy renovation decisions. In the end, less than 50% of respondents considered energy renovation.

Half of the Lithuanian households favour Lithuanian goods or consider packing issues during the buying process, and just 40% limit their meat consumption for environmental reasons. The majority of Lithuanian residents are saving energy and water, but less than half of respondents agree to limit their resource consumption due to environmental reasons as the major driver of resource conservation and are high prices of these resources.

Most respondents think state policies do not support sustainable energy consumption in Lithuanian households. More than 70% are assured that state support for energy renovation and renewable energy sources is not enough to make the decision on energy renovation or installation of renewable energy technologies in their homes. Also, information about support measures for sustainable energy consumption in households is difficult to obtain for Lithuanian households.

Therefore, scientific literature identified the significance of technical, institutional, behavioural etc., barriers to sustainable energy consumption in households. The financial barriers to sustainable energy consumption dominate the Lithuanian household sector, and state policies cannot deal effectively with them.

Therefore, it is necessary to reshape Lithuanian policies and measures supporting sustainable energy consumption in households. The policies targeting information dissemination and environmental awareness-raising should be taken as a priority as currently mainly financial motives drivers sustainable energy consumption in Lithuanian households.

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