Unpacking the Complexities of Energy Renovation Programs for Family Houses: Case Study of Croatia

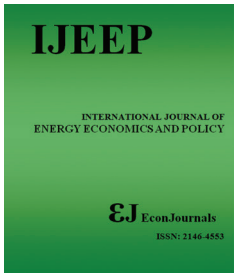
Šostar, Marko; Škoko, Ines

Source / Izvornik: **International Journal of Energy Economics and Policy, 2024, 14, 12 - 25**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

https://doi.org/10.32479/ijeep.15965

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:277:872598



International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(4), 12-25.

Unpacking the Complexities of Energy Renovation Programs for Family Houses: Case Study of Croatia

Marko Sostar*, Ines Skoko

University of Osijek, Faculty of Tourism and Rural Development in Pozega, Croatia. *Email: msostar@ftrr.hr

Received: 20 January 2024 **Accepted:** 07 May 2024 **DOI:** https://doi.org/10.32479/ijeep.15965

ABSTRACT

This study investigates the impact of administrative barriers on the financing of energy renovation of family homes in the Republic of Croatia. The research aims to prove a causal relationship between the limitations of the support system and citizen satisfaction with the existing support system for energy renovation of family homes, which directly affects an individual's motivation to apply for a competition. A survey was conducted on 308 respondents, and mathematical methods were used to determine the impact. The research results show that different factors have varying degrees of influence on the perception of family homeowners and their decision to apply for a project, and that this perception depends on age, employment status, and monthly income of the individual.

Keywords: Energy Renovation Programme, Family Houses, Administrative Barriers, Support System
JEL Classifications: Q28, Q40, Q42, Q48

1. INTRODUCTION

Energy efficiency and the renovation of residential buildings have gained significant attention globally due to the potential benefits related to energy conservation, reduction in greenhouse gas emissions, and enhanced living conditions for residents. With homes being central to daily life and major energy consumption points, renovation programs that enhance energy efficiency are a crucial strategy in any nation's sustainability agenda. The Republic of Croatia, with a significant portion of its housing stock consisting of family homes, is no exception. Family homes make up 65% of the housing stock in Croatia, which is responsible for 40% of the total energy consumption at the national level. However, many of these homes were constructed before the modern era of energy-efficient building standards and practices, making them prime candidates for energy renovation.

On March 27, 2014, the Government of the Republic of Croatia, the Ministry of Construction and Spatial Planning, and the Ministry of Environmental and Nature Protection adopted the Energy Renovation Program for Family Houses, which is implemented by the Environmental Protection and Energy Efficiency Fund. The Program's goal is to increase the energy efficiency of existing houses, reduce energy consumption and CO_2 emissions into the atmosphere, and reduce monthly energy costs, while overall improving the quality of life. At the same time, planning such interventions implies the engagement of local companies and experts, thereby promoting economic activity. Amendments and adaptations to the Program were first introduced in 2015, and a 2nd time in 2020, after which the Government decided to extend the program into 2021. Currently, a plan for the continuation of financing the energy renovation of family homes for the future period is being developed.

Family homes account for 65% of the housing stock in Croatia, which is responsible for 40% of the total energy consumption at the national level. Most family homes in Croatia were built before 1987 and have little to no thermal insulation (energy class E and worse). Such houses spend 70% of their energy on heating,

cooling, and preparing hot water for use, and energy efficiency measures can significantly reduce their consumption, in some cases by up to 60% compared to current levels. To facilitate the energy renovation of family homes, the Government of the Republic of Croatia has introduced a program that subsidizes household investments in comprehensive energy renovation (enhancing the thermal protection of the external envelope of the heated space through the implementation of at least one measure on the external envelope of the family home and the installation of systems for using renewable energy sources), increasing the thermal protection of the external envelope of the heated space (implementation of at least one measure on the external envelope of the family home), and the installation of systems for using renewable energy sources (Environmental Protection and Energy Efficiency Fund, 2024).

Despite the availability of programs and funds dedicated to this cause, numerous barriers-administrative, legal, and informational-exist, potentially hindering homeowners from participating fully and effectively. This paper takes a deep dive into the intricate landscape of energy renovation programs in Croatia, specifically focusing on the administrative complexities and the consequent perception and response of the targeted beneficiaries: the homeowners of family houses. By understanding the nexus between administrative barriers and homeowner participation, this study hopes to shed light on areas for improvement, ensuring more effective program implementation and maximizing the benefits of energy renovation for all stakeholders.

2. LITERATURE REVIEW

The primary goals defined in the Integrated Energy and Climate Plan for the Republic of Croatia for the year 2030 include lowering greenhouse gas emissions, increasing the share of renewable energy sources (RES) in total final energy consumption, and enhancing energy efficiency, as measured by primary energy consumption and direct energy use (Ministry of Environment and Energy, 2019). Each country has its own policy for the energy renovation of family homes and other buildings. The European Union attempts to reduce energy poverty among its member states through various subsidies and funds. Reducing administrative procedures in project applications, investing in human resources, and educating people are key to success (Šostar, 2021). Nonetheless, it demands decision-making grounded in economic rather than political considerations. Achieving a higher level of institutional cooperation, particularly among knowledge multipliers, is crucial. Moreover, it's essential to innovate in how information and knowledge about funds are utilized (Šostar, 2021).

Unsustainable energy consumption adversely affects ecosystems, climate change, human health, and quality of life, but sustainable and energy-efficient cities can mitigate these impacts while promoting social and economic development, equity, and resilience (El Hafdaoui et al., 2023). Based on metrics such as energy per GDP unit, GHG emissions per million residents, and CO_2 emissions from public electricity and heat production, Latvia, Sweden, Portugal, Croatia, Austria, Lithuania, Romania, Denmark, and Finland emerge as the leading nine countries in renewable energy use, exceeding the EU average in consumption from renewables and biofuels (Remeikienė, 2021). Around 75% of EU structures are residential, contributing to roughly 25% of the EU's total energy use, placing the residential sector as the second-highest energy consumer, following transportation (Tsemekidi et al., 2019). Over 50 countries, accounting for three-quarters of global CO_2 emissions, have committed to achieving a net-zero carbon footprint by 2050, with energy efficiency enhancements playing a pivotal role in policy strategies to reach this objective (Papineau et al., 2022). Canadian case studies (Tardy and Lee, 2019) indicate that energy policies amplifying wealth disparities among different income groups are ineffective, and that free riding undermines the credibility of subsidy programs. The information regarding costs and energy consumption on utility bills serves as the most potent incentive for homeowners to invest in energy renovation (European Commission, 2019). In their research, Levesque et al., 2018 project that global energy demand for buildings could potentially increase up to threefold between 2010 and 2100.

Renovating buildings for energy efficiency can significantly boost overall energy conservation, paving the way for decarbonization and enhancing sustainable outcomes (Zachariadis et al., 2018). The residential sector significantly contributes to energy consumption, offering substantial potential for energy conservation (Du et al., 2022). Policies and policy packages, which include tools such as information, pricing mechanisms, financing, and regulatory policies, have been published in many countries to overcome the barriers faced by homeowners (Bertoldi, 2022). Ebrahimigharehbaghi et al., 2019 identified the lack of reliable experts and information, the time and effort required to find information, and the complexity of the task/process as key factors influencing the decision to renovate a house energetically. When deciding, individual factors dominate over other factors such as psychological, social, and cultural ones (Šostar and Ristanović, 2023).

The COVID-19 pandemic has also had a significant impact on individual fear in decision-making and investments, particularly due to uncertainty and shifting priorities during the crisis (Šostar and Ristanović, 2023). It's widely believed that the building sector, particularly homeowners, requires enhanced knowledge and expertise to make informed decisions on energy-efficient renovations and select the right refurbishment options, thereby boosting the renovation rate (Myhren et al., 2018). Enhancing the energy efficiency of current buildings is a primary objective for many nations, leading both public and private sectors to develop numerous tools to motivate homeowners to adopt energy-saving measures (Seddiki et al., 2021). The amount homeowners truly need to invest in the energy efficiency of their homes depends on several factors. The heating expenses don't directly correlate with a household's income or the technical features of the dwelling; instead, they are influenced by sociological factors like dwelling usage, lifestyle, and comfort requirements (Gróf et al., 2022). This research (Pérez-Navarro et al., 2023) indicates that the prevalent bureaucratization in public administration poses a significant obstacle to the implementation of energy renovation, even more so than traditional factors like economic constraints. The study (Azizi et al., 2019) confirm hypothesizes that various homeowner groups in Sweden may perceive the advantages and

challenges of energy renovation differently, which can account for the variations in their motivation to undertake energy renovation of their houses. Findings of Siddique et al., 2022 underscore the need for policymakers in Denmark to refine subsidy distributions and enhance decision-making tools for quicker decarbonization, emphasizing a grassroots approach to optimize the balance between public expenditure and carbon reduction, thereby facilitating a more cost-effective and rapid energy transition. The study by Jalilzadehazhari et al., 2021 indicates that, in Sweden, property owners prioritize their expected lifespan over energy savings when deciding on energy renovations, further highlighted by findings that lifespan changes have a greater impact on subsidies than interest rate growth. Energy efficiency is a critical pillar of action, and heightened efforts in the building sector are vital to meet European objectives by 2030 (Attia et al., 2022). Recently gaining traction, EU promoted one-stop shops provide customers with a unified access point, guiding them through the intricate renovation process and assisting with financial access (Bertoldi et al., 2020; Pardalis et al., 2022; Lakatos and Arsenopoulos, 2019). However, several barriers to the implementation of one-stop shop model have been identified: Budgetary constraints of local governments, an absence of sustainable, reasonably-priced funding, prolonged approval processes for financing, elevated transaction costs from small-scale investments, modest financial returns, concerns over repayment reliability, limited bank knowledge on the topic, energy upgrades not necessarily leading to higher rents or property values, and inadequately quantified benefits (Biere-Arenas et al., 2021). Klöckner and Nayum, 2017 believe the most significant barriers to investing in energy efficiency in privately owned properties are strict building protection regulations, the perception of contractors' lack of competence, doubts about the reliability of information, and the feeling that the right time has not yet come. Michelsen and Madlener, 2016 identified commonly recognized barriers, including risk, high initial technology costs, split incentives, imperfect information, hidden costs, and bounded rationality.

A national building renovation strategy in Turkey, aligned with the Urban Transformation Plan, should be crafted with yearly renovation targets, explicit policies, and funding methods, grounded in a grassroots evaluation of the potential, costs, and benefits of energy efficiency technologies for refurbishing the existing building inventory (Saygin et al., 2019). In China, information and voluntary action policies are relatively scarce, facing implementation barriers such as insufficient testing mechanisms, limited experience, and lack of awareness, with a notable absence of policy tools tailored to their specific requirements and situations (Huang et al., 2016). A study by Sankelo et al., 2022 suggests that subsidy strategies in Finland and across other EU nations should prioritize deep renovation, heat recovery from ventilation, and local electricity production. While the EU's policy to promote low-carbon home retrofit has historically cantered on distinguishing and addressing drivers and barriers, this static approach overlooks the evolving nature of these factors throughout the retrofit process (Bobrova et al., 2022). During transitional periods, energy renovations are more likely to take place, suggesting an optimal window to motivate homeowners to invest in energy retrofits, especially with policies tailored for properties undergoing tenure or occupancy changes (Curtis and Grilli, 2020). While energy retrofit projects are often framed around addressing technical challenges, achieving energy and cost savings, or securing a return on investment, the decisions to renovate might stem from profound social or familial considerations (Abreu et al., 2019; Tjørring and Gausset, 2019). Various obstacles may prompt homeowners to opt for phased retrofitting rather than a 1-time comprehensive approach. These include financial constraints for a full renovation, discomfort during the renovation process, specific urgent issues like a leaking roof or faulty boiler, personal family circumstances, or a lack of understanding about how to implement the measures (Maia et al., 2021). Murto et al., 2019 confirm numerous constraints in the energy renovation of buildings and emphasize the complexity of the project implementation system, which demotivates individuals from deciding to undertake energy renovation measures.

Every project should focus on attention to detail and adapting to the needs of the specific region and its residents, ensuring long-term value and sustainability (Šostar and Čevapović, 2016). Alsabbagh, 2019 concluded several challenges in energy investments in houses, including initial costs, lack of information, and maintenance requirements. When families move into new homes, it's vital to implement infrastructure or service-based interventions to promote new energy-efficient behaviours (Schaffner et al., 2017). Member States should offer up to 100% subsidies for clean heating transitions, prioritizing low-income households, with sustained budget allocations, and adjusting subsidies based on household income and size, supplemented by suitable financing if needed (Sunderland and Gibb, 2022). Policy efficacy could be enhanced by pairing subsidies with mechanisms like low-interest loans or augmented tax incentives, potentially elevating the cost efficiency of public spending related to direct grants (Fernandez-Luzuriaga et al., 2022). The study of Gatt et al., 2020 suggests shifting from feed-in tariffs to subsidizing direct energy use, storage, and load alignment due to their high costs, and emphasizes the importance of including costs related to thermal discomfort, energy poverty, and grid discrepancies in macroeconomic analyses for a comprehensive approach to building renovations. Bennadji et al.'s 2022; Zhang et al., 2021 study revealed that the most significant energy savings across the housing stock come from window replacements, draught-proofing, and the installation of mechanical ventilation with heat recovery. All stakeholder discussions emphasized the need for increased awareness regarding the importance of residential energy retrofitting, which remains a crucial area for further development to support sustainable community growth and contribute to the EU's energy goals (Small-Warner and Sinclair, 2022). Ma et al., 2022 found that when homeowners decide on renovation projects, they frequently consider barriers such as high initial costs, imbalanced financial planning, ambiguous procedures, comfort concerns, and rising energy prices. The research of Houde and Wekhof, 2021 introduces a new method using narratives to understand and prioritize the barriers and determinants of household energy efficiency investments, revealing that such investments are primarily opportunistic, with non-takers perceiving limited potential in their homes and takers motivated by the need to replace aging components or the perceived profitability of the investment.

To align policy goals with homeowners' self-interests, it's essential to communicate the wide-ranging benefits of enhancing home energy efficiency through smart technology, and this can be achieved by enhancing online calculation tools, standardizing, and testing smart meter rollouts to measure added advantages, and tailoring government support to amplify these benefits, including assistance for energy-deprived households (Ringel et al., 2019). The decision to renovate family homes is often interrupted by various "moments of truth" in the homeowner's journey, such as life events, unexpected financial costs, realizing the larger-than-anticipated investment size, facing financing challenges, negative encounters with the building sector, declining trust in the renovation scheme due to misinformation or process inefficiencies, and the complexities of decision-making with co-homeowners or in multi-apartment settings (Benigna et al., 2021). The study of Maciosek et al., 2022 indicate homeowners waning interest in energy investments, but the positive impact of subsidies, especially among single homeowners familiar with such incentives, counters the cost concerns, highlighting an affinity for the one-stop-shop concept. Various factors, including time, effort, renovation complexities, inconveniences, and uncertainties, contribute to the reluctance of individuals to undertake energy renovations in their homes (Ebrahimigharehbaghi et al., 2020). Energy retrofit policies should closely consider the genuine reasons people decide to renovate their homes, understand how trust is cultivated, recognize the unique experiences of various social groups, and be mindful of how these elements evolve over time (Bolton et al., 2023). Historically, energy-saving programs often led to inefficient measures and negatively affected architecture and heritage, but their efficiency improved over time, varying across cities based on policy implementation and learnings from involved actors (Legner and Femenias, 2020). In their study, Gróf et al., 2022 emphasize that in the Hungarian system of energy renovation, a significant issue is the limitation of citizen credit programs, which leads to a smaller volume of energy renovation program implementation. The main issue is that citizens of Kosovo are not adequately informed about the benefits of sustainable buildings due to insufficient promotion (Hoxha and Shala, 2019). Comparing the depth of renovation, it was not determined that the depth of energy renovation of buildings increased if the renovation was subsidized compared to those that were not (Hondeborg et al., 2023). Research in Estonia (Lihtmaa et al., 2018) shows that the distribution of subsidies for energy renovation is related to regional socio-economic indicators, and that subsidies should be distributed more evenly to mitigate growing regional disparities. The study of Alabid et al., 2022 highlights the importance of tailoring retrofitting approaches to individual cases within the UK's complex context, emphasizing social sustainability and the use of products with low embodied carbon and energy, proving beneficial for homeowners, decision-makers, and those interested in building retrofits.

When creating energy renovation policies, tenants of houses and buildings often do not want to participate due to fear of ignorance and personal underestimation of their contribution (Broers et al., 2022). Palm et al., 2020 found that there are different categories of tenants, i.e., different perceptions related to energy renovation, identifying satisfied, demanding, dissatisfied, playful, skeptical, and tenants who resist energy renovation. What truly demotivates investment in energy renovation is that the actual energy savings are significantly less than those predicted by calculations before the implementation of energy renovation of buildings (Filippidou et al., 2019). The study found that a homeowner's life stage, personal/family events, daily practices, lifestyle, and social network significantly influence their initial intention to renovate, with desires to maintain or change routines and indoor space usage being common factors, while motivations related to aesthetics, trends, and social status were identified as particularly impactful (Abreu et al., 2019). Research by Azizi et al., 2020 shows that in the case of conducting a major renovation, Swedish respondents are interested in at least one of the offered energy renovation measures.

Simulation analyses by Bataineh and Alranee, 2018 show that various energy measures in Jordan would contribute to reducing the total annual energy consumption and increasing the number of jobs, with significant cooling load reduction achieved because of using lighting control. Recommendations by Broers et al., 2022 indicate that it is necessary to create a fairer energy renovation system with an emphasis on the most vulnerable population groups. The study conducted by Abreu et al., 2020 shows that younger respondents show greater eagerness for undertaking energy-related home renovations, including less visible updates like insulation, without many constraints, but this willingness diminishes with age; those up to 50 are more environmentally conscious and interested in energy efficiency, while individuals between 50 and 65 are open to renovations under certain conditions related to comfort, safety, and physical ability to manage renovations, but beyond 60, the motivation to renovate decreases, with a notable percentage considering buying a new home instead, and pensioners are generally unmotivated due to limited perceived benefits and disruption concerns. Additionally, the research by Bravo et al., 2019 shows that that income, education level, and place of residence influence renovation decisions solely by affecting homeowners' energy concerns, with their combined effect with residence duration also impacting renovation choices. The study by Nguyen et al., 2019; Amoah and Smith, 2024 concludes that while the design and construction of buildings, particularly their envelopes, significantly impact occupant comfort, energy consumption in homes is not statistically linked to these factors, but rather strongly influenced by financial status and occupant behavior, with refurbishments enhancing housing performance notably when aimed at improving the indoor environment. It is evident that existing energy renovation policies will need to undergo significant improvements in their design to accommodate the population of potential users as a heterogeneous rather than a homogeneous group (Kerr et al., 2018). Blomqvist et al., 2022 highlight that the most significant barriers to adopting energy efficiency are lack of time, other priorities, and the structure of slim organizations, especially in smaller ones, while the reduction of costs and availability of more capital in the private sector serve as major drivers, with the study acknowledging the influence of regulatory measures and linking organizational development to the prioritization of energy efficiency, noting future challenges in hidden costs and knowledge acquisition. The main reasons homeowners decide against pursuing energy renovation subsidies for their homes are when they perceive the distribution of subsidies as unfair, when they have already undertaken renovations at their own expense, or when they feel they will not

receive the subsidy (Ma et al., 2022). In their research, Liao et al., 2023 highlight how some regions in Belgium face challenges in financing energy renovations of family homes, emphasizing the role of national policies in creating an investment environment conducive to the realization of energy renovations. In their research, Cattaneo, 2019 emphasizes the importance of targeted environmental care interventions towards the population that is most financially and status sensitive. Wekhof and Houde, 2023 emphasize that energy renovation subsidies are very popular but misdirected, and that there should be an increase in the availability of information and a reduction in bureaucratic barriers to project implementation. The research results in Brazil (Cristino et al., 2021) show that the two most important categories in energy renovation programs relate to regulatory (governmental) barriers and financial constraints in project implementation. Seddiki et al., 2020 highlighted the following groups of constraints in implementing energy renovations in Algerian households: The absence of subsidies and rebates for energy-efficient equipment, the high initial costs of energy-efficient equipment, a shortage of techniques and tools for estimating energy savings, a reluctance to take on loans, and challenges in identifying, procuring, installing, operating, and maintaining energy efficiency measures. Thailand's energy policy lacks clear objectives for green economy development, missing a definitive vision that could foster active participation and alignment among the public sector, private sector, and civil society, in stark contrast to countries like Germany and South Korea that have pursued such goals diligently (Sutthichaimethee, 2024). Transitioning countries looking to boost domestic solar power generation should consider India's approach, which offers financial support for solar rooftop installations to help individuals overcome the primary financial hurdles to adopting such systems in developing nations (Aggarwal et al., 2023). Garcia's 2023 findings indicate that in the municipality of São José dos Campos, Brazil, photovoltaic panel adoption is most advantageous among individuals aged 51-60, who possess a higher education level and earn higher salaries.

3. MATERIALS AND METHODS

At the beginning of the research, variables and hypotheses were defined, which provided clear direction and focus, ensuring consistent, valid, and objective data collection and analysis. They set clear expectations, guide the methodology, and facilitate the communication of research intent to others.

Table 1 displays the set hypotheses based on the defined variables. Three main limiting areas in the application system for energy renovation projects of family homes were detected: Limitations in the availability of information; System complexity limitations; Legal limitations. Based on these variables, four hypotheses were established and tested: H1: Each limiting factor differently influences the decision of the family homeowner to apply for non-refundable funds for energy renovation; H2: The perception of legal limitations in applying for non-refundable funds for energy renovation varies depending on the age of the family homeowner; H3: The perception of limitations in the availability of information about non-refundable funds for energy renovation varies based on the employment status of the family homeowner; H4: The perception of the complexity of the system for non-refundable funds for energy renovation is consistent regardless of the total monthly income of the family homeowner.

Table 1: Variables and hypothesis

Variables		
Limitations in the availability of information	**System complexity limitations**	**Legal limitation**
Hypothesis		
H1: Each limiting factor differently influences the decision of the family homeowner to apply for a for non-refundable funds for energy renovation.		
H2: The perception of legal limitations in applying for non-refundable funds for energy renovation varies depending on the age of the family homeowner.		
H3: The perception of limitations in the availability of information about non-refundable funds for energy renovation varies based on the employment status of the family homeowner.		
H4: The perception of the complexity of the system for non-refundable funds for energy renovation is consistent regardless of the total monthly income of the family homeowner.		

Source: Authors elaboration

Table 2: Sociodemographic indicators

	n	%
Gender		
Male	180	58.4
Female	128	41.6
Total	308	100.0
Age		
18-25	37	12.0
26-35	45	14.6
36-45	109	35.4
46-55	79	25.6
56+	38	12.3
Total	308	100.0
Employment status		
Employed	210	68.2
Unemployed	98	31.8
Total	308	100.0
Total number of household members		
1	30	9.7
2	59	19.2
3	61	19.8
4	73	23.7
5 or more members	85	27.6
Total	308	100.0
Total monthly income of all household members		
Up to 499 euros	12	3.9
From 499 – 999 euros	53	17.2
From 1000 – 1399 euros	123	39.9
Above 1399 euros	120	39.0
Total	308	100.0

The methods used in the research included an analysis of available scientific literature in the field of energy renovation, energy savings, efficient use of energy sources, and the like. Additionally, primary research was conducted as a scientific contribution by the author. A survey questionnaire was created, which included 308 respondents. The respondents were family homeowners, and the aim was to determine their socio-demographic structure and based on that, to investigate the impacts of administrative limitations on their perceptions and attitudes related to the Energy Renovation Program for Family Houses in Croatia. The survey

Table 3: Mean and standard deviation

	n	%	$\bar{X}$	SD
I am informed about the existence of non-refundable funds for the energy renovation of family homes (R).				
Strongly Disagree	200	64.9		
Disagree	84	27.3		
Neither Agree nor Disagree	14	4.5		
Agree	6	1.9		
Strongly Agree	4	1.3		
Total	308	100.0	1.47	0.78
Due to insufficient information about non-refundable grants, citizens are not interested in the energy renovation of family homes.				
Strongly Disagree	187	60.7		
Disagree	85	27.6		
Neither Agree nor Disagree	22	7.1		
Agree	4	1.3		
Strongly Agree	10	3.2		
Total	308	100.0	1.59	0.92
The system for applying for projects in the competition for non-refundable funds for the energy renovation of family homes is complicated and unreliable.				
Strongly Disagree	31	10.1		
Disagree	9	2.9		
Neither Agree nor Disagree	13	4.2		
Agree	71	23.1		
Strongly Agree	184	59.7		
Total	308	100.0	4.19	1.28
The documentation required to apply for projects in the competition for non-refundable funds for the energy renovation of family homes is complex and redundant.				
Strongly Disagree	27	8.8		
Disagree	13	4.2		
Neither agree nor disagree	25	8.1		
Agree	68	22.1		
Strongly agree	175	56.8		
Total	308	100.0	4.14	1.26
The duration of the project approval process from the competition for non-refundable funds for the energy renovation of family homes is long.				
Strongly Disagree	20	6.5		
Disagree	9	2.9		
Neither agree nor disagree	19	6.2		
Agree	73	23.7		
Strongly agree	187	60.7		
Total	308	100.0	4.29	1.14
The method of allocating non-refundable funds from the competition for non-refundable funds for the energy renovation of family homes is transparent (R).				
Strongly Disagree	11	3.6		
Disagree	9	2.9		
Neither agree nor disagree	27	8.8		
Agree	90	29.2		
Strongly agree	171	55.5		
Total	308	100.0	4.30	1.00
The complexity of the approval procedures for non-refundable funds from the competition for non-refundable funds for the energy renovation of family homes demotivates citizens from applying to the competition.				
Strongly Disagree	26	8.4		
Disagree	15	4.9		
Neither agree nor disagree	23	7.5		
Agree	76	24.7		
Strongly agree	168	54.5		
Total	308	100.0	4.12	1.25
Unresolved property-legal relations of the house prevent citizens from applying for the allocation of non-refundable funds from the competition for non-refundable funds for the energy renovation of family homes.				
Strongly Disagree	44	14.3		
Disagree	39	12.7		
Neither agree nor disagree	65	21.1		
Agree	72	23.4		

(Contd...)

Table 3: Contd...

	n	%	$\bar{X}$	SD
Strongly agree	88	28.6		
Total	308	100.0	3.39	1.39
Illegally built/expanded family homes prevent citizens from applying for the allocation of non-refundable funds from the competition for non-refundable funds for the energy renovation of family homes.				
Strongly Disagree	40	13.0		
Disagree	29	9.4		
Neither agree nor disagree	45	14.6		
Agree	56	18.2		
Strongly agree	138	44.8		
Total	308	100.0	3.72	1.44

was conducted in 2023 on the social network Facebook using the Google Forms application. The obtained results were statistically and mathematically processed, and conclusions were drawn based on the following methods used: calculation of the arithmetic mean; questionnaire reliability calculation method (Cronbach's Alpha); testing for normality of distribution (Kolmogorov-Smirnov and Shapiro-Wilk test); using Spearman's correlation coefficient; testing differences in observed questions concerning observed variables using the Chi-squared test; testing differences in observed indicators using the Mann-Whitney U test and Kruskal-Wallis test.

4. RESULTS

In the vast arena of energy efficiency and renovation, understanding the administrative complexities, perceptions, and responses of homeowners stands as a paramount concern, particularly when the goal is to foster a sustainable, energy-efficient future. The results gleaned from the exhaustive study, systematically presenting the outcomes of the survey conducted among family homeowners in Croatia. By unraveling the impacts of administrative limitations on these homeowners, we aim to highlight not only the current situation but also areas that potentially require urgent reform. Utilizing a range of statistical methods, the following section offers insights into the hypothesis set forth, seeking to either validate or challenge preconceived notions related to the Energy Renovation Program for Family Houses in Croatia. As we navigate through this section, readers will be endowed with an empirical understanding of how the myriad of administrative barriers influence perceptions, intentions, and actions of family homeowners in the realm of energy renovation.

From the gender data of the respondents (Table 2), it can be observed that 58.4% are male, while 41.6% are female. Regarding age, 12.0% are between 18 and 25, 14.6% are between 26 and 35, 35.4% are between 36 and 45, 25.6% are between 46 and 55, and 12.3% are 56 or older. For employment status, 68.2% stated they are employed, while 31.8% said they are unemployed. In terms of the total number of household members, the highest proportion of respondents indicated having 4 members (23.7%) or 5 and more members (27.6%). For the total monthly income of all household members, most respondents fall into the 1000-1399 euros bracket (39.9%) and above 1399 euros (39.0%).

On the following pages, descriptive indicators for the observed questions will be displayed. For each group of questions, frequencies, and percentages, as well as the mean and standard deviation, will be shown. Questions with the highest and lowest mean respondent values will be commented upon.

Table 4: Cronbach alpha reliability of the questionnaire

Questions	Cronbach's alpha	N of items
Limitations in information availability	0.773	2
System complexity	0.928	5
Legal constraints	0.856	2

Table 5: Average indicators for observed factors

	Limitations in information availability	System complexity	Legal constraints
$\bar{X}$	1.5308	4.2097	3.5584
SD	0.77409	1.04792	1.32189
Min	1.00	1.00	1.00
Max	5.00	5.00	5.00

Table 3 suggest that the highest mean respondent values are recorded for the questions: The method of allocating non-refundable funds from the competition for non-refundable funds for the energy renovation of family homes is transparent (R) where the mean respondent value is 4.30 and the standard deviation is 1.00, and then the duration of the project approval process from the competition for non-refundable funds for the energy renovation of family homes is long, where the mean respondent value is 4.29 and the standard deviation is 1.14. The lowest mean respondent values are recorded for the questions: I am informed about the existence of non-refundable funds for the energy renovation of family homes (R) where the mean respondent value is 1.47 and the standard deviation is 0.78, and then due to insufficient information about non-refundable grants, citizens are not interested in the energy renovation of family homes where the mean respondent value is 1.59 and the standard deviation is 0.92.

Furthermore, on the following pages, the results for the reliability of the questionnaire (Cronbach's Alpha) for the observed factors in the analysis will be displayed.

Looking at the value of the Cronbach's Alpha coefficients for the observed factors in Table 4, it can be observed that its value is quite high for all observed factors (higher than 0.7), and accordingly, the grouping will be carried out according to the specified categories.

Additionally, Table 5 presents the average indicators for the observed factors.

On the following pages, the testing of normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests will be presented, to determine how the observed variables in the research are distributed. Based on this, it will be decided whether parametric or non-parametric tests will be applied. The normality testing will be carried out for all variables in the study.

From the provided significances in Table 6, one can observe how the significances of the Kolmogorov-Smirnov and Shapiro-Wilk tests are distributed. Specifically, if the significance for a particular category (factor) is >0.05 (P > 0.05), it indicates a normal distribution. However, if the significance is <0.05, the distribution deviates from normal. Since the significance level for all observed categories is not >0.05, it can be concluded that the normality of the distribution has not been established in all cases. Therefore, the analysis will be conducted using non-parametric tests.

From the mentioned Table 7, it can be observed that there is a recorded positive and negative correlation between the observed variables. A weak negative correlation was noted between the indicators: limitations in information availability and system complexity ($r = -0.148$; $P < 0.01$), while a stronger positive correlation was recorded between system complexity and legal constraints ($r = 0.659$; $P < 0.01$).

On the following pages, testing will be presented in relation to the observed variables. The testing will be conducted using the Chi-square test.

When looking at the significance level (Table 8) for questions like "I am informed about the existence of grant programs for the energy renovation of family houses (R)," "I received information about grants for the energy renovation of family houses through," "due to insufficient information about grants, citizens are not interested in the energy renovation of family houses," and "illegally built/expanded family house prevents citizens from applying for the award of grants from the competition for grant funds for the energy renovation of family houses," it can be seen that the significance value of the Chi-square test is $P < 0.05$. This means that a statistically significant difference was observed in the questions in relation to employment status.

Looking at the Table 9, significance level of all the observed questions except for the complexity of procedures for approving non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses demotivating citizens from applying to the competition, the significance value of the Chi-square test is $P < 0.05$, which means that a statistically significant difference was observed in the questions in relation to monthly income.

On the following pages, testing will be carried out for the observed variables with respect to the observed indicators, using the Mann-Whitney U test and the Kruskal-Wallis test. Ranks. Limitations in the availability of information.

Looking at the significance value for legal limitations Table 10 and 11, it can be noted that p is >5% $P < 0.05$; therefore, it can be said, with a 95% confidence level, that there is a statistically significant difference regarding the age question, where the ranks are higher (response value is higher) for younger respondents.

Looking at the significance value for limitations in the availability of information and legal limitations, it can be noted that p is <5% $P < 0.05$; thus, it can be said, with a 95% confidence level, that there is a statistically significant difference regarding the employment status question, where the ranks are higher (response value is higher) for the unemployed.

Looking at the significance value for limitations in the availability of information (Tables 14 and 15), it can be noted that p is <5% P

Table 6: Testing the normality of distribution

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Limitations in information availability	0.276	308	0.000	0.697	308	0.000
System complexity	0.225	308	0.000	0.747	308	0.000
Legal constraints	0.163	308	0.000	0.876	308	0.000

a. Lilliefors Significance Correction

Table 7: Spearman's correlation coefficient

	Limitations in information availability	System complexity	Legal constraints
Limitations in information availability			
r	1.000	−0.148**	−0.052
p		0.010	0.367
N	308	308	308
System complexity			
r	−0.148**	1.000	0.659**
p	0.010		0.000
N	308	308	308
Legal constraints			
r	−0.052	0.659**	1.000
p	0.367	0.000	
N	308	308	308

**.Correlation is significant at the 0.01 level (2-tailed).

Table 8: Chi-square test-employment status

	Employment status
I am informed about the existence of non-refundable programs for the energy renovation of family houses. (R)	
Chi-square	13.955
df	4
Sig.	0.007*
Chi-square	14.971
df	3
Sig.	0.002*
Due to a lack of information about non-refundable grants, citizens are not interested in the energy renovation of family houses.	
Chi-square	25.624
df	4
Sig.	0.000*
The system for applying for projects to competitions for non-refundable funds for the energy renovation of family houses is complicated and unreliable.	
Chi-square	7.310
df	4
Sig.	0.120
The documentation required to apply for projects to competitions for non-refundable funds for the energy renovation of family houses is complex and redundant.	
Chi-square	6,977
df	4
Sig.	0.137
The duration of the approval process for projects from competitions for non-refundable funds for the energy renovation of family houses is lengthy.	
Chi-square	4.121
df	4
Sig.	0.390
The method of allocating non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses is transparent. (R)	
Chi-square	2.278
df	4
Sig.	0.685
The complexity of procedures for approving non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses demotivates citizens from applying to the competition.	
Chi-square	7.497
df	4
Sig.	0.112
Unresolved property rights of the house prevent citizens from applying for the award of non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses.	
Chi-square	5.741
df	4
Sig.	0.219
Illegally built/expanded family houses prevent citizens from applying for the award of non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses.	
Chi-square	15.419
df	4
Sig.	0.004*
Determine the degree of your satisfaction with the support system for the energy renovation of family houses in Croatia.	
Chi-square	5.866
df	4
Sig.	0.209

*. The Chi-square statistic is significant at the 0.05 level

Table 9: Chi-square test-total number of household members

	Total number of household members
I am informed about the existence of non-refundable programs for the energy renovation of family houses. (R)	
Chi-square	81.447
df	12
Sig.	0.000*
I received information about non-refundable grants for the energy renovation of family houses through.	
Chi-square	28.595
df	9
Sig.	0.001*
Due to a lack of information about non-refundable grants, citizens are not interested in the energy renovation of family houses.	
Chi-square	49.631
df	12
Sig.	0.000*
The system for applying for projects to competitions for non-refundable funds for the energy renovation of family houses is complicated and unreliable.	
Chi-square	36.598
df	12
Sig.	0.000*
The documentation required to apply for projects to competitions for non-refundable funds for the energy renovation of family houses is complex and redundant.	
Chi-square	26.843
df	12
Sig.	0.008*
The duration of the approval process for projects from competitions for non-refundable funds for the energy renovation of family houses is lengthy.	
Chi-square	28.753
df	12
Sig.	0.004*
The method of allocating non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses is transparent. (R)	
Chi-square	30.308
df	12
Sig.	0.003*
The complexity of procedures for approving non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses demotivates citizens from applying to the competition.	
Chi-square	19.668
df	12
Sig.	0.074
Unresolved property rights of the house prevent citizens from applying for the award of non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses.	
Chi-square	37.938
df	12
Sig.	0.000*
Illegally built/expanded family houses prevent citizens from applying for the award of non-refundable funds from competitions for non-refundable funds for the energy renovation of family houses.	
Chi-square	27.359
df	12
Sig.	0.007*
Determine the degree of your satisfaction with the support system for the energy renovation of family houses in Croatia.	
Chi-square	27.273
df	12
Sig.	0.007*

*. The Chi-square statistic is significant at the ,05 level.

Table 10: Ranks-age

Age	n	Arithmetic means of ranks
Limitations in the availability of information		
18-25	37	156,68
26-35	45	151,58
36-45	109	154,21
46-55	79	141,24
56+	38	184,25
Total	308	
Complexity of the system		
18-25	37	163,84
26-35	45	178,84
36-45	109	145,11
46-55	79	148,13
56+	38	156,76
Total	308	
Legal limitations		
18-25	37	181,76
26-35	45	197,79
36-45	109	139,42
46-55	79	140,72
56+	38	148,61
Total	308	

Table 11: Test statistics[a, b]

	Limitations in the availability of information	Complexity of the system	Legal limitations
Kruskal-Wallis H	7.009	5.649	19.878
df	4	4	4
Asymp. Sig.	0.135	0.227	0.001

a. Kruskal Wallis test, b. Grouping variable: Age

Table 12: Ranks-employment status

Employment status	n	Arithmetic means of ranks	Sum of ranks
Limitations in the availability of information			
Employed	210	142,78	29984,00
Unemployed	98	179,61	17602,00
Total	308		
Complexity of the system			
Employed	210	149,18	31327,50
Unemployed	98	165,90	16258,50
Total	308		
Legal limitations			
Employed	210	146,16	30693,50
Unemployed	98	172,37	16892,50
Total	308		

Table 13: Test statistics[a]

	Limitations in the availability of information	Complexity of the system	Legal limitations
Mann-Whitney U	7829,000	9172,500	8538,500
Wilcoxon W	29984,000	31327,500	30693,500
Z	−3635	−1569	−2443
Asymp. Sig. (2-tailed)	0.000	0.117	0.015

a. Grouping variable: Employment status

Table 14: Ranks-total number of household members

Total number of household members	n	Arithmetic means of ranks
Limitations in the availability of information		
1	30	171,08
2	59	176,50
3	61	162,91
4	73	142,86
5 and more members	85	137,34
Total	308	
Complexity of the system		
1	30	135,90
2	59	140,28
3	61	163,87
4	73	162,10
5 and more members	85	157,68
Total	308	
Legal limitations		
1	30	146,38
2	59	133,18
3	61	166,89
4	73	164,89
5 and more members	85	154,35
Total	308	

Table 15: Test statistics[a,b]

	Limitations in the availability of information	Complexity of the system	Legal limitations
Kruskal-Wallis H	11,082	4311	5984
df	4	4	4
Asymp. Sig.	0.026	0.366	0.200

a. Kruskal Wallis test, b. Grouping variable: Total number of household members

Table 16: Ranks-total monthly income of all household members

Total monthly income of all household members	n	Arithmetic means of ranks
Limitations in the availability of information		
Up to 499 euros	12	204,92
From 499-999 euros	53	198,57
From 1000-1399 euros	123	160,26
Above 1399 euros	120	124,10
Total	308	
Complexity of the system		
Up to 499 euros	12	163,17
From 499-999 euros	53	148,78
From 1000-1399 euros	123	161,50
Above 1399 euros	120	148,98
Total	308	
Legal limitations		
Up to 499 euros	12	188,21
From 499-999 euros	53	153,93
From 1000-1399 euros	123	156,96
Above 1399 euros	120	148,86
Total	308	

< 0.05; thus, it can be said, with a 95% confidence level, that there is a statistically significant difference regarding the total number of household members, where the ranks are higher (response value is higher) for households with fewer members.

Table 17: Test statistics[a,b]

	Limitations in the availability of information	Complexity of the system	Legal limitations
Kruskal-Wallis H	36,204	1621	2368
df	3	3	3
Asymp. Sig.	0.000	0.655	0.500

a. Kruskal Wallis Test, b. Grouping Variable: Total monthly income of all household members

Table 18: Logistic regression for the dependent variable gender (M=1)

	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for EXP (B)	
							Lower	Upper
Step 1[a]								
Limitations in the availability of information	−0.194	0.149	1.688	1	0.194	0.824	0.615	1.104
Complexity of the system	0.123	0.161	0.583	1	0.445	1.130	0.825	1.549
Legal limitations	−0.002	0.128	0.000	1	0.990	0.998	0.777	1.283
Constant	0.130	0.536	0.059	1	0.808	1.139		

a. Variable (s) entered on step 1: Limitations in the availability of information, Complexity of the system, Legal limitations

Looking at the significance value for limitations in the availability of information (Tables 16 and 17), it can be noted that p is <5% $P < 0.05$; therefore, it can be said, with a 95% confidence level, that there is a statistically significant difference regarding monthly income, where the ranks are higher (response value is higher) for households with lower incomes.

From Table 18, it can be observed that the significance of the coefficients is >0.05, which means that the logistic regression model is not statistically significant ($P > 0.05$).

From the data provided above, it is evident that the hypotheses have been proven and confirmed. Namely, each of the limiting factors differently affects the decision of a family house owner to apply for an energy renovation project (H1). Furthermore, the perception of legal restrictions in applying for grants for energy renovation projects differs depending on the age of the family house owner (H2), while the perception of limitations in the availability of information about grants for energy renovation differs depending on the employment status of the family house owner (H3). We can also confirm that the perception of limitations in the complexity of the system for awarding grants for energy renovation is the same regardless of the total monthly income of the family house owner (H4).

5. CONCLUSION

Energy renovation of family homes and buildings is an extremely sensitive issue. It is certainly necessary to consider the risk of poverty for individual countries, regions, cities, villages, and individuals. Financial expenditures for implementing a more energy-efficient system are often beyond the means of households, so the policy of energy renovation is implemented extremely slowly. National authorities have the task of preparing quality programs for energy renovation that will finance (co-finance) investments in the mentioned sector and thus help the most vulnerable citizens. There are also various programs that subsidize investors at the EU level and other potential sources of funding.

This research has proven a causal relationship between the limitations of the support system and citizens' satisfaction with the existing system of support for the energy renovation of family homes in the Republic of Croatia, i.e., the decision to give up (demotivation) of citizens to apply for the competition for said supports. Here, 3 variables that affect the application/satisfaction of citizens were detected: Limitations in the availability of information on the possibilities of applying for projects for financing the energy renovation of family homes; The complexity of the system for applying for projects for financing the energy renovation of family homes; Legal restrictions in applying for projects for financing the energy renovation of family homes. The research highlights the need for policymakers to simplify the application process for energy renovation projects. By addressing the identified barriers-complexity of the system, legal restrictions, and information availability-policies can be tailored to make the process more accessible to homeowners. Understanding that the perception of barriers varies by age, employment status, and income enables the development of targeted support programs. These programs can be designed to address the specific needs and concerns of different demographic groups, ensuring wider participation and satisfaction. The study underscores the importance of improving the availability and dissemination of information regarding energy renovation projects. Efforts to increase public awareness through educational campaigns and easily accessible information resources could motivate more homeowners to participate. Encouraging energy renovation contributes to reducing energy consumption and greenhouse gas emissions, aligning with environmental sustainability goals. Additionally, it supports economic growth by stimulating demand for renovation services and creating jobs. By identifying and subsequently reducing the barriers to applying for energy renovation projects, the research supports efforts to make energy efficiency improvements more accessible to all citizens, regardless of their economic status. This could help alleviate energy poverty and improve living conditions.

The implications and benefits of this research are multifaceted and significant for stakeholders involved in the energy renovation sector, policymakers, and the citizens of Croatia. The findings of this study offer a comprehensive understanding of the administrative barriers that hinder the effective implementation of energy renovation programs for family houses in Croatia and present a foundation for improving current practices and policies.

REFERENCES

Abreu, I.M., De Oliveira, F.A.R., Lopes, J. (2019), Energy-related housing renovations from an everyday life perspective: Learning from Portuguese homeowners. WIT Transactions on Ecology and the Environment, 237, 63-74.

Abreu, I. A., De Oliveira, F. A. R., Lopes, J. (2020), Younger vs. older homeowners in building energy-related renovations: Learning from the Portuguese case. Energy Reports, 6(1), 159-164.

Aggarwal, S., Meenual, T., Usapein, P. (2023), An international comparison of regulatory and licensing for solar rooftop household electricity: A case study of Thailand, India, and Indonesia. International Journal of Energy Economics and Policy, 13(5), 171-178.

Alabid, J., Bennadji, A., Seddiki, M. (2022), A review on the energy retrofit policies and improvements of the UK existing buildings, challenges and benefits. Renewable and Sustainable Energy Reviews, 159, 112161.

Alsabbagh, M. (2019), Public perception toward residential solar panels in Bahrain. Energy Reports, 5, 253-261.

Amoah, C., Smith, J. (2024), Barriers to the green retrofitting of existing residential buildings. Journal of Facilities Management, 22(2), 194-209.

Attia, S., Kosiński, P., Wójcik, R., Węglarz, A., Koc, D., Laurent, O. (2022), Energy efficiency in the polish residential building stock: A literature review. Journal of Building Engineering, 45, 103461.

Azizi, S., Nair, G., Olofsson, T. (2019), Analysing the house-owners' perceptions on benefits and barriers of energy renovation in Swedish single-family houses. Energy and Buildings, 198, 187-196.

Bataineh, K., Alrabee, A. (2018), Improving the energy efficiency of the residential buildings in Jordan. Buildings, 8, 85.

Benigna, B.K., Bertoldi, P., Valle, D.N., Economidou, M. (2021), One-stop Shops for Residential Building Energy Renovation in the EU: Analysis & Policy Recommendations. European Commission. Available from: https://op.europa.eu/en/publication-detail/-/publication/423a4cad-df95-11eb-895a-01aa75ed71a1/language-en [Last accessed on 2023 Dec 12].

Bennadji, A., Seddiki, M., Alabid, J., Laing, R., Gray, D. (2022), Predicting energy savings of the UK housing stock under a step-by-step energy retrofit scenario towards net-zero. Energies, 15, 3082.

Bertoldi, P. (2022), Policies for energy conservation and sufficiency: Review of existing policies and recommendations for new and effective policies in OECD countries. Energy and Buildings, 264, 112075.

Bertoldi, P., Economidou, M., Palermo, V., Boza-Kiss., Todeschi, V. (2020), How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU. Wires Energy and Environment, 10(1), e384.

Biere-Arenas, R., Spairani-Berrio, S., Spairani-Berrio, Y., Marmolejo-Duarte, C. (2021), One-stop-shops for energy renovation of dwellings in Europe - approach to the factors that determine success and future lines of action. Sustainability, 13, 12729.

Blomqvist, S., Glad, W., Rohdin, P. (2022), Ten years of energy efficiency-exploring the progress of barriers and drivers in the Swedish residential and services sector. Energy Reports, 8, 14726-14740.

Bobrova, Y., Papachristos, G., Cooper, A. (2022), Process perspective on homeowner energy retrofits: A qualitative metasynthesis. Energy Policy, 160, 112669.

Bolton, E., Bookbinder, R., Middlemiss, L., Hall, S., Davis, M., Owen, A. (2023), The relational dimensions of renovation: Implications for retrofit policy. Energy Research and Social Science, 96, 102916.

Bravo, G., Pardalis, G., Mahapatra, K., Mainali, B. (2019), Physical vs. Aesthetic renovations: Learning from Swedish house owners. Buildings, 9, 12.

Broers, W., Kemp, R., Vasseur, V., Abujidi, N., Vroon, Z. (2022), Justice in social housing: Towards a people-centred energy renovation process. Energy Research and Social Science, 88, 102527.

Cattaneo, C. (2019), Internal and external barriers to energy efficiency: Which role for policy interventions? Energy Efficiency, 12, 1293-1311.

Cristino, M.T., Neto, F.A., Wurtz, F., Delinchant, B. (2021), Barriers to the adoption of energy-efficient technologies in the building sector: A survey of Brazil. Energy and Buildings, 252, 11452.

Curtis, J., Grilli, G. (2022), Does Moving Home Affect Residential Heating Decisions? Exploring Heating Fuel Switching in Ireland. Working Paper, 684.

Du, H., Han, Q., de Vries, B. (2022), Modelling energy-efficient renovation adoption and diffusion process for households: A review and a way forward. Sustainable Cities and Society, 77, 103560.

Ebrahimigharehbaghi, S., Qian, K.Q., Meijer, M.F., Visscher, J.H. (2019), Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making? Energy Policy, 129, 546-561.

Ebrahimigharehbaghi, S., Qian, K.Q., Meijer, M.F., Visscher, J.H. (2020), Transaction costs as a barrier in the renovation decision-making process: A study of homeowners in the Netherlands. Energy and Buildings, 215, 109849.

El Hafdaoui, H., Khallaayoun, A., Ouazzani, K. (2023), Activity and efficiency of the building sector in Morocco: A review of status and measures in Ifrane. AIMS Energy, 11(3), 454-485.

Environmental Protection and Energy Efficiency Fund. (2024), Energy Renovation of Family Houses. Available from: https://www.fzoeu.hr/en/energy-renovation-of-family-houses/7679 [Last accessed on 2024 Jan 21].

European Commission. (2019), Comprehensive Study of Building Energy Renovation Activities and the Uptake of Nearly Zero-Energy Buildings in the EU. Available from: https://op.europa.eu/en/publication-detail/-/publication/97d6a4ca-5847-11ea-8b81-01aa75ed71a1/language-en [Last accessed on 2024 Feb 13].

Fernandez-Luzuriaga, J., Flores-Abascal, I., del Portillo-Valdes, L., Mariel, P., Hoyos, D. (2022), Accounting for homeowners' decisions to insulate: A discrete choice model approach in Spain. Energy and Buildings, 273, 112417.

Filippidou, F., Nieboer, N., Visscher, H. (2019), Effectiveness of energy renovations: A reassessment based on actual consumption savings. Energy Efficiency, 12, 19-35.

Garcia, L.B., Alves Fiore, F., Carvalho, F.L.C. (2023), Factors associated with the use of solar energy in Urban households - case study: Municipality of São José Dos Campos. International Journal of Energy Economics and Policy, 13(4), 522-530.

Gatt, D., Curuana, C., Yousif, C. (2020), Building energy renovation and smart integration of renewables in a social housing block toward nearly-zero energy status. Sustainable Energy Systems, 8, 560892.

Gróf, G., Janky, B., Bethlendi, A. (2022), Limits of household's energy efficiency improvements and its consequence - a case study for Hungary. Energy Policy, 168, 113078.

Hondeborg, D., Probst, B., Petkov, I., Knoeri, C. (2023), The effectiveness of building retrofits under a subsidy scheme: Empirical evidence from Switzerland. Energy Policy, 180, 113680.

Houde, S., Wekhof, T. (2021), The Narrative of the Energy Efficiency Gap. Center of Economic Research at ETH Zurich, Working Paper, 21/359.

Hoxha, V., Shala, F. (2019), The benefits and challenges of sustainable buildings in Prishtina, Kosovo. Facilities, 37(13/14), 1118-1152.

Huang, B., Mauerhofer, V., Geng, Y. (2016), Analysis of existing building energy saving policies in Japan and China. Journal of Cleaner Production, 112, 1510-1518.

Jalilzadehazhari, E., Vadiee, A., Johansson, J. (2021), Subsidies required

for installing renewable energy supply systems considering variations in future climate conditions. Journal of Building Engineering, 35, 101999.
Kerr, N., Gouldson, A., Barrett, J. (2018), Holistic narratives of the renovation experience: Using Q-methodology to improve understanding of domestic energy retrofits in the United Kingdom. Energy Research and Social Science, 42, 909-98.
Klöckner, A.C., Nayum, A. (2017), Psychological and structural facilitators and barriers to energy upgrades of the privately owned building stock. Energy, 140, 1005-1017.
Lakatos, E., Arsenopoulos, A. (2019), Investigating EU financial instruments to tackle energy poverty in households: A SWOT analysis. Energy Sources, 14(6), 235-253.
Legner, M., Femenias, P. (2020), The Implementation of Energy Saving Policies and their Influence on Energy Use and Cultural Values in the Housing Stock of Sweden. In: IOP Conference Series: Earth and Environmental Science, 588.
Levesque, A., Pietzcker, C.R., Baumstark, L., De Stercke, S., Grübler, A., Luderer, G. (2018), How much energy will buildings consume in 2100? A global perspective within a scenario framework. Energy, 148, 514-527.
Liao, H., Ren, R., Li, L. (2023), Existing building renovation: A review of barriers to economic and environmental benefits. International Journal of Environmental Research and Public Health, 20, 4058.
Lihtmaa, L., Hess, D.B., Leetmaa, K. (2018), Intersection of the global climate agenda with regional development: Unequal distribution of energy efficiency-based renovation subsidies for apartment buildings. Energy Policy, 119, 327-338.
Ma, J., Qian, Q.K., Visscher, H., Song, K. (2022), Barriers for homeowners in decisions to undertake government-led energy efficiency renovation projects in Northern China. Sustainability, 14, 7298.
Maciosek, B., Farsi, M., Weber, S., Jakob, M. (2022), Impact of Complexity and Experience on Energy Investment Decisions for Residential Buildings. IRENE Working Papers - IRENE Institute of Economic Research, 22-07.
Maia, I., Kranzl, L., Müller, A. (2021), New step-by-step retrofitting model for delivering optimum timing. Applied Energy, 290, 116714.
Michelsen, C.C., Madlener, R. (2016), Switching from fossil fuel to renewables in residential heating systems: An empirical study of homeowners' decisions in Germany. Energy Policy, 89, 95-105.
Ministry of Environment and Energy. (2019), Integrated National Energy and Climate Plan for the Republic of Croatia. Available from: https://mingor.gov.hr/userdocsimages/uprava%20za%20energetiku/strategije,%20planovi%20i%20programi/hr%20necp/integrated%20nacional%20energy%20and%20climate%20plan%20for%20the%20republic%20of_croatia.pdf [Last accessed on 2024 Jan 13].
Murto, P., Jalas, M., Juntunen, J., Hyysalo, S. (2019), Devices and strategies: An analysis of managing complexity in energy retrofit projects. Renewable and Sustainable Energy Reviews, 114, 109234.
Myhren, A.J., Heier, J., Hugosson, M., Zhang, X. (2018), The perception of Swedish housing owner's on the strategies to increase the rate of energy efficient refurbishment of multi-family buildings. Intelligent Buildings International, 12(3), 153-168.
Nguyen, P.A., Bokel, R., Dobbelsteen, A.V.D. (2019), Improving energy efficiency in Vietnamese tube houses: A survey of sustainable challenges and potentials. Smart and Sustainable Built Environment, 8(5), 366-390.
Palm, J., Reindl, K., Ambrose, A. (2020), Understanding tenants' responses to energy efficiency renovations in public housing in Sweden: From the resigned to the demanding. Energy Reports, 6, 2619-2626.
Papineau, M., Rivers, N., Yassin, K. (2022), Estimates of Long-Run Energy Savings and Realization Rates from a Large Energy Efficiency Retrofit Program. Carleton Economics Working Papers, 22-09.
Pardalis, G., Mahapatra, K., Mainali, B. (2022), Comparing public- and private-driven one-stop-shops for energy renovations of residential buildings in Europe. Journal of Cleaner Production, 365, 132683.
Pérez-Navarro, J., Bueso, M.C., Vázquez, G. (2023), Drivers of and barriers to energy renovation in residential buildings in Spain-the challenge of next generation EU funds for existing buildings. Buildings, 13, 1817.
Remeikienė, R., Gasparėnienė, L., Fedajev, A., Szarucki, M., Đekić, M., Razumienė, J. (2021), Evaluation of sustainable energy development progress in EU member states in the context of building renovation. Energies, 14, 4209.
Ringel, M., Laidi, R., Djenouri, D. (2019), Multiple benefits through smart home energy management solutions-a simulation-based case study of a single-family-house in Algeria and Germany. Energies, 12, 1537.
Sankelo, P., Ahmed, K., Mikola, A., Kurnitski, J. (2022), Renovation results of finnish single-family renovation subsidies: Oil boiler replacement with heat pumps. Energies, 15, 7620.
Saygin, D., Ercumen, Y., De Groote, M., Bean, F. (2019), Enhancing Turkey's Policy Framework for Energy Efficiency of Buildings, and Recommendations for the Way Forward Based on International Experiences. SHURA Energy Transition Center. Available from: https://www.shura.org.tr/wp-content/uploads/2019/06/buildings-energy-efficiency-policy-working-paper.pdf [Last accessed on 2024 Jan 08].
Schaffner, D., Ohnmacht, T., Weibel, C., Mahrer, M. (2017), Moving into energy-efficient homes: A dynamic approach to understanding residents' decision-making. Building and Environment, 123, 211-222.
Seddiki, M., Bennadji, A., Laing, R., Gray, D., Alabid, J.M. (2021), Review of existing energy retrofit decision tools for homeowners. Sustainability, 13, 10189.
Seddiki, M., Bennadji, A., Tehami, M. (2020), Barriers to the adoption of energy efficiency measures in Mostaganem, Algeria. Journal of Construction in Developing Countries, 25(2), 39-61.
Siddique, B.M., Bergaentzlé, C., Gunkel, A.P. (2022), Fine-tuning energy efficiency subsidies allocation for maximum savings in residential buildings. Energy, 258, 124810.
Small-Warner, K., Sinclair, C. (2022), Green Building Passports: A Review for Scotland. ClimateXChange. http://dx.doi.org/10.7488/era/2075 [Last accessed on 2024 Jan 13].
Šostar, M. (2021), Real Impact of EU Funding - Quality Versus Quantity. In: 65th International Scientific Conference on Economic and Social Development. Varazdin Development and Entrepreneurship Agency and University North. p99-105.
Šostar, M. (2021), Utilization of EU Funds: Impact on Development. In: Tenth International Scientific Conference Employment, Education and Entrepreneurship. Faculty of Business Economics and Entrepreneurship. p196-201.
Šostar, M., Čevapović, I. (2016), Difficulties and Challenges in Implementation Process of EU Projects in Croatia. In: 5th Eurasian Multidisciplinary Forum. European Scientific Institute. p321-334.
Šostar, M., Ristanović, V. (2023), An assessment of the impact of the COVID-19 pandemic on consumer behavior using the analytic hierarchy process model. Sustainability, 15, 15104.
Šostar, M., Ristanović, V. (2023), Assessment of influencing factors on consumer behavior using the AHP model. Sustainability, 15, 10341.
Sunderland, L., Gibb, D. (2022), Taking the Burn out of Heating for Low-income Households. Regulatory Assistance Project. Available from: https://www.raponline.org/wp-content/uploads/2022/11/rap-sunderland-gibb-clean-heating-for-low-income-households-2022-dec-1.pdf [Last accessed on 2024 Jan 22].
Sutthichaimethee, P. (2024), A framework on setting strategies for

enhancing the efficiency of state power use in Thailand's pursuit of a green economy. International Journal of Energy Economics and Policy, 14(1), 108-120.

Tardy, F., Lee, B. (2019), Building related energy poverty in developed countries - Past, present, and future from a Canadian perspective. Energy and Buildings, 194, 46-61.

Tjørring, L., Gausset, Q. (2018), Drivers for retrofit: A sociocultural approach to houses and inhabitants. Building Research and Information, 47(4), 394-403.

Tsemekidi, T.S., Bertoldi, P., Diluiso, F., Castellazzi, L., Economidou, M., Labanca, N., Ribeiro, S.T., Zangheri, P. (2019), Analysis of the EU residential energy consumption: Trends and determinants. Energies, 12, 1065.

Wekhof, T., Houde, S. (2023), Using narratives to infer preferences in understanding the energy efficiency gap. Nature Energy, 8, 965-977.

Zachariadis, T., Michopoulos, A., Vougiouklakis, Y., Piripitsi, K., Ellinopoulos, C., Struss, B. (2018), Determination of cost-effective energy efficiency measures in buildings with the aid of multiple indices. Energies, 11, 191.

Zhang, H., Hewage, K., Karunathilake, H., Feng, H., Sadiq, R. (2021), Research on policy strategies for implementing energy retrofits in the residential buildings. Journal of Building Engineering, 43, 103161.