# THESIS

**SHAHRIA TANZIL**

**MSc Environmental Engineering**

**Gödöllő**

**2023**

# Hungarian University of Agriculture and Life Sciences

## Szent István Campus

### MSc Environmental Engineering


**Legal, Economic and Engineering Aspects of Climate Protection And Energy Efficiency in Buildings: An Analysis of Energy Poverty in Hungarian Residential Building**


**Primary Supervisor: Dr. Tibor László Csegődi**

**Author: Shahria Tanzil A2T5YS**

**Institute of Agricultural and Food Economics**



**Gödöllő**

**2023**

## ABSTRACT

Energy poverty refers to the state in which a household does not have adequate access to essential energy services within their residence, such as heating, cooling, lighting, and the usage of appliances. Energy poverty is a widespread issue affecting not only Hungary, but also Europe and the rest of the world. This problem arises from a combination of insufficient energy efficiency and ongoing climate change. This report provides an overview of the vulnerability of residential structures in Hungary to energy poverty, including the underlying causes, strategies for mitigation, and future possibilities. The income level has a substantial influence on the extent of energy poverty experienced by households, which in turn greatly affects their health conditions. The thesis investigates the relationship between housing expenses, quality of life, and the composition of building stock in order to gain insights into the issue of energy poverty in residential structures in Hungary. Additionally, it analyzes policy and legal matters, emphasizing the difficulties associated with energy preservation. The study examines the expenses and benefits associated with various energy conservation techniques and their impact on household spending, in order to evaluate Hungary's economic outlook and challenges. The thesis also assesses the construction materials and technologies used to enhance the energy efficiency of Hungarian dwellings. Additionally, it provides case studies illustrating the role of engineering in enhancing the energy efficiency of dwellings in Hungary. The paper additionally assesses the physical and societal ramifications of energy poverty and proposes remedies to enhance the well-being of all individuals. The report provides Hungary with evidence-based policy suggestions aimed at reducing energy poverty and promoting the adoption of sustainable building practices. Ultimately, the thesis highlights the specific focus of the study on tackling energy poverty in residential buildings in Hungary. Additionally, it suggests research and policy alternatives.

**Key words:** Energy Poverty, Energy Efficiency, Climate Protection, Building Stock, Energy Cost, Energy Conservation Practices.

## TABLE OF CONTENTS

## ABBREVIATIONS AND DEFINITIONS

| | |
|---|---|
| **EE** | Energy Efficiency |
| **CDD** | Cooling Degree Days |
| **HDD** | Heating Degree days |
| **EU** | European Union |
| **HEA** | Hungarian Energy and Public Authority |
| **KSH** | Central Statistical Office |
| **NABEPS Strategy** | National Building Energy Performance Strategy |
| **EPBD** | Energy Performance of Buildings Directive |
| **NZEB** | Nearly Zero Energy Building |
| **NECP** | National Energy and Climate Plan |
| **NE** | National Energy Strategy |
| **HRV** | Heat Recovery Ventilation |
| **ERV** | Energy Recovery Ventilation |
| **NÉeR** | National Building Registry System |
| **HEA** | Hungarian Energy and Public Utility Regulatory Authority |
| **IEA** | The International Energy Agency |
| **NZE** | Near Zero Emission |
| **ESIF** | European Structural and Investment Funds |
| **ESCOs** | Energy Service Companies |
| **FI** | Financial Instruments |
| **OP** | Operational Program |
| **ERDF** | European Regional Development Fund |
| **CF** | Cohesion Fund |
| **MFB** | Hungarian Development Bank |
| **EPC** | Energy Performance Contracting |
| **NEEAP** | National Energy Efficiency Action Plans |
| **LIHC** | Low Income High Cost |
| **EEEOP** | Environment and Energy Efficiency Operational Program |
| **MNB** | Magyar Nemzeti Bank |
| **CBI** | Central Building Institute |

**ACKNOWLEDGEMENTS**

Firstly, I would want to express my appreciation to the Almighty God for granting me the fortitude, well-being, bravery, wisdom, affection, and guidance throughout this difficult journey. Furthermore, I would like to extend my heartfelt appreciation to the esteemed MATE University and the Stipendium Hungaricum Scholarship committee for granting me the remarkable opportunity to further my academic endeavors. On the verge of completion of my graduate thesis program, I would want to express my gratitude to a few individuals who have played an indispensable role in the successful completion of my thesis. Initially, I would want to convey my utmost appreciation to my supervisor, Dr. Csegődi Tibor László, who has served as an exceptional guide during the entirety of my thesis duration. He has provided me with comprehensive explanations of every crucial aspect and guided me diligently through each step with unwavering dedication. I appreciate his commitment, diligence, endurance, eagerness, assistance, encouragement, and the considerable amount of time he has devoted to my studies, even amidst his hectic schedules. This thesis would not have been feasible without the patient instruction, perceptive critique, and expert direction provided by him. Next, I would want to express my gratitude to my family and friends, who have consistently been by my side and provided me with their invaluable advice. Throughout the entire duration, they served as my primary source of inspiration and unwavering support, consistently standing by my side throughout challenging moments. Finally, I would want to express my gratitude to my department and MATE for granting me the chance to work on an exceptional thesis topic and for supporting my personal and academic development. In conclusion, I would want to express my gratitude once again to the individuals named above for their invaluable assistance and unwavering support during this entire endeavor.

**LIST OF FIGURES**

**LIST OF TABLES**

# 1 INTRODUCTION

## 1.1 Research significance

Hungarian residential building’s energy poverty harms public health, social welfare, and environmental sustainability and must be addressed promptly. Energy poverty worsens social inequality and resource allocation in disadvantaged areas. High energy prices drive low-income households to cut other essentials, lowering living standards and social isolation. Energy poverty harms public health beyond socioeconomics. Poor heating and cooling infrastructure can endanger the old and young, especially due to energy affordability issues. This could worsen respiratory and other health issues. Energy poverty increases carbon emissions and environmental harm, threatening urban ecosystems and climate change. Thus, Hungarian home energy poverty must be addressed for community welfare, sustainable growth, and a healthier, more ecologically resilient future. Energy poverty affects those without enough social safety nets to afford dwellings. The hard environment has worsened energy poverty and requires targeted and varied actions (Anna Zsófia Bajomi et al., 2020). Policy changes, affordability, and low-quality housing affect energy poverty risk. Talks on poverty and social exclusion highlight differences in possibilities and living conditions among society segments (Bouzarovski et al., 2015b). Residential energy use is highest and mitigation is cheap. This is essential for the EU's energy framework and low-carbon economy. Recent studies demonstrate significant impediments to maximizing technically and economically feasible energy reduction potential (Trotta, Spangenberg and Lorek, 2018b).

Since 2000, €5 billion from Cohesion Policy has funded energy efficiency projects in EU member states (Toth and Péter Tamás Szemes, 2013). Low energy efficiency can slow economic recovery, but sustainable building upgrades are smart and affordable. Energy-efficient renovations are necessary because decreasing prices do not always reduce energy use in the existing economic paradigm. The Hungarian Energy Efficiency Institute claims that 40% of refurbishment planners prioritize cost over energy efficiency (Nagy 2013). The Hungarian house study shows how crucial it is to immediately assess all aspects of energy poverty and how it impacts diverse groups. To aid housing policymakers, stakeholders, and communities, the study addresses significant research themes. Energy poverty will be measured in homes and apartments first.

This study analyzes whether family finances affect energy poverty. The study will examine how household income affects energy and essential service payments. This study highlights the primary societal elements that cause energy poverty and its effects on energy-poor areas. Discover how income inequality influences energy prices. The paper assesses government energy poverty programs. It will assess policy and implementation difficulties.

The research will also examine how energy-efficient practices and technologies might reduce energy poverty. Local energy savings and clean energy readiness will be evaluated. The study examines how people think and act about energy efficiency to promote energy conservation and sustainable living. Study examines energy efficiency attitudes and practices. In conclusion, this study aims to minimize energy poverty and increase Hungarian household energy efficiency. Local, non-governmental, and government collaboration will be emphasized. This project strives to investigate energy poverty and provide evidence-based solutions to improve vulnerable populations' lives and access to energy services.

Hungary uses 35–40% primary energy for electricity, hot water, and heating. EU energy reductions are expected to reach 4 Mtoe by 2020, but implementation is 20% behind. Public buildings are rebuilt using non-refundable EU funds (2014–2020, Environment and Energy Operational Program), saving less energy than home repairs. This gap demonstrates Hungary's home building sector needs energy poverty and efficiency improvements (Karácsony and Garibli, 2023)Demographic, psychological, sociopsychological, and environmental factors affect home energy use. Energy use is becoming social and environmental as climate change threatens low-energy homes while social groups adapt differently by resource (IEA, n.d.).

The socio-demographic, psychological, and structural aspects that affect energy use in Hungarian residential structures are examined in this study. To emphasize energy access discrepancies' environmental impacts, this study examines local energy usage effects on climate change and the consequences of diverse energy solutions on social and environmental well-being. This study analyzes how smart energy solutions might reduce energy poverty in residential buildings to address the ongoing challenge of economic competitiveness, social equality, and environmental sustainability. The study also examines how home dimensions, energy usage, and household income interact, focusing on socioeconomic energy affordability. Energy usage differences and household budget constraints underscore the need for targeted actions to satisfy marginalized communities' needs and promote inclusive development, according to the report.

Community engagement and empowerment are important to lasting change, and the research will promote energy-efficient behavior and technology. To promote domestic sustainability and resilience, the study examines energy-saving barriers and homeowners' willingness to invest in energy-efficient renovations.

Its overall energy poverty approach to Hungarian housing sector issues, choices, and solutions is its main contribution. A comprehensive research of energy poverty and its consequences on community welfare, public health, and environmental sustainability will guide evidence-based legislation and targeted strategies to alleviate energy poverty in Hungarian residential structures.

## 1.2 Hypothesis

Energy poverty will go down a lot if Hungarian homes are built in a way that is better for the earth and uses less energy. This will make people healthier, help the community, and protect the environment in the long run. To achieve the goal of the study, the following hypothesis have been made

1. Improved Energy Efficiency: Improving energy efficiency in Hungarian homes will significantly lower household energy costs.
2. Energy Poverty Reduction Measure: Lower energy prices will significantly reduce energy poverty, especially among low-income households.
3. Soundness of Health: Energy efficiency improves public health by providing households with enough heating and cooling, lowering severe temperature dangers.
4. Social Benefits: Energy poverty reduction increases household financial resources for other vital requirements, improving social welfare.
5. Sustainable Environment: Lowering home energy consumption reduces carbon emissions and other energy-related environmental impacts.
6. Building sustainability: Adopting sustainable building methods can help Hungary's houses survive and reduce energy poverty.

This hypothesis suggests that energy efficiency and sustainable building interventions can address Hungary's residential sector's energy poverty, public health, and environmental sustainability issues.

The goal of the thesis is to present a thorough grasp of the intricate dynamics pertaining to energy poverty in residential buildings in Hungary. It is set up to investigate engineering, economic, and legal facets pertinent to properly resolving this problem. The report begins with an introduction outlining the history of energy poverty in Hungary, highlighting the ways in which it affects vulnerable people and the pressing need for long-term solutions. The research aims are specified as well, highlighting the importance of the study in providing guidance for policy formulation and community actions. The assessment also looks at the economic effects of energy poverty, emphasizing how it affects both household budgets and the larger national economy. In order to lessen energy poverty in Hungarian residential buildings, it also examines different engineering approaches and sustainable building techniques. In addition, the thesis looks into technical ways to make houses in Hungary more energy efficient, judging how useful different building materials and technologies are. In addition, it has case studies that show how effective engineering methods were used to make Hungary's homes less energy poor. The study also does a health and social impact evaluation, which explains how energy poverty affects health and offers ways to improve health and well-being for everyone.

The study's results give Hungary ideas for the future and policy tips that are based on facts and can help reduce energy poverty and promote green building practices. In the end of the thesis, it is emphasized how important the study was in addressing energy poverty in Hungarian residential buildings. It also suggests areas for further research and policy development.

# 2 LITERATURE REVIEW

## 2.1 Energy poverty and housing challenges in Hungary

Energy poverty happens when a household does not have adequate access to basic energy services such as heating, cooling, lighting, and appliance usage (Bouzarovski and Petrova, 2015). The prevalent understanding in Europe attributes energy poverty to a combination of factors such as high energy costs, limited household incomes, inefficient buildings and appliances, as well as distinct household energy requirements and behaviors, which may be linked to chronic illnesses or specific family dynamics (Boardman, 2013).

Due to its private nature, variability over time and space, multifaceted nature, and sensitivity to cultural differences, measuring energy poverty comes with difficulties (Simcock, Walker and Day, 2016). The measurement strategy chosen will depend on whether the incidence of energy poverty is to be measured at a more granular scale to identify energy-poor families for focused policy interventions, or at a pan-European, national, or regional level for monitoring and benchmarking. Data accessibility, research capacity, and the current policy's emphasis on social groups who are deemed most in need of assistance all have an impact on this choice.

The idea of energy vulnerability is an innovative approach that can be utilized to appreciate the numerous factors that contribute to the formation of fuel and energy poverty. Energy vulnerability thinking stresses the contextual elements and interrelated pathways that lead to households' limited access to basic energy services (bloomsbury.com, 2013). This is in contrast to standard frameworks, which give viewpoints on these issues that are static and oversimplified. Because it takes into account multiple dimensions, this conceptual framework makes it possible to conduct an exhaustive investigation into the myriad of systemic impacts, which might range from large international organizations to individual families. This strategy offers a more comprehensive and nuanced grasp of the challenges associated with energy poverty (Gnansounou, 2008), despite the fact that most discussions regarding energy vulnerability revolve on the national or regional level. The rising cost of electricity and the increased financial strain it places on households combine to provide substantial issues for Hungary in the context of energy poverty. It is vital to address the affordability of energy and access for vulnerable groups in Hungary (Bouzarovski and Tirado Herrero, 2016). These issues are worsened by somewhat lower income growth compared to other study nations. This makes it essential to address energy affordability and access.

According to the figure below, in 2016, the average proportion of costs attributable to energy use in Hungary was higher than 10%. In order to gain a deeper comprehension of this topic, the Central Statistical Office of Hungary has compiled statistics regarding various income brackets. Each decile of households represents one tenth of the total number of homes in the nation, and the households have been categorized according to their income levels into ten distinct categories.
The share is calculated by dividing the whole amount of energy that was used by each person in a particular group, also known as deciles, by the total amount of money that was earned by each member in that group. It is clear that even in the eighth income decile, people spend more than 10% of their income on energy. However, it is also true that as income increases, the percentage of family spending on energy decreases. The European Commission conducted a report on energy prices and costs in 2016. According to the report, in 2014, Hungary had the second highest proportion of energy expenses compared to income in the European Union, with Slovakia being the only country ahead (European Commission; 2016).

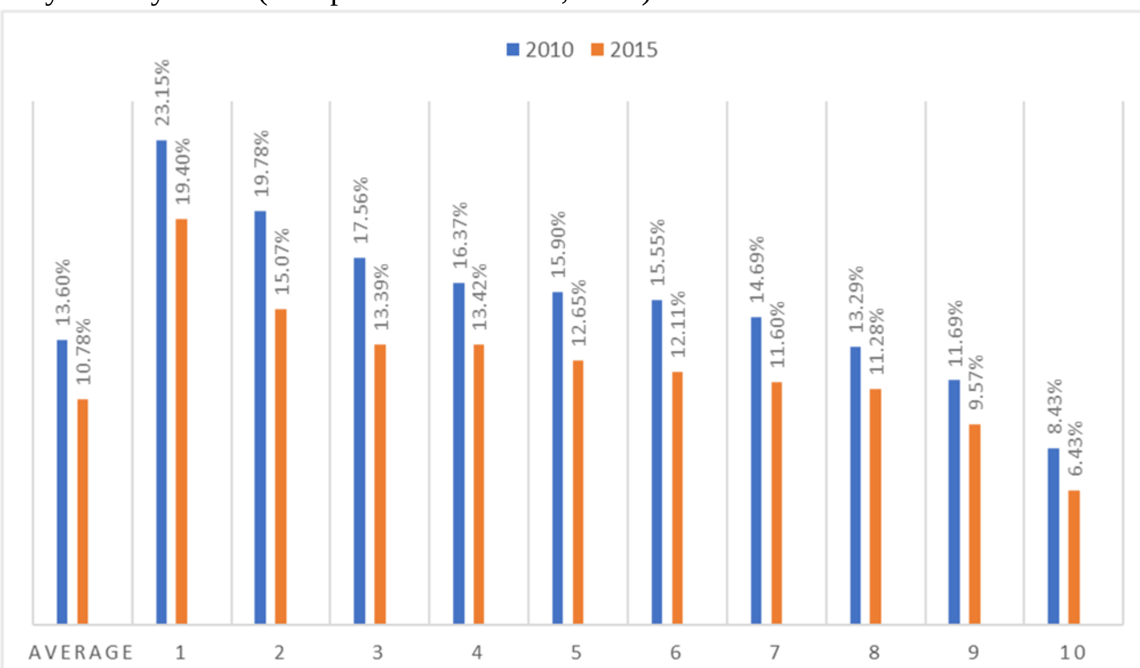


*Figure 1 The share of energy expenditure in income by deciles in 2010 and 2016. (Source: KSH)*

The current position has shown improvement as of today. Nevertheless, the Hungarian Energy and Public Utility Regulatory Authority (HEA) reported that we were unable to reproduce the Commission's computation technique. In 2019, Hungary's proximity to the European average was evident, with the country's household gas and electricity costs being among the lowest in Europe (ERRA, n.d.). We possess the statistical data from 2010 and upon comparison with the figures from

2016, it is evident that the proportion of energy expenses in families has declined across all ten percentiles. The decline in the national average share can be attributed mostly to the rise in income per capita, while the average energy expenditure has stayed constant since 2010. The decrease in utility costs in Hungary in 2013 may come as a surprising piece of data. Thus, it may be inferred that a decrease in energy costs would lead to a decrease in household expenses, given that the energy consumption of homes has remained constant (Eurostat; 2023). The data from the Hungarian Central Statistical Office indicates that the reduction in utility costs has had an impact on electricity and natural gas prices, resulting in a decline. However, the cost of solid fuel has shown a rise. Consequently, there has been a decrease in household expenditures on electricity and natural gas, but there has been a rise in spending on solid fuel. The two impacts canceled out the average energy expenditures. Although the proportion of energy expenses in income has declined, the national average remains around 10%.

When comparing energy expenses to all family expenditures instead of income per capita, the proportion of energy expenditures is considerably greater. According to the statistics from the Hungarian Central Statistical Office, although there has been a decrease in spending on energy by Hungarian families since 2010, the expenditure level remains high. This means that households are allocating more of their budget towards other products.

According to the Insight indicator list, the combination of low income and a large percentage of energy costs gives rise to affordability concerns. The indicators consist of income, energy prices, and energy consumption level. As previously stated, the income level in Hungary has risen (Hungarian Central Statistical Office). Energy costs, including those for natural gas, electricity, and district heating, have been subject to regulation since 2013. For home users, this implies that the utility fees have been limited, preventing any growth in the price per unit of energy sources. Despite Hungary now having one of the most affordable energy sources for households, the proportion of energy expenditure in relation to both income and total household spending remains high. Indeed, the primary energy consumption in Hungary has risen, while the household consumption remains at a similar level to that of 2010, or has even slightly reduced (ec.europa.eu, n.d.). Consequently, all the necessary conditions are in place for energy affordability to increase in Hungary.

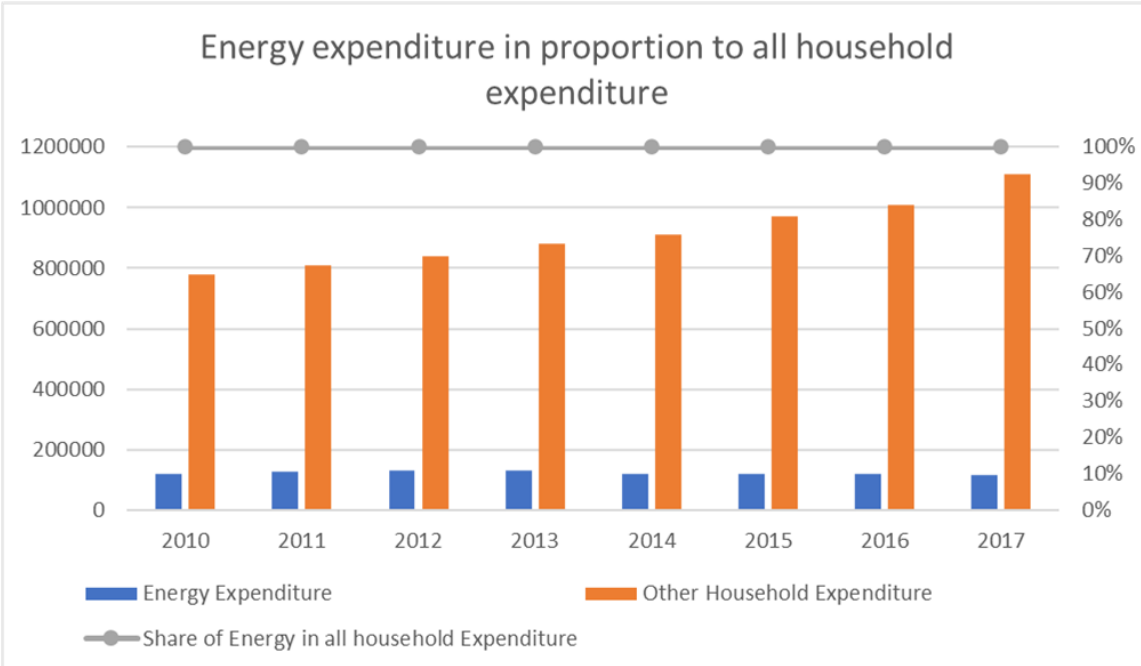


*Figure 2Energy expenditure in proportion to all household expenditure (www.ksh.hu, n.d.).*

In recent years, there has been a discernible change in the costs associated with maintaining a level of living in Hungary. The consistently climbing prices of utilities such as heating and electricity have placed a strain on the financial resources available to individual households. As a direct result of this change, a larger amount of people's monthly earnings is being set aside for the maintenance and repair of their homes.

### 2.1.1 Residential Building Stock

The Central Statistical Office (KSH) carried out the population census in 2022, which was postponed due to the Covid-19 epidemic, with preliminary results expected in the first quarter of 2023, therefore this study uses the available preliminary results. The housing stock in Hungary is continuously growing. In 2022, there were 4.6 million dwellings in the country, representing a 4.6% increase over an 11-year period. During the years 2011 to 2022, approximately 171 thousand new dwellings were built, resulting in a current total of 4.581 million dwellings in Hungary (www.emi.hu, 2023).

### 2.1.2 The Building Stock

In 2022, the Central Statistical Office (KSH) carried out the population census that had been postponed because to the Covid-19 epidemic. Preliminary results are expected to be released in the first quarter of 2023; nevertheless, this study uses the preliminary statistics that are now available. The number of homes available for purchase or rent in Hungary is steadily increasing (Figure 1). Over a period of 11 years, there was a gain of 4.6% in the number of residences in the country, which resulted in a total of 4.6 million homes in 2022. There were around 171 thousand new residences created in Hungary between the years 2011 and 2022, bringing the total number of dwellings in Hungary up to 4.581 million at the present time (Népszámlálás 2022, n.d.).

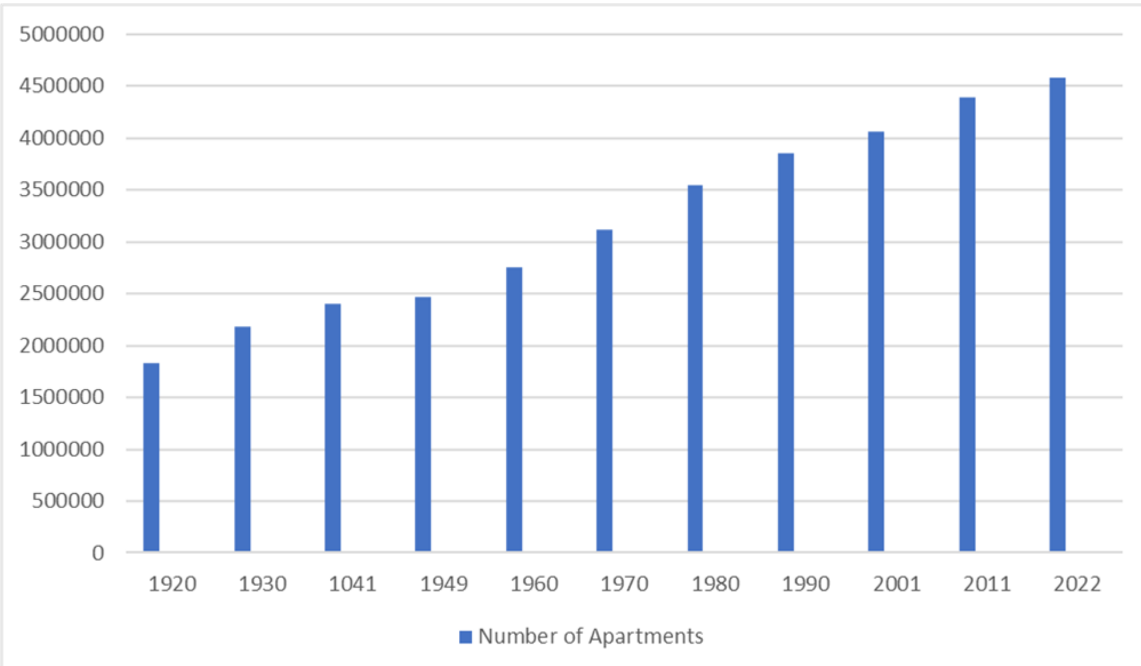


*Figure 3 Revolution of number of apartments ( Source: Népszámlálás 2022, n.d).*

However, this expansion displays substantial regional inequalities. With the exception of the county of Békés, all counties had an increase in the number of homes; however, the counties of Gyr-Moson-Sopron (+11.1%), Pest (+10.4%), and Somogy (+10.2%) saw the largest percentage increases.

*Table 1Spatial distribution of dwellings in 2011 and 2022 (%) (Source: KSH)*

| Spatial Distribution of Dwellings(%) | 2011 | 2022 |
|---|---|---|
| Budapest | 20.6 | 20.7 |
| Cities with county rights | 20.7 | 21.6 |
| Other cities | 30.2 | 30.5 |
| Municipalities | 28.5 | 27.2 |
| | 100 | 100 |

Comparatively, the eastern portion of the country saw a far lower increase rate in the number of houses (0-3.6%) than did the counties in the Transdanubia area, which saw growth rates ranging from 2-11.1 percent (www.ksh.hu, n.d.).

### 2.1.3 The Occupied Dwelling

A detailed account of the development of Hungary's architectural style may be pieced together from the information on the country's building stock, which is organized according to the era in which each building was constructed. Brick, stone, and aspects of manual masonry were the primary components utilized in the construction of the 1,451,658 homes that were built between 1961 and 1980. The details is shown below-

*Table 2 Masonry of dwellings by date of construction (Source: KSH, Census database 2022 (Népszámlálás 2022, n.d.)*

| Dwellings by period of construction | Total | Brick, stone, manual masonry element | Panel masonry | Concrete, medium or large block masonry | Loam, mud masonry | Other masonry |
|---|---|---|---|---|---|---|
| Census year:**2022** | | | | | | |
| before 1919 | 272,364 | 191,596 | | | 71,073 | 9,695 |
| between 1919 and 1945 | 361,594 | 215,718 | | | 133,479 | 12,397 |
| between 1946 and 1960 | 466,423 | 292,469 | | 5,072 | 152,569 | 16,313 |
| between 1961 and 1980 | 1,451,658 | 821,632 | 326,966 | 122,541 | 141,919 | 38,600 |
| between 1981 and 2000 | 909,978 | 584,216 | 187,689 | 75,637 | 17,450 | 44,986 |
| between 2001 and 2010 | 351,836 | 312,454 | | 13,346 | 4,327 | 21,709 |
| Built after 2010 | 194,688 | 171,045 | | 10,000 | 1,243 | 12,400 |

Other construction materials such as panel masonry and concrete, medium to large block masonry were also utilized. This time period is representative of an important phase of development, which indicates that Hungary's primary focus has been on increasing the capacity of its housing infrastructure.

In addition, the data shed light on the historical relevance of the housing landscape. A sizeable percentage of residences in Hungary date back to before 1945, which is evidence of the rich architectural heritage that is embedded throughout the country's building stock. The ensuing time periods, particularly between 1981 and 2000, showed a steady expansion in house construction, with notable features that prominently featured brick, stone, and hand masonry elements. This further underscored the country's sustained commitment to housing development. Despite the fact that the rate of building has slowed down in more recent times, with a lesser number of homes completed after 2010, the numbers signify Hungary's continuing efforts to maintain a balanced approach to housing construction, taking into consideration both historical preservation and the housing necessities of the present day.

The National Building Energy Performance Strategy required a background study, which was produced, in which the typology of residential buildings in Hungary was defined based on statistical data. This study was prepared for the National Building Energy Performance Strategy. The goal was to determine the amount of potential energy savings that may be achieved through the creation of refurbishment packages (Csoknyai et al., 2016). The following characteristics are used to define the various types of buildings:

• The number of dwellings (1-3, 4-9, and over 10 units);

• The construction time;

•The construction technology (typical wall structure: adobe, masonry, prefabricated, and other industrial);

• The size of the house (below 80m2 floor area for single-story homes or over for two-story homes for detached homes).

There was a total of 15 types found, including 7 detached houses, 2 condominiums with between 4 and 9 units, and 6 condominiums with 10 or more units. Since approximately one fourth of detached houses were built before 1945 and nearly half of them were built between 1946 and 1980, this indicates that nearly three quarters of family homes were constructed before 1980. According to the findings of the study that was carried out in 2013, less than 8% of the total stock was produced after the year 2001. The percentage of the total housing stock that is comprised of prefabricated and other manufactured homes is 42%. There are 14% of condominiums in structures that were constructed before 1945. Buildings constructed after the year 2001 account for approximately 16% of the total housing stock (www.emi.hu, 2023).

When calculating the primary energy consumption of various types of buildings, it is possible to observe that single-family homes that were built prior to 1980 have the highest values (about 400-550 kWh/m2a). This is because single-family homes have a larger floor area than other types of buildings. The apartment buildings with

10 or more units that were erected before 1945, excluding panel structures, have roughly 350 kWh/m2a of energy use, making them the least energy-efficient of all apartment buildings. Panel apartment buildings have a primary energy usage that ranges between approximately 200 and 220 kWh/m2 of floor space (www.emi.hu, 2023).

The renovation to the cost-optimal level, which was launched in 2015, and the renovation to the almost zero energy level were both ideas that were studied further as possible renovations.

The primary energy consumption for single-family homes dropped to between 110 and 140 kWh/m2a in the case of the cost-optimal restoration scenario, whereas it rose to between 80 and 100 kWh/m2a in the case of apartment complexes.

### 2.2 Legal framework and EU directives on energy efficiency in Hungarian buildings

The European Union has implemented legislative responsibilities to address housing difficulties of this sort as they are seen as an essential component of an individual's overall well-being. This is because the quality of a person's living situation is viewed as a vital component of a person's overall well-being. These standards place a focus on the necessary for member states to secure access to adequate and affordable housing for all people, which includes the implementation of measures to boost the overall energy efficiency of buildings. This is done by placing an emphasis on the necessity for member states to provide access to adequate and affordable housing for all people (Dubois and Nivakoski, 2023)

In 2007, the European Union Council laid the groundwork for a comprehensive climate and environmental policy in Europe with the Energy Policy for Europe (eur-lex.europa.eu, n.d.). Together with reducing greenhouse gas emissions and increasing the proportion of renewable energy sources in the European energy mix, this declaration also set forth an energy efficiency objective, mandating that the EU reduce its energy usage by 20% by 2020.

The directive requires adjustments to match the December 2019 European Green Deal's enhanced climate ambition. On July 14, 2021, the Commission presented Europe's 2030 climate targets and a Renewable Energy Directive amendment proposal. It attempted to raise the 32% objective to 40% renewable energy in the EU's energy mix by 2030.

The Commission released the REPowerEU plan on 18 May 2022 to accelerate the clean energy transition and reduce the EU's dependence on Russian fossil resources by 2030. The REPowerEU strategy saves energy, generates renewable energy, and diversifies EU energy supplies. The Commission recommended increasing the directive's aim to 45% by 2030 to scale up renewable energy in power generation, industry, buildings, and transport. Following a Commission proposal of 9 November 2022, the Council enacted a temporary emergency regulation on 22 December 2022 to speed up renewable project permit-granting and power purchase agreements (energy.ec.europa.eu, n.d.).

To achieve its goal of having a low-carbon economy by 2050, the European Commission looked into several possible routes to a carbon-free energy system. The targets are to reduce greenhouse gas emissions by 80% and energy-related CO2 emissions by 85% by 2050, with a focus on the transportation sector. The EU's Energy 2020 Strategy must be fully implemented in order to achieve the targets set forth in the 2050 roadmap, which is why it is crucial.

In order provide support to these efforts, a number of European Directives have been adopted; these Directives are to be transferred by the Member States into the legislation of their respective countries. The following describes each of these Directives:

- Directive 2006/32/EC of 5 April 2006 on energy end-use efficiency and energy services
- Directive 2009/125/EC of 21 October 2009 establishing a framework for the setting of eco-design requirements for energy-related products
- Directive 2010/30/EU of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products
- Directive 2010/31/EU of 19 May 2010 on the energy performance of buildings (the ‘Energy Performance of Buildings Directive’)
- Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency Directive 2012/27/EU of 25 October 2012 on energy efficiency (the ‘Energy Efficiency Directive’)

- Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (European Commission, 2018)

The residential sector in Hungary, which accounted for 34.9% of total energy consumption in 2015, demonstrated a 20% decrease in space heating consumption between 1990 and 2015, reflecting the country's alignment with EU energy performance standards. This reduction is in line with the energy efficiency directives that have been issued by the European Union. Notably, nearly 70 percent of Hungary's existing residential dwelling stock was built before the year 2000, which indicates a pressing need for comprehensive renovations to boost energy efficiency. A coordinated effort to upgrade these older structures with modern insulation and appliances that are more energy-efficient could drastically cut the present final energy consumption per stock of permanently inhabited residences, which is in alignment with the EU's Energy Performance of Buildings Directive. Not only would such actions contribute to Hungary's national energy efficiency aims, but they would also strengthen the country's commitment to the larger EU sustainability objectives (Trotta, Spangenberg and Lorek, 2018a).

When compared to the core nations of the EU, the prevalence of energy poverty is significantly higher in Hungary, which is located in the central-eastern part of Europe (Bouzarovski et al., 2015b). Over one-fifth of Hungarian homes rely on the utilization of solid fuels, primarily firewood, as their primary source of heating, while an additional 20% of households utilize a combination of natural gas and solid fuels as their primary heating source (KSH 2011). It is notable that households in the most economically disadvantaged positions have a significantly higher prevalence of the use of solid fuels (Garba and Bellingham, 2021). While research on energy poverty in developing countries in the Global South focuses largely on the difficulties connected with the use of solid fuels, in particular the pollution of indoor air, the equivalent issues in developing countries in the Global North, such as Hungary, remain relatively underexplored (Mirza and Szirmai, 2010). Existing policy solutions frequently fail to adequately recognize the complications that are associated with the use of solid fuels for heating.

**Some Overview of energy performances of building stock:**

In the process of establishing the building types that will be utilized for the analysis of the domestic residential building stock, appropriate consideration was given to the qualities that play the most important role in determining how well a building performs in terms of its energy efficiency. The database of the 2011 census that was maintained by the HCSO was used to filter the buildings. The following characteristics serve as the basis for classifying various types of buildings:

• The size of the building (number of apartments): the census questionnaire included discrete categories for capturing data on size. The available options were buildings with 1 to 3, 4 to 9, or more than 10 units. These options were also included in the NABEPS.

• Year of construction: data were asked according to year, and the periods were decided in the course of writing up the NABEPS, based on significant changes in construction technology. This was done in order to account for the shifts in the industry.

• Construction technique: according to the census data, buildings were classified as adobe, masonry, prefabricated panels, or other industrialized structures based on the usual construction technology utilized to build the walls of their structures.

•The total square footage of the building (for single-family homes and multi-family homes with two or three apartments). In general, homes with a floor space of less than 80 square meters are considered to be single-story buildings, whereas homes with a floor space of more than 80 square meters are considered to be multi-story buildings. When analyzing energy efficiency, the number of storeys in a building is an important factor to consider (Ref and Ares, 2015).

Hungary has implemented several policies and programs to address a wide variety of concerns and make substantial progress in enhancing the energy efficiency of its buildings. This country's government has implemented comprehensive policies and protocols to ensure strict compliance with the Energy Performance of Buildings Directive (EPBD). Additionally, the government has taken several measures to guarantee that all buildings fulfill the standards for energy efficiency. These two accomplishments demonstrate the country's commitment to enhancing energy efficiency in its various institutions and activities. Hungary has implemented rigorous energy standards for newly constructed buildings and ambitious renovation initiatives for existing buildings in order to achieve its goal of having nearly zero energy buildings (NZEBs) by 2050. This goal can be achieved by renovating or refurbishing existing structures (Ref and Ares, 2015).

## 2.3 Economic implications of energy poverty and climate protection measures in Hungary

### Hungary's National Energy and Climate plan

Both the National Energy and Climate Plan (NECP) of Hungary and the National Energy Strategy (NES) 2030 of that country underline the nation's commitment to strengthening energy independence and security while concurrently transitioning to cleaner, more environmentally friendly energy sources (National Energy and Climate Plan, n.d.). These goals are emphasized in the National Energy and Climate Plan (NECP) of Hungary. Notably, the study stresses the necessity for Hungary to update its NECP in accordance with the EU's net zero targets by 2050 and the Climate Law, both of which require constant monitoring and revision of both national and EU-wide efforts.

*Table 3Hungary's 2020 and 2030 energy sector targets and 2020 status (IEA 2022)*

| | | 2020 | 2020 Targets | 2030 Targets |
|---|---|---|---|---|
| Non-ETS greenhouse gas emissions | CO2-eq emissions versus 2005 | -2% | Not exceeding a 10% increase | 7% |
| Energy Efficiency | Primary energy consumption | 23.9 Mtoe 1000PJ | 23.6 Mtoe 1110PJ | 30.7 Mtoe 12850PJ |
| | Final Energy Consumption | 18.0 Mtoe 754PJ | 18.2 Mtoe 761PJ | 18.8 Mtoe 785PJ |
| Renewable Energy Share | Gross Final Energy Concumption | 13.90% | 13% | 21% |
| | Electricity | 11.90% | 10.90% | 20.00% |
| | Heating and Cooling | 17.70% | 18.90% | 30.00% |
| | Transport | 11.60% | 10% | 14% |
| Cross-border Electricity Interconnection | | 50%(2018) | 55% | 60% |

In addition, the research reveals that Hungary must do this by the year 2050. In addition to this, the study emphasizes the significance of achieving a net zero emission of greenhouse gases by the year 2050. As a result of the study that was carried out by the European Commission, it has become clear how critical it is for Hungary to more closely align its aims with the standards that have been established by the EU, notably in the areas of energy efficiency and renewable energy. In addition, the research highlights the necessity of implementing the expanded climate ambitions of the EU, particularly the Fit for 55 packages, into Hungary's amended NECP. As a result, the research highlights the necessity for a comprehensive alignment with the EU's goal of reducing greenhouse gas emissions by 55% by the year 2030 (National Energy and Climate Plan, n.d.).

## 2.4 Assessment of building materials and technologies for energy efficiency in the Hungarian

When considering Hungary, a country with a temperate continental climate, it is vital to take into account building materials and technologies that can improve energy efficiency, minimize heat loss, and decrease overall energy usage. Hungary has frigid winters and scorching summers, necessitating the use of excellent insulation and efficient heating and cooling systems in buildings. The following architectural materials and technologies can enhance energy efficiency in the Hungarian context:

**Insulation Materials**: The use of superior insulation materials is crucial in order to reduce heat loss in winter and heat gain in summer. By incorporating materials like mineral wool, polyurethane foam, and expanded polystyrene (EPS), the energy efficiency of buildings can be significantly improved (Dong et al., 2023)

**Choose energy-efficient windows with low U-values:** To prevent heat loss in winter and reduce heat gain in summer. Implementing double or triple glazing, incorporating low-emissivity coatings, and utilizing gas fills between panes can greatly enhance the energy efficiency of buildings (www.atozglazing.com, n.d.).

**Thermal mass materials**: Concrete, brick, or stone, can be used to manage indoor temperatures. These materials have the ability to absorb and store heat during the day, and then release it at night. This can enhance thermal stability inside indoor environments and diminish the need on heating and cooling equipment (Shafigh, Asadi and Mahyuddin, 2018)

**Passive Solar Design**: By using passive solar design techniques, such as optimal building orientation, strategic window placement, and the utilization of shading devices, it is possible to optimize the utilization of natural light and heat, hence minimizing the need for artificial lighting and heating systems (Kumar et al., 2021)

**Consider the installation of high-efficiency heating systems**: Heat pumps or condensing boilers, as they have the ability to greatly decrease energy use. In addition, the integration of energy-efficient cooling solutions, such as geothermal cooling or highly efficient air conditioning units, can assist in sustaining pleasant indoor temperatures throughout the summer. (Article 14(1) of Directive 2012/27/EU: A comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling in Demark, 2015)

**Renewable Energy Integration** Incorporate renewable energy sources, such as solar panels or small-scale wind turbines, into buildings to diminish dependence on conventional energy sources and minimize the overall carbon footprint (Farghali et al., 2023)

**Ventilation Systems**: Implementing energy-efficient ventilation systems, such as heat recovery ventilation (HRV) or energy recovery ventilation (ERV), can effectively maintain a healthy interior atmosphere while minimizing energy wastage (Guillén-Lambea, Rodríguez-Soria and Marín, 2017)

**Green Retrofitting**: Implement green roofing technologies that offer insulation, mitigate the urban heat island effect, and enhance stormwater management, thereby promoting energy efficiency and environmental sustainability(Cascone, 2019)

**Implement building automation and intelligent systems**: To enhance energy optimization, monitor energy usage, and regulate indoor ambient conditions, resulting in improved energy management efficiency (Aguilar et al., 2021)

**Sustainable Construction Practices:** Priorities sustainable construction practices, such as utilizing locally procured materials, implementing efficient construction methods, and employing waste reduction initiatives, in order to mitigate the ecological footprint of the construction process (Amaral et al., 2020)

Recent research indicates that buildings account for around 40% of Hungary's overall energy usage, highlighting the pressing necessity to improve energy efficiency in the country's ageing residential structures (MEHI, n.d.). Approximately 75% of the 4 million residences require renovation. By implementing several improvements such as replacing doors and windows, adding external thermal insulation, and updating heating systems, it is possible to realize energy savings of more than 40% (152 PJ). The National Building Energy Performance Strategy aims to achieve a substantial reduction of 40 PJ in energy consumption. This decrease was part of a larger effort to achieve a total of 49 PJ in energy savings by 2020, with a particular focus on improving residential buildings. This technique provides both a sustainable alternative for reducing energy use and a lucrative investment opportunity that outperforms traditional bank deposits. In addition, Hungary's recent law, which has strengthened energy efficiency standards for both public and private buildings, highlights the country's dedication to fostering sustainable practices. This legislation includes the adoption of almost zero energy requirements starting from 2021. Surveys indicate that a significant section of the population plans to repair their homes, primarily motivated by the goal of reducing excessive utility expenses. Therefore, it is clear that governmental funding programs are necessary to support these important refurbishment projects. This investment not only boosts the economy but also supports the national objective of reducing energy reliance and meeting crucial climate protection goals (energiaklub.hu, 2023)

Hungary encountered difficulties in establishing a distinct pattern of enhancement in energy efficiency for residential space heating, mostly as a result of data-related problems. Significantly, the transition from gas and district heating to wood and garbage as fuel sources, which were less efficient, has resulted in a rise in space heating use since 2009. Between 2000 and 2015, the proportion of gas used for space heating declined from 64% to 49%, while the proportion of solid biomass climbed from 8% to 40%. The government's 2011 decision to impose a freeze on home network-based energy prices had an impact on the selection of heating fuels, giving preference to those that were comparatively more affordable. Since 2015, there has been a decrease in the proportion of wood used for heating, while gas has been gaining renewed appeal. From 2000 to 2018, the energy consumption of households experienced a 4.7% growth, mostly due to the increased number of household equipment and the larger average size of homes. The implementation of the 2002/91/EC directive (EPBD) in Hungary resulted in the adoption of more stringent technical heat requirements. Subsequent revisions further enhanced energy efficiency standards. In 2013, the implementation of the National Building Registry System (NÉeR) was intended to simplify the process of renovating buildings to be more energy-efficient and promote the adoption of renewable energy sources. The MFB Hungarian Development Bank Plc. managed an interest-free loan plan in 2017, which aimed to encourage energy-efficient building upgrades. The financing for this scheme came from EU funding. In addition, Hungary has recently implemented a government initiative that offers a subsidy program for home repairs. This program is specifically targeted towards households with at least one kid and aims to highlight Hungary's dedication to boosting energy efficiency in the residential sector (www.odyssee-mure.eu, n.d.).

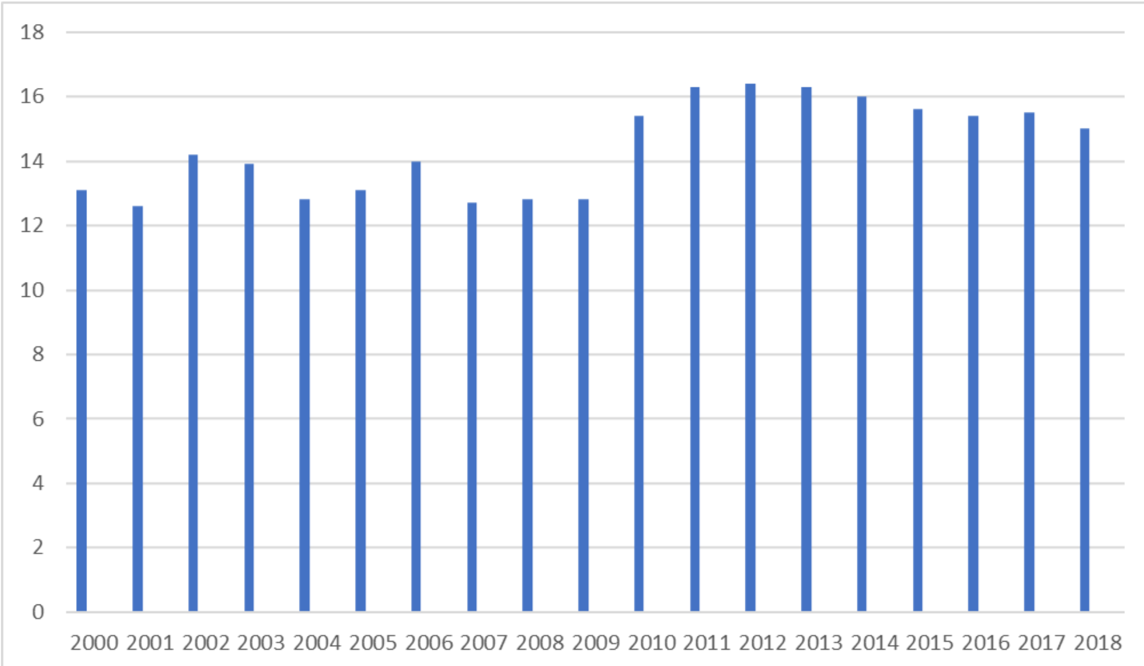


*Figure 4 Energy consumption of per space heating m^2 (normal Climate) (Source: www.odyssee-mure.eu, n.d.)*

# 3 METHODOLOGY

## 3.1 Research design

This research makes use of a comprehensive mixed-methods strategy, which consists of an intense literature review in addition to a quantitative survey as its primary data collection tools. The quantitative survey is designed to capture essential data points related to the socio-demographic composition, housing characteristics, income levels, energy consumption behaviors, and experiences with energy poverty among 200 participants from a variety of age groups and residential locations in Hungary. The survey participants will be from Hungary. The questions on the survey have been formulated in such a way as to provide insights regarding the incidence of energy poverty in Hungarian residential structures as well as its impact on those buildings. These insights will be provided in the form of a report. In addition, the examination of the pertinent literature incorporates a complete and rigorous review of pertinent research papers, journal articles, national data, reports from NGOs, and important policy documents. Using this method, it is possible to carry out an in-depth analysis of the myriad of facets that comprise energy poverty as well as the effectiveness of the many policy efforts that are now in place in Hungary.

## 3.2 Sources and methods of data collection

Data from the Survey: The data from the survey are collected using a structured questionnaire that consists of 23 questions. These questions have been carefully crafted to delve into important aspects such as the composition of households, the types of housing, the distribution of income, patterns of energy expenditure, challenges in meeting energy costs, and perceptions of governmental support initiatives. The survey was conducted in Hungary by Hungarian households also by foreigners living in Hungary.

The survey is administered to a large number of participants from a diverse range of ages and residential settings in order to assure accurate representation of both of these demographic categories. This is done so that a complete picture of energy poverty within the context of Hungary can be obtained.

An Analysis of the Previous Research and Its Relevance Data: In order to successfully complete a literature review, one must first do an intensive search and then perform an analysis on a wide range of academic sources. Research papers, scholarly publications, official reports, and statistical data from reputable national and international organizations are all examples of possible academic sources. The purpose of this study technique is to provide an informed viewpoint on the underlying issues contributing to energy poverty in Hungarian residential buildings by conducting an in-depth analysis of the body of literature that is currently available. In the meantime, an investigation into the various possible approaches and policy frameworks for dealing with this critical problem in contemporary society will also be carried out.

This method of analysis seeks to provide a comprehensive and sophisticated comprehension of the complexities that lie behind energy poverty in the context of Hungarian residential buildings. The overall goal of this work is to educate successful policy actions and establish habits that are sustainable with regard to energy use.

# 4 ENERGY POVERTY AND HOUSING CONDITIONS IN HUNGARY

## 4.1 Analysis of changes in the cost of living and housing expenses

In Hungary, the average proportion of energy expenses exceeded 10% in 2016. To better understand this, the Hungarian Central Statistical Office has collected data on different income groups. The households have been divided into 10 equal income groups, with each decile representing 1/10 of the total number of households in the country. The share represents the energy expenditure of each individual in a specific group, known as deciles, divided by the income per person in the same group. It is evident that even in the 8th income deciles, energy expenditures exceed 10%. However, it is also true that as income increases, the percentage of family spending on energy decreases. The European Commission conducted a report on energy prices and costs in 2016. According to the report, in 2014, Hungary had the second highest proportion of energy expenses compared to income in the European Union, with Slovakia being the only country ahead (European Commission; 2016). The current position has shown improvement as of today. Nevertheless, the Hungarian Energy and Public Utility Regulatory Authority (HEA) reported that we were unable to reproduce the Commission's computation technique. In 2019, Hungary's proximity to the European average was evident, with the country's household gas and electricity costs being among the lowest in Europe (HEA; 2019). We possess the statistical data from 2010 and upon comparison with the figures from 2016, it is evident that the proportion of energy expenses in families has declined across all ten percentiles. The decline in the national average share can be attributed mostly to the rise in income per capita, while the average energy expenditure has stayed constant since 2010. The decrease in utility costs in Hungary in 2013 may come as a surprising piece of data.

Thus, it may be inferred that a decrease in energy costs would lead to a decrease in household expenses, given that the energy consumption of homes has remained constant (Eurostat 2019). The data from the Hungarian Central Statistical Office indicates that the reduction in utility costs has had an impact on electricity and natural gas prices, resulting in a decline. However, the cost of solid fuel has shown a rise. Consequently, there has been a decrease in household expenditures on electricity and natural gas, but there has been a rise in spending on solid fuel. The two impacts canceled out the average energy expenditures. Although the proportion of energy expenses in income has declined, the national average remains around 10%.

According to the Insight_E indicator list, the combination of low income and a large percentage of energy costs gives rise to affordability concerns. The indicators consist of income, energy prices, and energy consumption level (Maxim et al., 2016). As previously stated, the income level in Hungary has risen (Hungarian Central Statistical Office). Energy costs, including those for natural gas, electricity, and district heating, have been subject to regulation since 2013. For home users, this implies that the utility fees have been limited, preventing any growth in the price per unit of energy sources. Despite Hungary now having one of the most affordable energy sources for households (HEA 2019), the proportion of energy expenditure in relation to both income and total household spending remains high. Indeed, the primary energy consumption in Hungary has risen, while the household consumption remains at a similar level to that of 2010, or has even slightly reduced (Eurostat; 2019). Consequently, all the necessary conditions are in place for energy affordability to increase in Hungary. In recent years, there has been a discernible change in the costs associated with maintaining a level of living in Hungary. The consistently climbing prices of utilities such as heating and electricity have placed a strain on the financial resources available to individual households.

**Analyzing Hungary's Household Financial Trends from 2015 to 2021**

**Trends in the ratio of basic expenditures**

The analysis of the fundamental expenditure ratio, which represents the percentage of revenue allocated to necessary goods and services, revealed a gradual decrease from 57.1% in 2015 to 55.2% in 2021.

The decrease in spending indicates a possible change towards less necessary purchases and emphasizes an enhancement in the quality of life, enabling more freedom in spending on non-essential items.

**Fluctuations in actual earnings and spending**

The evaluation of fluctuations in real income per person and yearly per person consumption expenditures revealed a favorable pattern. Over time, there has been a stable and steady growth in purchasing power, as evidenced by a 3.4% increase in real income per capita. Likewise, there was a 3.1% increase in per capita yearly consumption expenditures, highlighting an overall improvement in the ability of households to spend.

**Analysis of the percentage total of annual income and expenditure**

The combined proportion of yearly net income and consumer spending offers a thorough assessment of the financial condition of households in Hungary. The progressive growth in the proportion of yearly net income, escalating from 11.27% in 2015 to 18.01% in 2021, indicated a substantial surge in income levels. In the same way, the proportion of yearly spending by Hungarian households increased from 11.76% in 2015 to 16.59% in 2021, suggesting a greater ability to spend.

**Detection and analysis of trends and patterns**

The thorough analysis of the data revealed steady higher trends in both income and spending, highlighting an overall enhancement in the economic welfare of Hungarian households. This was further supported by the slight decrease in the fundamental expenditure ratio, indicating a changing trend in spending towards non-essential goods and services.

**Interpretation in the Economic Context**

The results were analyzed in relation to the wider economic situation in Hungary, taking into account different external factors such as shifts in national economic policy, inflation rates, and employment levels. These factors were noted to have impacted household income and expenditure patterns, hence contributing to the favorable trend of financial indicators in the country.

## 4.2 Age and composition of building stock

There are around 4.4 million residences in total stock in Hungary's housing market, the vast majority of which are single-family detached homes, which make up approximately 62% of the country's total housing landscape. Notably, around 29% of these houses can trace their roots back to the time before World War II (MÉRŐ et al., 2022). This fact reflects the historical relevance and age of a considerable percentage of Hungary's housing infrastructure and demonstrates the age of a significant portion of Hungary's housing stockOn the other hand, only about 15% of the current housing stock was built after the fall of the Soviet Union. This shows that the housing market hasn't grown very much in the last few decades. The numbers also show an alarming number: about 10.9% of homes in Hungary are empty, which could mean problems with how they are used and maintained. Aside from that, almost 96% of houses in Hungary are privately owned, showing that private ownership rules the housing market in the country. This shows how important private property ownership is in Hungary. All of these numbers paint a complicated picture of Hungary's housing situation.

They show that we need comprehensive solutions to deal with issues like empty homes, old infrastructure, and the changing nature of private ownership in the housing sector (Csoknyai et al., 2016b).

**Hungary's Prospects for Energy Efficiency: A Comprehensive Analysis**

**Strategies for Ensuring Legal Compliance in New Construction Systems**

The process of granting notifications and building permits has been streamlined as part of a stringent new system of enforcement that has been implemented. This is a component of the novel system. The implementation of electronic documentation systems has eased administrative tasks, facilitating the verification of newly constructed buildings' compliance with energy performance regulations.

**Energy Efficiency of Existing Buildings**

Hungary has broadened the range of its legislation pertaining to energy performance to include existing structures, with a particular focus on significant renovations and expansions. This modification was implemented to guarantee that existing structures remain in compliance with energy efficiency regulations. Furthermore, alongside the dedicated focus on the technical aspects of constructing systems, the country has also launched endeavors to enhance the overall energy efficiency of the existing building stock. This is being done in collaboration with the focused consideration that has been given to the technical aspects of constructing systems. Financial instruments and incentive programs have been created to encourage the adoption of energy-efficient improvements in both residential and commercial buildings.

**Requirements for Acquiring an Energy Performance Certificate**

Hungary has made it compulsory for all types of buildings, both residential and non-residential, to acquire Energy Performance Certificates (EPCs). This requirement is aimed at enhancing energy usage transparency and promoting education on energy efficiency in the country. These certificates assess the energy efficiency of a structure. The adoption of an electronic registration system and a strict control mechanism has led to a fundamental reform of the EPC quality assurance process, resulting in significantly elevated standards.

The consequences of initiatives aimed at addressing energy poverty, as well as the advantages of enhancing energy efficiency. Hungary's emphasis on enhancing energy efficiency has yielded significant benefits for both the environment and the economy. The enhancements in building performance have led to a reduction in both energy consumption and $CO_2$ emissions. This has not only supported the nation's sustainable development objectives, but has also positively affected energy costs, thereby mitigating energy poverty to some extent. Enhancements in building performance have been achieved due to advancements in energy efficiency (Authors et al., n.d.)

### 4.3 Share of income on housing maintenances

Because of the severe winters that the country experiences, Hungary has a high rate of energy consumption for heating, which places enormous financial obligations on the country's populace. Energy expenditures constitute a noticeably bigger share of income for Hungarians when compared to the EU median, and this is compounded by the fact that the median income in Hungary is lower than the average income in the EU (Odyssee-mure.eu, 2021).

The lowest income quintile of the Hungarian population spent 13% of their income on energy in 2015, which is over twice as much as the EU average of 7% for that particular category. This pattern is true across all income brackets, with even the wealthiest quintile in Hungary devoting a greater proportion of their income to energy expenditures than the average for the EU. According to these data, the population of Hungary is more likely to be impoverished in terms of energy resources when compared to the average of the EU (Directorate-General for Energy (European Commission), 2020)

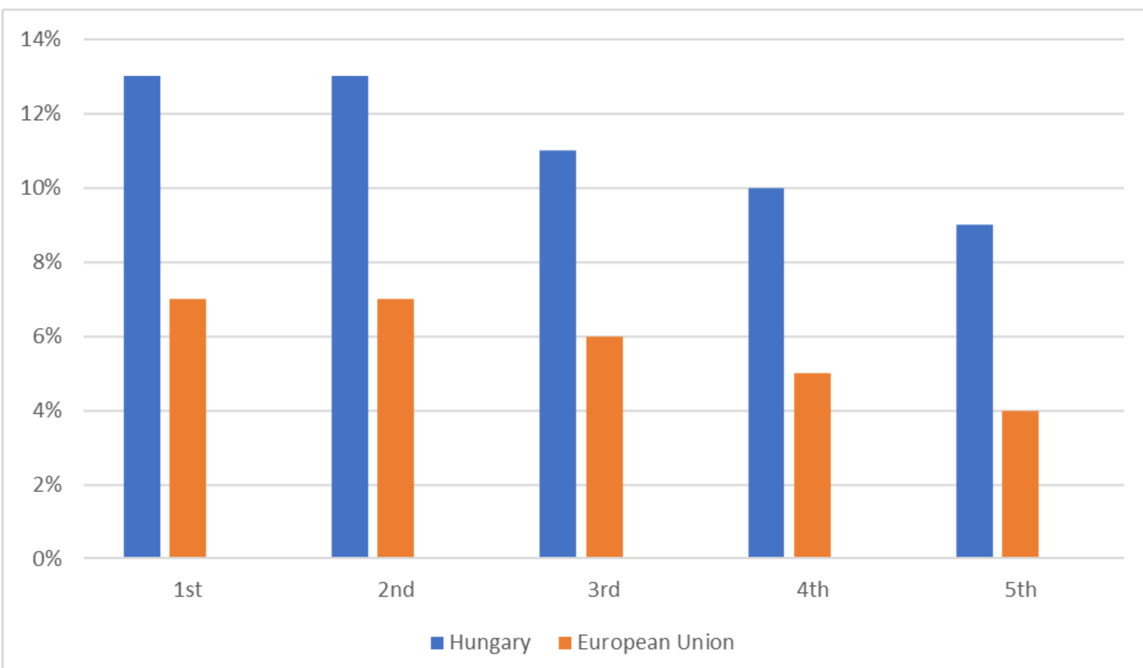


*Figure 5 Share of energy expenditure by income quantile (2015) (Souce: KSH)*

The pattern of household energy costs in Hungary shows that electricity prices stayed reasonably consistent between the years 2008 and 2012, then witnessed a slow fall from 2012 to 2014, and have subsequently maintained a steady trajectory (powerpoor.eu, n.d.). This pattern was observed between 2008 and 2012.

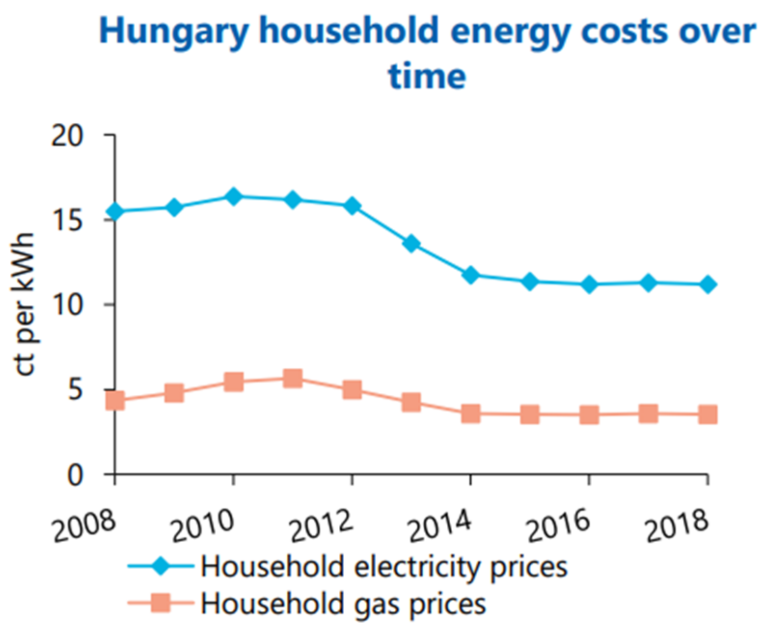


*Figure 6 Household Energy Cost Over Time, (Source: Member State Report on Energy Poverty 2019)*

From the data above, between 2008 and 2011, there was a little increase in the price of a gallon of gas. By 2014, however, the price had dropped and has since stabilized. The cost was 3.53 euros cents per kilowatt-hour in 2018, which helped explain why residential energy costs in Hungary were comparatively lower in 2018 than the EU average. Even while these actions have eased some of the financial burden, there is still reason for concern because of the disparity in energy costs between income levels.

In light of these facts, it is absolutely necessary for the policymakers in Hungary to carry on with the implementation of sustainable energy policies that strike a balance between affordability and considerations of the environment. Initiatives that encourage energy efficiency, renewable energy sources, and targeted help for low-income households can play a significant role in decreasing the danger of energy poverty and guaranteeing a more equal energy landscape for all of Hungary's residents. This is especially true in Hungary, where energy poverty is very prevalent (Directorate-General for Energy (European Commission), 2020). The information that is presented in the tables provides an in-depth look at the shifting financial landscape and the fluctuating cost dynamics that are present in Hungarian households. It is essential to have a thorough comprehension of the broader environment within which these tendencies exist in order to acquire priceless insights about patterns of consumption and the relative significance of various types of expenditures.

*Table 4 Average per capita consumption (HUF); Actual rental, Products, services for reg.maintenance & repair, total, Electricity, gas and other fuels, total, Water supply and services related to dwelling, total (Source: KSH)*

| Period of time | Total Deciles | Total Deciles | Total Deciles | Total Deciles |
|---|---|---|---|---|
| **2010** | 10764 ft | 9999 ft | 129197ft | 44531ft |
| **2011** | 9807 ft | 11187 ft | 137991ft | 46532ft |
| **2012** | 12309 ft | 10212 ft | 140198ft | 51901ft |
| **2013** | 22509 ft | 9739 ft | 130894ft | 48827ft |
| **2014** | 24171 ft | 9719 ft | 125052ft | 49723ft |
| **2015** | 22829 ft | 10047 ft | 125660ft | 51527ft |
| **2016** | 22668 ft | 11996 ft | 129317ft | 51734ft |
| **2017** | 23013 ft | 13066 ft | 134324ft | 51208ft |
| **2018** | 24708 ft | 17225 ft | 139881ft | 53619ft |
| **2019** | 26589 ft | 22265 ft | 141838ft | 55634ft |
| **2020** | 25269 ft | 28706 ft | 142913ft | 57321ft |

According to the table, in the first place, the fact that actual rental costs were expected to keep rising between the years 2010 and 2020 is illustrative of the difficulties Hungarian people experience in locating property that is within their price range.

The considerable increase that was seen between the years 2018 and 2019 hints to the possibility of an impact caused by economic reasons or the dynamics of the housing market during that time period. This shows that there is a necessity for a more in-depth investigation of the housing market and rental rules in Hungary.

Second, the variable trend in the expenditure on items and services for routine maintenance and repair may signal varying consumer preferences and economic conditions, although maintaining within a reasonably steady range. This is despite the fact that the range itself has remained very consistent. Understanding the variables that are causing these oscillations, such as shifts in discretionary income, changes in consumer confidence, or developments in the market, can provide crucial insights into the resiliency and adaptability of Hungarian households when it comes to managing their routine expenses.

In addition, the slow but steady rise in the average per capita consumption of electricity, gas, and other fuels sheds light on the evolving energy requirements and consumption habits of Hungarian households. A big reason that is contributing to this trend is the increased demand for heating, which is caused by the chilly winter environment that the country experiences. The investigation ought to look deeply into the implications of energy efficiency measures, government regulations, and infrastructure development with the goals of promoting sustainable energy usage and alleviating the financial burden placed on households.

For a thorough knowledge of the larger financial backdrop that shapes household spending patterns in Hungary, it is vital to conduct further research and analysis on income trends, socio-economic indicators, and the impact of programs addressing energy poverty. Policymakers and other stakeholders can design targeted measures to ease financial burdens, enhance energy efficiency, and promote sustainable living standards for all sectors of the population if they take into consideration the interplay of many economic and social elements.

# 5 LEGAL FRAMEWORK AND POLICY IMPLICATIONS IN HUNGARY

## 5.1 Overview of Hungarian legislative measures for energy efficiency and climate protection

The residential sector in Hungary, which accounted for 34.9% of total energy consumption in 2015, demonstrated a 20% decrease in space heating consumption between 1990 and 2015, reflecting the country's alignment with EU energy performance standards (Győri, Huszár and Balogh, 2021). This reduction is in line with the energy efficiency directives that have been issued by the European Union. Notably, nearly 70 percent of Hungary's existing residential dwelling stock was built before the year 2000, which indicates a pressing need for comprehensive renovations to boost energy efficiency. A coordinated effort to upgrade these older structures with modern insulation and appliances that are more energy-efficient could drastically cut the present final energy consumption per stock of permanently inhabited residences, which is in alignment with the EU's Energy Performance of Buildings Directive. Not only would such actions contribute to Hungary's national energy efficiency aims, but they would also strengthen the country's commitment to the larger EU sustainability objectives (Trotta, Spangenberg and Lorek, 2018)

The Hungarian energy industry is currently undergoing a comprehensive reform to assure its continued viability over the long term, improve its level of security, and boost its level of competitiveness.

The Energy Strategy includes key ideas that priorities energy savings, a shift towards renewable energy sources, the modernization of power plants, and improvements in energy efficiency across a variety of sectors. In this paper, an in-depth analysis of the comprehensive Energy Strategy is provided, highlighting its most important components, aims, and recommended efforts for the purpose of establishing a competitive, sustainable, and secure energy supply in Hungary.

**Energy savings and Energy Efficiency**

One of the most important aspects of the Energy Strategy is making an effort to cut energy usage by increasing energy efficiency and finding ways to save energy. By the year 2030, it is planned to implement a strategic strategy to bring domestic primary energy consumption down to the level it was in 2010. In order to accomplish these objectives, the strategy recommends giving top priority to energy-efficient methods and strictly implementing the Energy Performance of Buildings Directive in the commercial building industry.

**Integration of Renewable Energy Sources**

The Energy Strategy places a strong emphasis on expanding the use of renewable energy sources, with the end goal of increasing the proportion of primary energy consumption that comes from renewable sources from the present 7% to around 20% by the year 2030. The development of biogas and biomass power plants that generate both heat and electricity, as well as the utilization of geothermal energy for heating purposes, is given the highest priority. In addition, the policy promotes the use of renewable energies like solar and wind power, with a particular emphasis on making the most of Hungary's solar energy potential for the generation of direct electricity after the year 2020. The integration strategy for renewable energy also gives significant weight to the development of bioenergy derived from energy-producing units that are decentralized as well as the potential energy content of waste from municipal and industrial sources.

**Modernization of Power Plants and District Heating**

The upgrading of older power plants to ones that are more environmentally friendly and efficient in terms of energy use is an essential component of the overall strategy. Specifically, the focus is being placed on prolonging the lifecycle of the currently operating nuclear power plant while also introducing new units. The findings of the analysis suggest that the $CO_2$ intensity associated with the generation of electricity should be reduced from 370g $CO_2$/kWh to about 200g $CO_2$/kWh. In addition, the strategy emphasizes the need to improve community district heating systems by integrating low-temperature district heating and renewable energy sources. By the year 2030, the goal is to have 25% of the total heat energy consumption come from renewable heat sources.

**Enhancing Energy Efficiency in Transport and Industry**

The research has a strong emphasis on boosting the energy efficiency of the transportation sector by encouraging electric and hydrogen-based transportation systems. By 2030, the report aims to achieve a 9% share for electric and hydrogen-based transportation and a 14% share for biofuels. The policy also emphasizes the need to encourage environmentally friendly practices in industries and agriculture, with a primary emphasis on the research, development, and implementation of low-carbon technology throughout the entirety of the production lifecycle.

In addition, in order to bring about an overall reduction in emissions of greenhouse gases, the report promotes the effective utilization of waste-to-energy solutions as well as agricultural byproducts.

**Strengthening Governmental Involvement**

The Energy Strategy suggests the implementation of strong regulatory frameworks and regulations in recognition of the role that the government plays in ensuring an efficient and well-regulated energy sector. In addition, the measures that will be highlighted include those that will increase electric grid regulatory powers, stimulate competition, and diversify natural gas import sources. In addition, the strategy places an emphasis on the critical requirement for a trained labor force, which makes it necessary to reinvigorate high-quality vocational education programs within the energy industry (National Energy and Climate Plan, n.d.)

In 2017, the International Energy Agency (IEA) performed a research which revealed that Hungary has made significant advancements in meeting its climate goals and enhancing its energy policy framework. The report for 2017 highlighted these accomplishments. The government has officially announced its commitment to achieving carbon neutrality by 2050. To guide its energy policy decisions, it has developed a comprehensive National Clean Development Strategy. Both of these actions warrant acknowledgment. These two accomplishments are significant independently and are self-standing. Hungary has had remarkable development in solar photovoltaic (PV) capacity and has prolonged the operational lifespan of its nuclear reactors into the mid-2030s, with a particular emphasis on reducing carbon emissions. Both of these achievements were facilitated by the nation's dedication to mitigating carbon emissions. Both of these triumphs can be attributed to the nation's resolute commitment to reducing carbon emissions. Both of these successes can be ascribed to the nation's unwavering dedication to decreasing the quantity of carbon emissions generated.

To attain Hungary's ambitious goal of obtaining 90 percent of its electricity from renewable sources by 2030, the country must persistently prioritize and enhance its low-carbon power generation. This entails prioritizing a wide range of renewable energy sources and enhancing the adaptability of the power system to incorporate higher percentage of photovoltaic, or PV, solar panels. Both of these components are necessary for attaining the intended outcome. Furthermore, the study emphasizes the crucial significance of Hungary diminishing its reliance on Russia for the supply of gas, oil, and nuclear energy. This argument is reiterated consistently throughout the paper. This criterion is extensively examined in many settings throughout the entire study. To achieve a fair and comprehensive transition, it is imperative to implement policies that not only decrease the use of fossil fuels but also promote investments in renewable energy technologies and human capital. Only until we have reached that point can we have confidence that the shift will be accomplished with success.

Hungary is prioritizing the use of hydrogen not just in the transportation sector, but also in the industrial sector. This aligns with the ongoing endeavors to reduce carbon emissions from companies that have a significant carbon footprint. This action has been taken to effectively tackle the issue of minimizing carbon emissions.

The International Energy Agency (IEA) has formulated a set of recommendations for Hungary about its energy strategy, aiming to assist the country in effectively overseeing the transition of its energy sector while staying consistent with its overarching objectives. The IEA's recommendations are located in the subsequent paragraphs. The list compiled by the IEA can be accessed here. The objective of these proposals is to foster the growth of a resilient and enduring energy industry that facilitates the United States' shift towards a greener, varied, and secure energy landscape (IEA, n.d.)

Through its National Energy and Climate Plan (NECP) and the National Energy Strategy (NES) 2030, Hungary aims to develop its energy independence and security while transitioning to cleaner energy that is also more affordable. These lofty goals were established with the intention of achieving these goals. Among the most important goals that have been set for 2030 are:

- A reduction in emissions of forty percent in comparison to the levels in 1990.
- Setting a limit on the total final consumption of 785 PJ (levels from 2005).
- obtaining carbon-neutral sources to generate at least 90 percent of the nation's electricity and devising a strategy to wean the nation off of coal.
- By the year 2030, we want to have installed 6.5 GW of solar PV capacity, and our next aim is to attain 12 GW by the year 2040.
- Installation of at least 200,000 solar panels on the roofs of residential buildings, with each panel having an output of approximately 4 kW on average.
- Ensuring that the contribution from renewable sources to the gross final energy consumption reaches at least 21%.
- By the year 2030, obtaining all of the final energy consumption, above levels achieved in 2005, from carbon-free sources (IEA, n.d.).

## 5.2 Compliance and implementation challenges in the context of energy poverty

Energy poverty is a big problem in Hungary, which is shown in the high amount of household income that is assigned to energy bills, particularly in rural areas. This problem is especially severe in rural areas (Tirado Herrero and Ürge-Vorsatz, 2010). The research conducted by Energiaklub reveals that approximately 21% of households, or approximately 800,000 dwellings across the nation, are at risk of experiencing energy poverty. This risk is especially prevalent among people who live in inefficient detached houses, rely on antiquated heating appliances, and frequently turn to alternative fuel sources that emit pollutants like waste and lignite. However, ineffective mitigation efforts have been hampered by legal limits, a lack of established supportive measures, and the limited competence and resources of local municipalities. This situation has been made worse by the fact that legal constraints exist.

To address this serious problem, immediate action is required, with a focus on empowering municipal stakeholders through programs such as the EnPover Project to implement cost-effective energy conservation measures and relieve the burden of energy poverty on communities that are particularly vulnerable (Eurostat)

In Hungary, aid for energy-poor individuals is largely supplied through two channels: vulnerable consumer status, which offers social benefits and cost reductions for utilities; and the utility price reduction program, which lacks targeted support but does offer cost reductions for utilities. If a person has a limited income or is physically or mentally disabled, they may qualify for the vulnerable customer classification, which grants them access to flexible payment options including prepayment meters. However, as a result of the state's decision to stop funding the housing allowance, support has been significantly reduced, and in some regions, local subsidies continue to fall short of requirements. Previous subsidy programs for home improvements lacked any sort of socioeconomic targeting, which made it difficult for energy-poor people to qualify. In the current 2021 rehabilitation program, families with children are eligible for a subsidy of up to HUF 3 million, but the program's efficacy among low-income groups is still unknown. This is further complicated by the restrictions placed on the program's usage for the renovation of shared buildings. With the exception of a modest reduction in borrowing rates, there is not yet a comprehensive subsidy program that is dedicated to the rehabilitation of multi-family buildings in order to make them more energy efficient (Overview report on the energy poverty concept Energy poverty in the privately-owned, multi-family environment, n.d.)

Based on a survey of household budgets conducted in 2011, a first analysis of energy poverty in Hungary found that around 10–20% of households, particularly those dwelling in detached houses, were impacted. These vulnerable households, which had high energy loads and restricted incomes, were predominantly found in suburban areas, towns, and regions that were typified by housing that was not up to standard (www.emi.hu, 2023) . The high prevalence of energy poverty is largely attributable to a number of factors, including Hungary's relatively low-income levels within the EU, the inadequate energy efficiency of its housing stock, as well as remnants from the communist era, such as inefficient district heating systems (Europa.eu, 2020). These factors all contribute considerably to the problem. Bouzarovski et al. investigated the coping mechanisms that Hungarian households used as a reaction to the rising cost of energy. They focused on the influence of structural variables and socio-technical legacies that continue to contribute to energy vulnerability. The research described how rising energy prices encourage consumers to switch from using natural gas to solid fuels. This change is most common among households with the lowest incomes since people in these income brackets have a more difficult time increasing the energy efficiency of their homes due to budgetary restrictions (Bajomi, Feldmár and Tirado-Herrero, 2021)

A major fraction of the population in Hungary is living in precarious conditions, which is one of the highest rates in the European Union. This is a direct result of the rise in economic inequality that has occurred in Hungary over the course of the last decade.

The fraying of the social safety net has contributed to the deterioration of the situation, which has been made worse by the fact that welfare policies predominantly cater to those with middle- and higher-incomes, ignoring the requirements of vulnerable and low-income segments (Anna Zsófia Bajomi, Nóra Feldmár and Kőszeghy, 2020). In spite of the fact that the country's building stock is inefficient in terms of energy use, domestic energy efficiency programs have been severely restricted, making them inaccessible to those with lower incomes. The addition of particular policy measures to combat energy poverty into the NECPs constitutes a step in the right direction, thus this is an encouraging development. However, recent studies have raised concerns about the main focus on solid biomass as a source of renewable energy, drawing attention to the sustainability and air pollution issues related with the use of home solid fuels (Bankwatch, n.d.). An in-depth analysis of the goals set to combat energy poverty in numerous member states located in central and eastern Europe, including Hungary, shows that there are no clear targets set, and no attempt has been made to address the multidimensional character of energy poverty. While individual member states are beginning to address the issue of energy poverty, the implementation plans developed by the European Commission are primarily comprised of soft tools. This highlights the necessity of more comprehensive policy actions being taken at the national level (Oberthür, 2019).The mitigation of energy poverty in Hungary depends on addressing various issues, as highlighted by the vulnerability factor table that is relevant to the Hungarian environment. The presence of a dependable combination of residential energy sources, such as gas or a district heating network, has a substantial impact on vulnerability. Affordability, ascertained through the income quintile and the ratio of median energy expenditure to total household spending, offers valuable insights into the economic burden that energy expenses place on households. Moreover, the repeated failure to make payment for utility bills throughout the year reveals ongoing financial difficulties. The ability to access the gas network and district heating network enhances the resilience of families in meeting their energy requirements. The annual specific energy consumption of different building typologies provides insight into the total energy performance of distinct structures, hence indicating their energy efficiency. Gaining insight into the requirements of households, namely their capacity to sufficiently warm their residences, is essential for fully grasping the seriousness of the problem. Examining household energy sources and heating systems, such as centralized and single-space heating, yields significant insights for conducting focused solutions. The various issues mentioned highlight the intricate nature of energy poverty in Hungary and emphasize the necessity for comprehensive policies and initiatives to tackle the diverse challenges experienced by disadvantaged households (Bajomi, Feldmár and Tirado-Herrero, 2021).

*Table 5 List of Vulnerable Factors to measure vulnerability factors for energy poverty alleviation (Bouzarovski and Petrova, 2015)*

| Vulnerability Factor | Variables |
|---|---|
| Access | Mix of energy sources used in the home; access to a district heating system or a gas network |
| Affordability | unable to pay electricity bills more than once in the previous 12 months; income quintile; |
| Flexibility | possesses access to both the district heating and gas networks. |
| Energy Efficiency | The annual specific energy consumption of every type of structure |
| Needs | Cannot heat their home adequately |
| Practices | Household energy source, heating method (centralized, single-space heating |

# 6 THE POTENTIAL FOR INVESTMENT IN ENERGY EFFICIENCY THROUGH FINANCIAL INSTRUMENTS

## 6.1 Energy Efficiency targets, measures in place and proposed

Hungary, being a transitional nation, faces the repercussions of its previous dependence on inadequately insulated prefabricated construction blocks, which still make up 20% of its residential building inventory. Despite diligent endeavors, a mere 36% of these edifices have received renovation. The residential sector of the country continues to exhibit a somewhat elevated level of energy consumption, with households responsible for 78% of the total energy consumed by structures. This consumption is predominantly reliant on gas (46%) and wood (28%). Hungary has established specific goals for the rehabilitation of buildings, with the objective of renovating an area of 15,000 square meters or 3 to 5 public buildings per year. This would account for around 3% of the total stock of public buildings. Nevertheless, the COVID-19 epidemic has impeded the progress of building construction and rehabilitation endeavors, posing difficulties in attaining the established objectives. The service industry, which includes public administration, currently utilizes around 10,000 to 12,000 buildings. In 2017, the estimated energy consumption of these buildings was 2.1 million tonnes of oil equivalent (Mtoe). This represents an 8% decline in energy consumption over the past five years, in contrast to a 2% growth observed across the European Union's 28 member states.

The National Energy Strategy and the National Energy Efficiency Action Plans are two pieces of evidence that demonstrate how Hungary has thoughtfully and purposefully positioned energy efficiency (EE) as a priority within its policy framework. The emphasis is placed on achieving goals such as lowering energy imports, enhancing energy security, and ensuring that energy is affordable, particularly for household use. Despite the fact that the country has been reaping the benefits of a positive economic climate since 2014, the persisting ramifications of the current crisis necessitate a comprehensive appraisal of future prospects. The nation has been diligently pursuing a comprehensive rehabilitation plan for buildings.

Notably, the National Energy Strategy established specific parameters, such as the implementation of cost-optimal requirements for buildings receiving state-backed renovations and the integration of Near Zero Emission (NZE) standards for all new public buildings after 2019, followed by all buildings after 2021. Both of these milestones will be accomplished in the coming years. A new energy performance labeling system, the enforcement of energy audits and performance certificates during property transactions, and the alignment of technical specifications for the renovation of existing buildings with those governing new constructions are also prioritized by this strategy. A yearly objective has been established for building renovations across all industries, and a variety of intensive awareness programs have also been developed to complement this initiative.

*Table 6Hungary's energy savings targets and 2019 and 2020 status ( Source: EUROSTAT)*

| EE targets (Mtoe) | 2017 Data | Target 2020 | Target 2030 |
|---|---|---|---|
| Primary energy consumption | 24.5 | 27.0 | 31.0 |
| Final Energy Consumption | 18.5 | 19.0 | 21.0 |

Notably, the current policies mainly rely on the financial mechanisms provided by the European Structural and Investment Funds (ESIF) as well as domestic resources, most prominently in the form of grants and other financial instruments. In spite of these efforts, the prediction for 2030 anticipates a significant 18% increase in final energy consumption compared to the statistics for 2016. This significant increase is mostly attributable to a surge in industrial production as well as an increase in fuel consumption. Importantly, the National Energy and Climate Plan (NECP) presents key new measures that will be implemented between the years 2020 and 2030. These measures include the construction of two new nuclear power plants to facilitate the phased withdrawal of carbon power generation in Hungary as well as an aggressive push toward renewable energy sources, most notably solar power. Notable new additions to the existing policy repertoire include the introduction of tax relief initiatives aimed at businesses that invest in EE enhancement, the implementation of an obligatory framework for energy providers and end users, and an overarching promotion of Energy Service Companies (ESCOs) and Energy Performance Contracting (EPC) mechanisms. These extensive efforts, taken together, demonstrate Hungary's unwavering dedication to advancing sustainable development and embracing a future characterized by energy efficiency and environmental awareness (IEA 2022)

**Residential Sector Context or Target**: The National Energy and Climate Plan (NECP) forecasts a 20% reduction in household energy consumption by 2030 compared to 2015, indicating a significant decline of 30% in the usage of natural gas and district heating, further emphasizing Hungary's commitment to energy efficiency. This reduction is expected to take place in the residential sector. In order to accomplish these goals, a number of different measures, both those that are already in place and those that are still in the planning stages, have been identified. The primary focus of these measures is the execution of severe repair and construction criteria for buildings, which are supported by a variety of financing strategies.

**Existing Actions**: To support its energy efficiency initiatives, Hungary has mostly relied on grants and financial instruments (FIs), with a noteworthy emphasis on panel refurbishing programs for block dwellings. In addition, since 2014, the 'Warmth of Homes' grant program has contributed 86 million EUR worth of grant support toward the modernization of over 130,000 households through the provision of grant assistance. In addition, the Hungarian Development Bank has introduced the New Residential Loan Scheme, which exemplifies the country's multidimensional approach to financing energy-efficient renovations in the residential sector. This strategy is an example of the New Residential Loan Scheme.

**Existing and planned actions:** Looking ahead, Hungary has the intention of implementing a number of cutting-edge measures that will further improve energy efficiency in the residential sector. This includes the creation of small power plants that may be used in homes, particularly photovoltaic systems, as well as the incorporation of smart metering and other methods for the storage of electrical energy. In addition, it is predicted that an emphasis will be placed on the modernization of domestic heating equipment as well as the utilization of sustainable heating fuels that are based on biomass in an effort to encourage the responsible and efficient use of fuel wood. In addition, a large-scale project is currently under way to install one million intelligent energy meters in homes across the country. This project is part of a holistic campaign that aims to highlight the nation's proactive stance toward increasing energy efficiency and sustainability at the residential level.

## 6.2 ESIF resource, key grant programs, and other existing financial instruments

With significant money allotted to many sectors, particularly for energy efficiency (EE) efforts, Hungary has emerged as one of the main recipients of support from the European Union (EU). This has allowed Hungary to emerge as one of the major beneficiaries of EU support. The nation has done a good job of putting the European Structural and Investment Funds (ESIF) to good use in order to support its extensive variety of programs, the majority of which have been carried out through Operational ProgrammS (OPs). In addition, the exploitation of financial mechanisms, particularly in conjunction with ESIF funds, has been an essential component of Hungary's strategy for promoting environmental efficiency.

**1. The Distribution of Funds from the ESIF**

The European Structural and Investment Fund (ESIF) allocated a total of 25 billion EUR to Hungary, or an average of 2,532 EUR per person, during the period of 2014-2020.

About 3.25 billion Euros were set aside for the low carbon economy. Of this total, the European Regional Development Fund (ERDF) contributed 1.85 billion Euros, the Cohesion Fund (CF) contributed 994.1 million Euros, and the European Agricultural Fund for Rural Development contributed 394.3 million Euros.

Distribution of ESIF money as follows:

10,7 billion euros for the ERDF.

6.0 billion Euros for the Cohesion Fund

4.7 billion euros for the ESF

3.4 billion Euros for the EAFRD

39 million Euros for the EMFF

**2. The use of various types of financial instruments**

With a total contribution to the ESIF of 2.3 billion Euros, Hungary is the second-largest country in Europe in terms of its position as the second-largest contributor to financial instruments. This represents around 9% of Hungary's budget for the EU.

The provision of financial instruments for EE was allocated 204 million Euros, which was approximately 13.5% of the total support allocated for EE-related activities.

Both the Hungarian Development Bank (MFB) and the agricultural guarantee fund AVHGA have been very active in the implementation of a variety of financial instruments, such as loans, guarantees, and equity investments, with a primary focus on providing assistance to small and medium-sized businesses.

In conjunction with ESIF funding, a number of different financial instruments have been put into action, which has resulted in the creation of separate and efficient operations aimed at the same projects.

**3. Financial Tools Aimed at Improving Energy Efficiency**

During the present programming period, the MFB has identified and executed a total of sixteen different financial instruments, with a particular emphasis on RDI, EE, and the social economy. The following are examples of notable financial instruments

- SME financing for energy projects

- grants and loans to improve energy efficiency in houses
- Combined loans for improvements to small and medium-sized buildings

**4. Reflections on Previous Experiences and Future Prospects**

It is clear that Hungary has a great amount of expertise in the application of financial instruments, particularly in the form of loans, which indicates that there is significant potential for EE improvement across a variety of industries.

The growth of the residential sector and the increase in median household income have paved the way for favorable conditions that are favorable for the adoption of financial instruments.

Beneficiaries in the residential sector have shown a positive response to financial instruments, despite the fact that grants have been made available to them; this demonstrates the efficiency of integrated models.

The investigation of the opportunities presented by the prospective activation of Energy Service Companies (ESCOs) and Energy Performance Contracting (EPC) will continue to be an important part of future attempts.

**5. The Primary Grant Programs of the ESIF**

The following are the key grant programs that are financed by ESIF:

Residential energy efficiency subsidies offered through a grant scheme

Subsidies for buildings owned by national and local governments that have been awarded through a grant program It is clear that Hungary is committed to encouraging energy efficiency and sustainable practices across a variety of industries as seen by its decision to use financial mechanisms and award programs. Continuing efforts and developing creative tactics are going to be absolutely necessary in order to guarantee the continued advancement and success of EE programs across the country.

# 7 ENGINEERING SOLUTIONS FOR ENERGY EFFICIENCY IN HUNGARIAN BUILDINGS

## 7.1 Integration of renewable energy sources in Hungarian building design

The Hungarian government has achieved significant progress in its energy policy by incorporating renewable energy sources into the country's construction industry. The strategic documents developed from 2010 to 2013, such as the National Energy Strategy, National Energy Efficiency Action Plans, New Széchenyi Plan, National Renewable Energy Action Plan, Fourth Environmental Programme, and National Climate Change Strategy, emphasize the importance of giving priority to sustainability, energy efficiency, and the use of renewable energy in the construction sector.

The National Energy Strategy prioritizes the attainment of sustainability and security in energy supply. The document presents a detailed plan for implementing energy-saving strategies and supports the development of clean energy sources. It emphasizes the importance of implementing strong building insulation programs to tackle the issues caused by excessive natural gas usage, especially in winter.

In addition, the National Energy Efficiency Action Plans (NEEAP) provide comprehensive information on current and future energy efficiency initiatives, with the objective of decreasing overall energy usage. The alignment of the NEEAP with the NABEPS highlights the significance of developing institutional and monitoring measures to ensure effective policy implementation (National Energy and Climate Plan, n.d.)

The Green Economic Development initiative, under the New Széchenyi Plan (NSZP), places renewable energy and energy efficiency as top priorities in order to improve building energy performance. The initiative aims to support the building of a viable economic framework, assist the generation of employment opportunities, and encourage equitable development in rural areas.

The National Renewable Energy Action Plan (HUNREAP) establishes a compulsory objective for the proportion of renewable energy in the total energy consumption. The strategy prioritizes the utilization of renewable energy sources for building energy supply, with the goal of reducing greenhouse gas emissions (Tatai et al., 2021)

In addition, the National Energy Efficiency Action Plans (NEEAP) provide comprehensive information on current and future energy efficiency initiatives, with the objective of decreasing overall energy usage. The alignment of the NEEAP with the NABEPS highlights the significance of developing institutional and monitoring measures to ensure effective policy implementation

(National Energy and Climate Plan, n.d.)

The Green Economic Development initiative, under the New Széchenyi Plan (NSZP), places renewable energy and energy efficiency as top priorities in order to improve building energy performance. The initiative aims to support the building of a viable economic framework, assist the generation of employment opportunities, and encourage equitable development in rural areas.

The National Renewable Energy Action Plan (HUNREAP) establishes a compulsory objective for the proportion of renewable energy in the total energy consumption. The strategy prioritizes the utilization of renewable energy sources for building energy supply, with the goal of reducing greenhouse gas emissions (Tatai et al., 2021).

### 7.2 Energy efficiency engineering practices for energy poverty alleviation in Hungary

Solid biomass makes up 80% of Hungary's renewable energy consumption, demonstrating the country's reliance on traditional energy sources. Spas that don't use heat recovery and the residential and agricultural sectors are the main users of geothermal energy, despite the abundance of this resource. Wind energy's potential is small and regional, but solar's growth is tremendous. Large-scale hydropower plants continue to provide political issues despite relatively constant utilization. Oil and natural gas account for around 60-70% of Hungary's principal energy use, with the remaining 10% coming from nuclear power and the other 10% from fossil fuels. The three largest consumers of energy are the residential, transportation, and industrial sectors (Bart, Csernus and Sáfián, 2018).

In Hungary, notable renewable energy methods have been successfully incorporated into building infrastructure, with a primary emphasis on geothermal heating systems. This is evident from the case studies conducted in Lenti and Mórahalom.

Geothermal Heating System by Lenti

Summary:

Lenti, Hungary, has effectively established a geothermal heating system for 10 public facilities by utilizing a production well and a re-injection well. The project, with an estimated value of over EUR 3 million, seeks to deliver sustainable geothermal heat while achieving a substantial reduction in carbon emissions.

Accomplishments:

The yearly output amounts to 8344 gigajoules of renewable heat.

A significant decrease of 520 metric tons per year of carbon dioxide ($CO_2$) emissions, which is equivalent to approximately 60-70% of the overall emissions. Intended for future scalability to include individual consumers. Successfully tackled obstacles pertaining to escalating building expenses and legal limitations linked to the current categorization of thermal water.

The Mórahalom Geothermal Cascade System is a geothermal energy system

Summary:

The Mórahalom Geothermal Cascade System, which was started in 2008, provides heating for 12 public buildings in the municipality, resulting in a significant reduction of 1054 t/year in CO2 emissions. The project was a crucial component of the town's complete smart city strategy, demonstrating a dedication to sustainable economic growth and environmental conservation.

Technical specifics:

The initiative, with an estimated cost of around EUR 115,000, secured funding from many sources, including the EU Structural Funds, the Geocom project financed by FP7, and the EEA/Norway awards program.

The single-pipe system integrates a co-generator that utilizes methane content to generate power, resulting in an efficient and cost-effective operation.

The municipality's inadequate human capacity necessitated the involvement of external expertise, highlighting the significance of external support in ensuring the successful execution of the project.

Hungary's geothermal heating programs showcase the country's commitment to sustainable energy solutions, highlighting the crucial role of geothermal resources in mitigating carbon emissions and promoting lasting environmental sustainability in infrastructure development (Heves, 2021).

# 8 HEALTH AND SOCIAL IMPACT ASSESSMENT IN HUNGARY

## 8.1 Health implications of energy poverty in Hungarian buildings

For low-income families, the threat of freezing temperatures throughout the winter months increases the likelihood that they may resort to heating their homes with anything, including toxic combustible garbage, which has devastating effects on the environment and people's health (Győri, Huszár and Balogh, 2021)

From 2003 to 2022, figures for Hungary show that a large percentage of households will be unable to affordably heat their homes due to energy poverty. From a high of 17.7% in 2003, the proportion peaked at 15.0% in 2011 and is expected to decline to 4.7% by 2022 (Joint Research Centre (European Commission) and Menyhért, 2023)

Indicating probable socioeconomic issues and poor access to resources necessary for maintaining efficient heating, this data shows the challenges faced by vulnerable individuals. Although there has been a declining trend in energy poverty over the past few years, more work may be required to address the root causes of the problem and guarantee long-term solutions for the poor.

Here is a look at the numbers for Hungary between 2003 and 2022 that focus on the percentage of the population that is living in substandard housing conditions because of their low incomes (SDG_07_60):

From 2003 to 2022, figures for Hungary show that a large percentage of households will be unable to affordably heat their homes due to energy poverty. From a high of 17.7% in 2003, the proportion peaked at 15.0% in 2011 and is expected to decline to 4.7% by 2022. Indicating probable socioeconomic issues and poor access to resources necessary for maintaining efficient heating, this data shows the challenges faced by vulnerable individuals. Although there has been a declining trend in energy poverty over the past few years, more work may be required to address the root causes of the problem and guarantee long-term solutions for the poor (Europa.eu, 2011)

## 8.2 Social consequences and vulnerable population groups affected by energy poverty

According to the housing report that was issued by Habitat for Humanity Hungary in the year 2020, vulnerable social groups that are disproportionately affected by energy poverty include single retirees, people who are unemployed, families with children, and single-parent households (Europa.eu, 2011).

A comprehensive study of the social composition of energy-poor households was carried out by Fulop and Lehoczki-Krsjak, who used data from 2012 to compare two unique definitions of energy poverty (Martey et al., 2021). The findings of this study can be found in the following paragraphs.

According to the initial definition, which was referred to as the 2M indicator, households that spent more than thirty percent of their income on energy were considered to be energy poor. As a result, ten percent of Hungarian homes were placed in this category. Notably, there were twice as many single-person households in this group compared to the average for the nation; these households made up half of all energy-inefficient homes.

The second criterion, known as the Low Income High Cost (LIHC) method, was used to identify households that spent more than the median amount on energy but still had incomes that were lower than the federal poverty level after accounting for this expense. 21% of Hungarian households were determined to be in an energy-poor category when evaluated using this criterion. When compared to the whole population, the percentage of single-person homes in this subgroup was slightly higher than average, coming in at 30% rather than 24%. In spite of this, a sizeable proportion of this group was made up of families with children—42%, to be exact—whereas just 22% of the whole population was.

The study highlighted how the 2M indication highlighted the vulnerability of mostly single households, whereas the LIHC definition focused light on the energy poverty suffered by families with one or more children, concentrating on disposable income after the payment of utility bills. The analysis also highlighted how the 2M indicator highlighted the vulnerability of predominantly single households (Turai , chmatzberger and Broer, 2021)

The 2018 disaggregated data shows that 8.9% of households in Hungary's social housing sector were unable to keep their homes adequately warm and that 21.6% of households in this sector had electricity bill arrears. Although private tenants only make up 5% of the population, they are the second most vulnerable group. Energy poverty and its related financial consequences in Hungary are particularly severe in rural areas, highlighting the need for immediate, focused actions (Springford, Eadie and Thomson, 2020)

### 8.3 Proposed strategies and interventions for improving public health and well-being in Hungary

The Hungarian government prioritizes public health to increase citizens' well-being, life expectancy, and quality of life. There is no youth health policy, however the 'Healthy Hungary 2021-2027' Healthcare Sectoral policy and the '5 national health programmes' considerably impact youth health. The government wants to encourage regular physical activity in children aged 6 to 14/15, sports interest, and an active lifestyle. The government is also working to implement the five hours of physical education per week for all schoolchildren, modernize health facilities for children, establish health centers for youth, and develop networks for adolescent psychiatry and addiction medicine (national-policies.eacea.ec.europa.eu, 2023).

Healthcare spending in Hungary is below the EU average in absolute terms and as a proportion of GDP. Public health expenditure as a proportion of GDP fell from 5% in 2010 to 4.4% in 2019. The country confronts issues with families struggling to pay for healthcare since two-thirds of it is state-funded. Despite acceptance of recovery funding, the government applied partially, prioritizing medical salary hikes and the construction of a large Budapest hospital. Lack of strategic planning, medical personnel leaving owing to low pay and poor working conditions, and a lack of preventative healthcare reinforce this constricted approach to healthcare growth.

Given Hungary's healthcare situation, public health and well-being initiatives and interventions should be comprehensive. Long-term strategic planning for healthcare development, effective use of EU funds for healthcare infrastructure and preventative programs, and efforts to improve working conditions and retain medical professionals may be priorities. Sustainable healthcare solutions must address the difficulties of an aging population and chronic diseases (Kökény, Süli and Ujhelyi, 2021)

Even though they may appear challenging, climate neutrality by 2050 requires significant investments across sectors. However, long-term environmental sustainability, energy security, and public health benefits surpass the early costs. Low-carbon technology and infrastructure investments help Hungary's climate goals and national prosperity. Encouraging energy efficiency reduces emissions, energy consumption, air pollution, and public health, lowering health expenses. Climate change and public health are linked, thus institutions and the public must be prepared for its health effects and strategies to minimize them. Comprehensive institutional and municipal response plans and cooling measures for vulnerable groups are needed. Controlling animal carriers, monitoring illness statistics, and implementing standards for swift public health responses to climate-related catastrophes are also important for public health in Hungary (National Energy and Climate Plan, n.d.)

# 9 POLICY RECOMMENDATIONS AND FUTURE DIRECTIONS FOR HUNGARY

## 9.1 Proposed policy interventions for alleviating energy poverty and improving climate protection in Hungarian buildings

Income, the price of energy, and the energy efficiency of households are the three primary elements that contribute to energy poverty. According to Broadman's (1991) definition of energy poverty, a household is said to be deemed energy poor if it spends more than ten percent of its income on energy (Herrero-Ürge-Vorsatz; 2014). This was one of the first definitions of energy poverty to be developed in Europe (Tirado Herrero and Ürge-Vorsatz, 2010)

Energy poverty is considered to impact 10 to 30 percent of the population in Hungary and has been on the rise since the middle of the 2000s. A key contributor to the growing rate of energy poverty in the country is the inefficient use of energy at home in Hungary, which is a major contribution to the growing rate of energy poverty in the country. Prior to the year 2010, the topic of fuel poverty was largely disregarded, which led to little attention being given to the energy efficiency of homes and domestic appliances as a significant underlying source of concerns associated with issues related to the affordability of energy.

Energy poverty in Hungary results in disproportionately high energy expenditures for households as well as a lack of acceptable energy services. In addition, there is a lack of suitable energy resources. As a consequence of this, homes that are adversely affected are compelled to resort to coping mechanisms such as switching their fuel source, most typically from natural gas to firewood.

Although there are currently domestic energy efficiency programs and price support programs sponsored by the state, the efficiency of these programs in assisting energy-poor households is still restricted to a certain degree. It is crucial to recognize the synergistic benefits that are linked with governmental interventions that aim to promote creative residential energy efficiency solutions if we are going to be successful in overcoming these challenges. By making the most of these co-benefits and putting them to good use, policymakers have the opportunity to effectively tackle energy poverty and contribute to the country's commitment to achieving global climate goals. This strategy is particularly pertinent for nations that are confronting comparable challenges, where a redefined approach to climate investments can deliver great results for both energy relief and climate action. This method is particularly relevant for nations that are facing comparable issues. This tactic is especially applicable for nations who are dealing with problems that are analogous to their own (Szlavik and Csete, 2012).

In Hungary, aid for people who are unable to afford adequate energy consumption is primarily supplied through two different methods. To begin, consumers who are considered to be vulnerable are eligible for social benefits and direct reductions in the cost of their energy bills. These advantages can take the form of instalment payment choices, postponement, or prepayment meters. This status is dependent on the applicant having a very low income or being physically or mentally disabled. In addition, there is a targeted subsidy available for firewood in rural regions, although the provisions of this subsidy are limited. However, in 2015 the state cut its financing for housing allowances, which resulted in a considerable reduction in the amount of support available to low-income consumers. Now it is up to individual municipalities to decide whether or not they will continue sponsoring the program.

Notably, the policies that are now in place in Hungary show that there is a gap between efforts to enhance energy efficiency and efforts to reduce energy poverty. Previous subsidy programs for building renovations lacked social targeting and accessibility for energy-poor households; however, a new 2021 rehabilitation program offers a 50% subsidy of up to HUF 3 million (€8,000) for all families with children. This program is intended to encourage families to reduce their energy use and save money. The incapacity of this program to handle the needs of multi-family buildings' common areas in terms of refurbishment, on the other hand, may be a factor that reduces the efficiency of the program. Notably, there are currently a limited number of subsidy programs available, with low provisions for interest rate subsidies, for the energy-efficient rehabilitation of the multi-family building stock (Turai , chmatzberger and Broer, 2021)

## 9.2 Strategies for promoting sustainable building practices and energy efficiency initiatives in Hungary

In Hungary, there are multiple subsidy programs designed to incentivize energy-efficient renovations in various sectors.

The main focus of the KEHOP programme is to provide full financial support for public buildings, covering all associated expenses (PALYAZAT and .gov.hu,). The GINOP/VEKOP programme provides assistance to small and medium-sized firms (SMEs) in implementing energy-efficient and renewable energy systems in their facilities. The TOP programme, which is a component of the Operational Programme for Urban Development, provides assistance to municipalities in establishing energy efficiency and renewable energy systems(PALYAZAT and .gov.hu,). A new programme is being developed to promote domestic energy efficiency. This programme will provide loans with a 0% interest rate. Furthermore, this programme aims to offer a 50% subsidy for the installation of more efficient boilers, replacing outdated equipment, and upgrading old freezers to versions that consume less energy. Nevertheless, a significant hindrance arises from the relatively improvised and informal style of these programmers, which frequently results in reorganization and the swift exhaustion of funding.

The Ministry for National Development implemented the Action Plan to Improve Awareness for Energy Efficiency and Climate Protection in 2015 (Ref and Ares, 2015). This plan focuses on communication, education, and monitoring mechanisms to ensure the plan is executed effectively. The policy outlines numerous financial opportunities for applications, which will be co-financed by the European Union, to promote a range of activities focused on diminishing energy use.

In addition, Hungary hosted the Solar Decathlon Europe 2019, a prestigious global competition that tasks university teams with creating and building houses that rely only on renewable energy sources. The event, which took place in Szentendre, emphasised the significance of refurbishing current buildings and presented attendees with distinctive obstacles such as incorporating local recycled materials, integrating solar photovoltaic and solar cell systems, tackling summer overheating problems, and utilizing high-performance composite materials.

The ÉMI Non-profit Limited Liability Company for Quality Control and Innovation in Building (ÉMI), which operates under the Ministry of Innovation and Technology, has actively participated in several worldwide initiatives (www.emi.hu, 2023). ÉMI notably spearheaded the Hungarian Build Up Skills Pillar I project, which focused on creating a plan to improve construction training. In addition, the organization managed the coordination of the Build Up Skills Pillar II TRAINBUD project, which aimed to provide a comprehensive training programme for HVAC skilled personnel to improve their expertise in energy efficiency and renewable energy solutions. ÉMI also formed a Sustainable Construction Skills Alliance, which includes several stakeholders from the education and construction industries.

The forthcoming reconstruction endeavor in Budapest will prioritize suburban regions, which are particularly vulnerable to environmental and health issues due to the extensive utilization of highly contaminating fuels, such as firewood. Furthermore, the initiative aims to provide assistance and advisory services to households experiencing financial difficulties, particularly those facing energy poverty. Furthermore, it promotes the generation of energy at a local level, the establishment of regions with a favorable energy surplus, and the adoption of energy-saving building materials and construction techniques. Furthermore, the program prioritizes the importance of advancing technology that facilitate climate adaptation.

Having a comprehensive financial model that incorporates both domestic and international funds is crucial for a successful implementation of the building rehabilitation program. Based on the data collected from the community during the situational analysis, the presence of financial aid is a crucial determinant of the potential success of this endeavor. The Budapest citizens' climate assembly highlighted the crucial requirement for financial assistance in the renovation of buildings to enhance their energy efficiency. It was suggested to establish an advisory and consultancy office to offer guidance and support to the public regarding refurbishment opportunities.

Efficient collaboration among key stakeholders, including the Municipality of Budapest, district municipalities, the state, and financial institutions, is important for the successful implementation of the plan. This technique aligns with measures aimed at mitigating energy poverty in residential structures in Hungary. These initiatives prioritize the significance of providing financial assistance, involving the community, and adopting energy-efficient technologies to enhance living circumstances and decrease energy expenses for low-income households. This strategy highlights the significance of providing financial assistance, involving the community, and adopting energy-efficient technologies (Tatai et al., 2021)

Reviewing the allocation of funds for renewable energy sources, energy-saving initiatives, and energy-efficiency enhancements, along with the assessment of the performance of the excise and value-added tax system for energy sources, particularly in terms of sustainability, are both essential in order to address energy poverty in residential buildings in Hungary. In addition, the participation of utility companies in the development and execution of plans and initiatives aimed at increasing energy efficiency needs to be carefully analyzed.

Additionally, there is a need to improve the energy certification of buildings, including the energy label, in order to guarantee that occupants are provided with an accurate evaluation of the building's energy performance and that this information is communicated to them. It is also vital to have a thorough system for the certification of buildings' sustainability if one wants to encourage the use of sustainable practices throughout the construction and operation of structures.

By tackling these issues, Hungary will be able to establish an atmosphere that is more conducive to the reduction of energy poverty in residential buildings. Reviewing funding systems and tax structures can make it easier to implement energy-efficient measures, which in turn makes these measures more accessible and cheaper for those that are living in energy poverty. The participation of utility companies in energy-saving projects can increase the likelihood that those projects will be carried out successfully and widely. Enhancing the processes for obtaining energy certification will assist residents in making more educated decisions regarding their energy consumption and encourage the adoption of activities that are more energy efficient. In a similar vein, the development of a sustainability certification for buildings might encourage the use of environmentally friendly materials and construction practices, so contributing to the long-term relief of energy poverty and the promotion of sustainable living standards (NATIONAL FRAMEWORK STRATEGY ON SUSTAINABLE DEVELOPMENT OF HUNGARY, 2013)

### 9.3 Future trends and challenges in the context of climate protection and energy efficiency in Hungarian buildings

Despite the enormous potential that has been discovered for this industry in Hungary, there is a noticeable lack of comprehensive support that is non-refundable for energy-efficient renovations in residential structures. The recovery plan for the country does not address the considerable energy efficiency opportunities linked with housing, completely ignoring the specific expectations given in the technical guidelines for the RRF issued by the European Commission as well as the EU Renovation Wave strategy. The current level of support from the EU has been inadequate during the course of the previous decade, principally resulting in restricted access to concessionary loans. A recent poll found plans to repair nearly 1.4 million apartments within the next five years, highlighting the urgent necessity for a robust energy home rehabilitation scheme with a considerable non-refundable element of 30 to 40 percent under the recovery plan. If carried out as planned, the refurbishment of around 650,000 apartments within the next five years might result in yearly energy savings of approximately 7.5 gigawatt hours (PJ) and a reduction of nearly 420,000 metric tons (tonnes) of $CO_2$ emissions. Such activities would not only be beneficial to the environment but also boost the state budget, causing a considerable increase in the demand for employment that might potentially surpass 100,000 individuals(Barbara, 2021)

In spite of the presence of numerous support programs falling under various components of the recovery plan and the Environment and Energy Efficiency Operational Program (EEEOP+), as well as the presence of energy service companies (ESCO) and other energy efficiency obligation schemes, the full energy-saving potential of housing renovations remains largely untapped. The strategy that was advised, which consisted of providing comprehensive support that was non-refundable and offering counseling services at a single point of access, has not been implemented

very successfully.
Although it is believed that the installation of smart meters is vital to improve the flexibility of consumers, it is recommended that this be supplemented with dynamic pricing that varies according to the time of day. This should be adopted in combination with a reassessment of the current pricing structures, specifically to compensate for projected increases in overhead costs for people who are living in energy poverty. This holistic strategy is essential for addressing future trends and difficulties in the context of climate protection and energy efficiency in Hungarian buildings (Assessment of Hungary's recovery and resilience plan Key points, 2021) Improving the standard of housing in Hungary is one of the most important factors that can be done to make the country more energy self-sufficient. In each of the past three decades, residential buildings have been responsible for a sizeable amount of total energy consumption, ranging from 34 to 40 percent. This percentage is significantly higher than the average for the European Union, which is 26 to 29 percent. The proportion of a household's total energy consumption that is allocated to heating is largely determined by the energy characteristics of the building in question. In order to achieve an appreciable reduction in the amount of energy that is consumed, the occupancy of residential buildings will be mandated to have a minimum energy rating of BB beginning on July 1, 2022.

In spite of these efforts, the rate of housing stock renewal continues to be slow, which indicates a significant slowdown in the improvement of energy quality. The renewal rate, which reflects the years needed for complete housing stock replacement based on current building statistics, has remained below 1 percent for the past three decades, implying a considerable level of obsolescence. This can be explained by the fact that the figures for current construction have not changed. Even when considering a rolling average of 10 years, the percentage of contracts being renewed has been steadily falling since 1995, with the exception of some recent incremental gains. The renewal rate in 2021 was at 0.33 percent, which was somewhat higher than the rate in 2019, which was at 0.30 percent. This indicates that the total housing stock would require around 303 years to be fully renewed based on the numbers from 2021 (Eurostat, 2011)

When compared to the annual increase of 4 kWh/m2a that was recorded for the period between 2016 and 2019, Hungary's energy demand increased at a significantly faster rate between 2016 and 2021, reaching 4.6 kWh/m2a. Despite this advancement, the top 15% of the housing stock, which is certified as green by the Climate Bond Initiative (CBI), demonstrated increased energy use. This may be due to a skewed sample that eliminates buildings of lesser quality that do not have energy certification.

In order for Hungary's building stock to become climate neutral by the year 2050, the Magyar Nemzeti Bank (MNB) and the Central Building Institute (CBI) collaborated to establish energy efficiency improvement targets for the stock. The present threshold for energy demand stands at 113 kWh/m2a, which is higher than the objective of 114 kWh/m2a for the year 2021. This trend implies a predicted average annual improvement rate of 4 kWh/m2a. These developments underscore the growing need of making ongoing efforts to satisfy energy efficiency standards and lessen the environmental impact that Hungarian buildings have (Renátó Ritter*: Making homes more energy efficient is key to Hungary’s energy independence, 1990).

# 10 QUESTIONNAIRE AND DATA ANALYSIS

A total of 268 individuals answered the 23-question questionnaire that was distributed at random to Hungarian citizens and foreign residents in Hungary. 201 respondents gave a complete response, and 61 gave a partial response, out of the 268 total. Data analysis has been done using the answers from the completed survey.

## 10.1 Age

The first question of the survey was the age of the participants. It was an only answer question to give the respondents open floor. Age is important to analysis the whole scenario as it has impact on the income and adaptability of environmental constraints. Also, it can show us the difference of knowledge based on the access to information as young people are more updated about the information and policies through internet than aged people as they are not that much familiar with using internet.

*Table 7Respondents age distribution, own work*

| Calculation | Result |
|---|---|
| Count | 201 |
| Standard deviation | 11.01 |
| Average | 35.29 |
| Minimum | 18 |
| 1st quartile (Q1) | 27 |
| 2nd quartile (Median) | 33 |
| 3rd quartile (Q3) | 44 |
| Maximum | 61 |

## 10.2 Type of accommodation

About three fifths of the people who answered live in houses, while about six fifths live in flats. This knowledge is important because it helps us understand the different ways people live. People who live in apartments may have to use shared areas to make their apartments more energy-efficient, so they need to work together. On the other hand, people who live in houses may have more power over their own energy systems, which could make efforts to save energy less effective.

*Table 8Type of accommodation of the respondent's, own work*

| Answer | Count | Percentage |
|---|---|---|
| Apartment/ lakás | 130 | 64.68% |
| House/ ház | 71 | 35.32% |

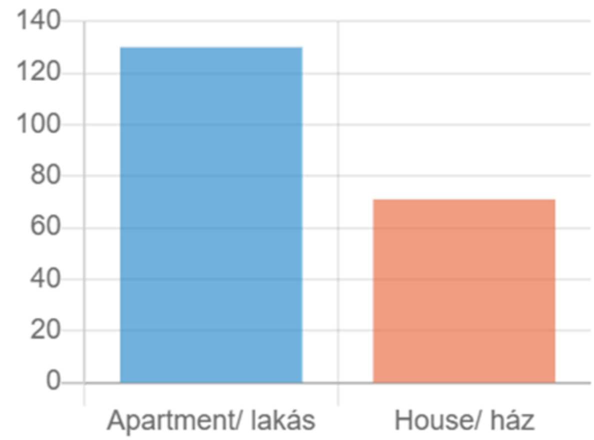


*Figure 7 Type of accommodation of the respondent's, own work*

## 10.3 If apartment, what kind of apartment

Based on the information about the types of apartments, 40.30% of those who answered live in brick-built apartments, 10.45 % live in panel apartments, 8.96% live in sliding formwork structures, and 22.3% live in apartment buildings built after 1990.

This breakdown is important for our study because it shows that different types of buildings may have different energy saving needs. For instance, the amount of insulation needed and how much energy is used could be affected by the building type and materials used, such as whether the building is made of bricks or of newer apartments.

*Table 9Type of Apartments, own work*

| Answer | Count | Percentage |
|---|---|---|
| Brick-built | 81 | 40.30% |
| Panel | 21 | 10.45% |
| Sliding formwork structure | 18 | 8.96% |
| Apartment building built after 1990 | 45 | 22.39% |

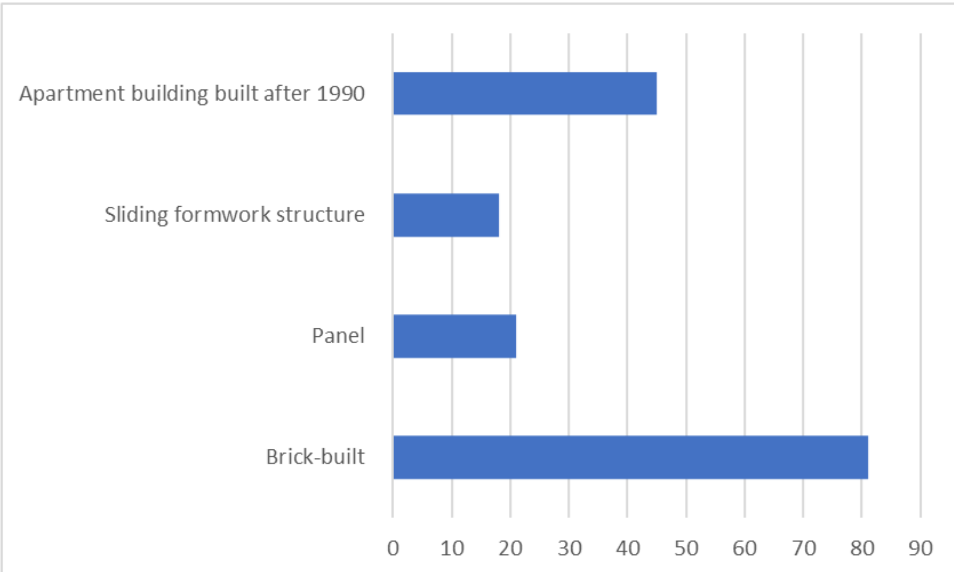


*Figure 8: Type of Apartments, own work*

## 10.4 If house, type of house

The data shows that 39.80% of respondents live in brick homes, 9.45% live in autoclaved aerated concrete (also called "ytong homes"), 7.96% live in homes made from prefabricated parts, and 2.49% live in mud homes. This knowledge is very important because it shows the different types of homes and how they should be built to protect the environment and save energy. For example, problems might be different for mud houses compared to homes made with modern building materials. By understanding these differences, suggestions and actions can be made that are specifically suited to the features of interviewees' homes.

*Table 10Types of houses, own work*

| Answer | Count | Percentage |
| --- | --- | --- |
| Mud house | 5 | 2.49% |
| Brick house | 80 | 39.80% |
| House from autoclaved aerated concrete | 19 | 9.45% |
| House built from prefabricated elements | 16 | 7.96% |

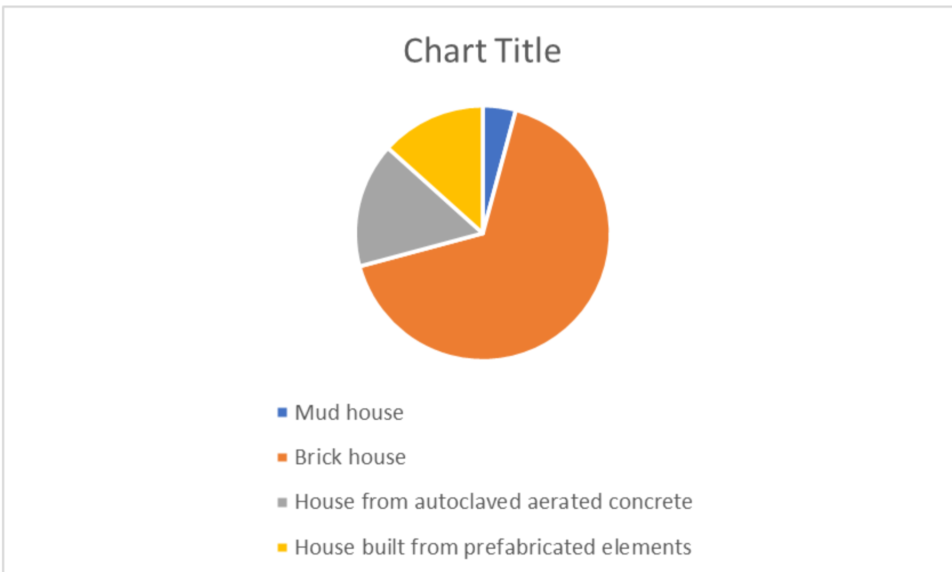


*Figure 9: Types of houses, own work.*

## 10.5 Type of settlement

Based on the type of residence, the responses show that most of them (53.23%) live in Budapest, which is Hungary's capital city. They also live in big cities (21.89%), small towns (17.91%), and villages (6.47%). This information is very important for our analysis because where the property is located can have a big effect on what climate protection and energy efficiency methods can be used for and how well they work. Cities like Budapest may have different facilities and policies than smaller towns or rural villages, which can make energy projects harder to carry out or less effective. By understanding the different types of settlements, it is possible to make suggestions and actions that are more useful to the respondents' different locations.

*Table 11Type of settlement, Own work*

| Answer | Count | Percentage |
|---|---|---|
| Village | 13 | 6.47% |
| Small Town | 36 | 17.91% |
| Big City | 44 | 21.89% |
| Budapest | 107 | 53.23% |

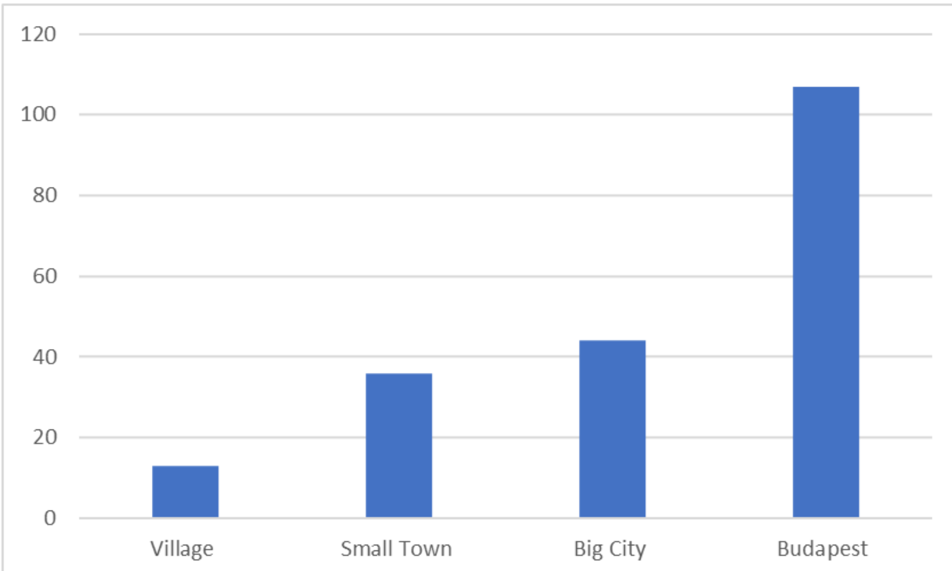


*Figure 10: Type of Settlement, own work*

## 10.6 Household Size (total number of people)

The results, with an average of 1.87, show that people have different opinions on the legal, economic, and engineering parts of protecting the climate and making Hungarian buildings more energy efficient. The standard deviation of 1.28 shows that the people who took part had a range of thoughts or experiences. To make tailored solutions to energy poverty in different building types and locations, it's important to understand these differences. The median and quartile numbers help you focus on specific areas that you want to learn more about and take action on.

*Table 12Summary of household size, own work*

| Calculation | Result |
|---|---|
| Count | 201 |
| Sum | 375 |
| Standard deviation | 1.28 |
| Average | 1.87 |
| Minimum | 1 |
| 1st quartile (Q1) | 1 |
| 2nd quartile (Median) | 2 |
| 3rd quartile (Q3) | 3 |
| Maximum | 5 |

## 10.7 Annual household income

The reported income levels of the participants shows a wide range. 12.41% made less than 1,000,000 HUF, 22.89% made between 1,000,000 and 2,000,000 HUF, 23.88% made between 2,000,001 and 3,000,000 HUF, 24.38% made between 3,000,001 and 4,000,000 HUF, and 17.41% made more than 4,000,000 HUF.

This question is very important for identifying energy poverty because it shows how respondents' finances are. How much money a person makes is a big factor in how much they can spend on energy-saving home improvements. People with lower incomes may have trouble paying for renovations or tools that save energy up front. On the other hand, people with better incomes may have more money to use environmentally friendly methods.

By looking at these income levels, we can see how different groups might be able to afford energy-saving options. To make policies and programs that help people who are poor with energy, you need to have a deep understanding of the financial problems that people from different income groups face. This knowledge is very important for making targeted plans that make sure everyone has equal access to energy-efficient technologies and help make energy use more sustainable overall.

*Table 13Household annual income of the respondents, own work*

| Answer | Count | Percentage |
|---|---|---|
| Less than 1,000,000 HUF | 26 | 12.94% |
| 1,000,000 - 2,000,000 HUF | 46 | 22.89% |
| 2,000,001 - 3,000,000 HUF | 48 | 23.88% |
| 3,000,001 - 4,000,000 HUF | 49 | 24.38% |
| More than 4,000,000 HUF | 35 | 17.41% |

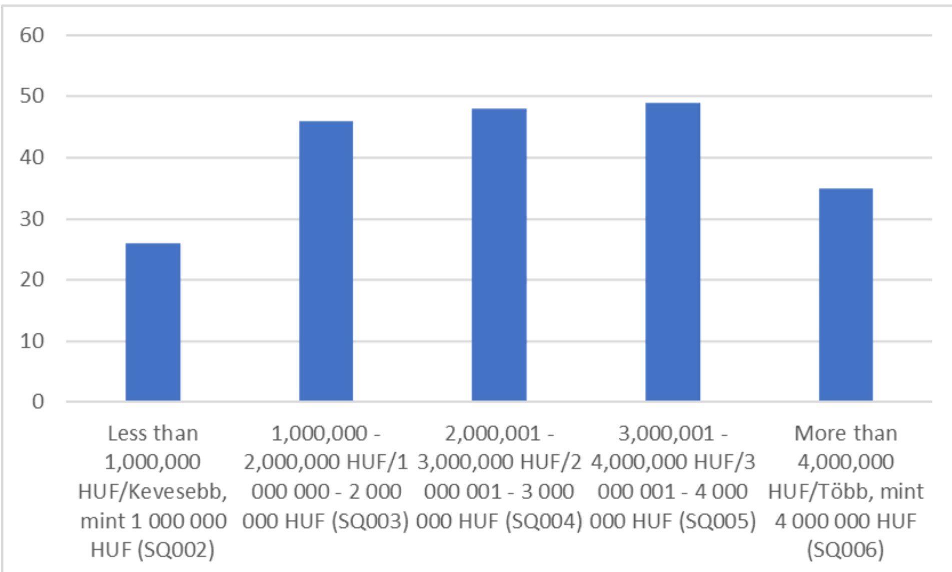


*Figure 11: Household annual income of the respondents, own work*

## 10.8 How often do they experience difficulty paying your energy bills (e.g., electricity, heating, gas)?

The answers show that the individuals had different experiences paying their energy bills. A split shows that 4.48% of people always have problems paying their energy bills, 11.44% often do, 26.87% sometimes do, 26.37% rarely do, and 31.34% never have problems.

This question is very important for knowing what energy poverty means. The number of times people have trouble paying their energy bills shows how much financial stress they may be under. People who always or often have trouble may be more likely to be energy poor, which means they might have trouble meeting their basic energy needs. Looking at these answers helps find groups that are more likely to be energy poor and guides targeted efforts to help them, like starting financial aid programs or encouraging energy-saving steps that can lower families' total energy costs.

*Table 14Frequency o difficulty in paying bills (e.g., electricity, heating, gas), own work*

| Answer | Count | Percentage |
|---|---|---|
| Always | 9 | 4.48% |
| Often | 23 | 11.44% |
| Sometimes | 54 | 26.87% |
| Rarely | 53 | 26.37% |
| Never | 63 | 31.34% |

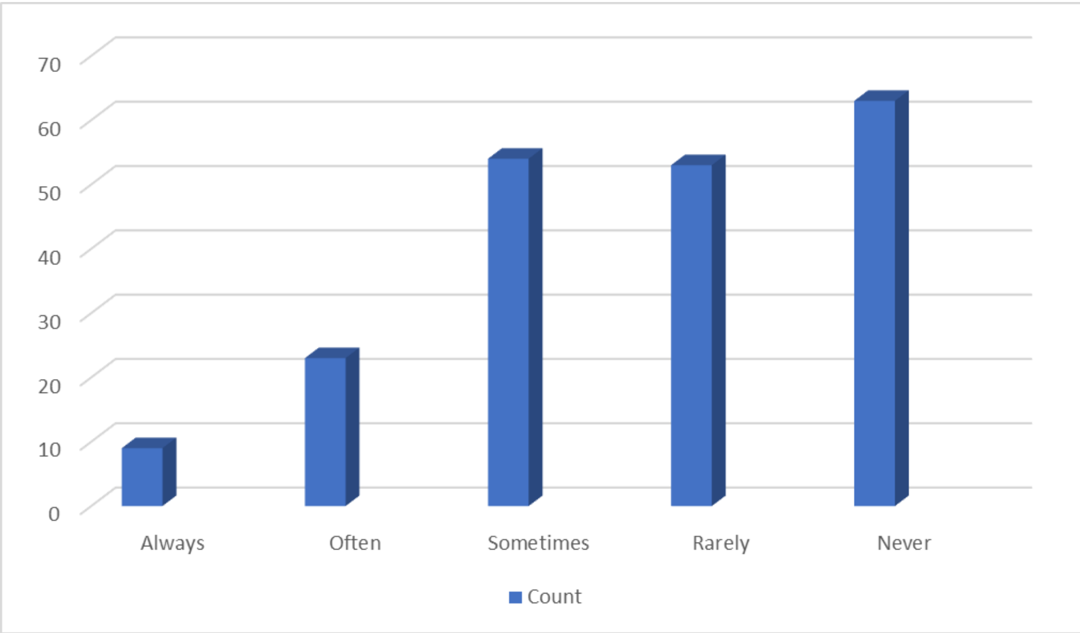


*Figure 12: Frequency of difficulty in paying bills (e.g., electricity, heating, gas), own work*

### 10.9 During the winter months, do they struggle to keep your home adequately heated due to financial constraints?

According to the findings, 42.29 percent of respondents stated they had financial problems keeping their homes warm in winter, while 55.72 percent replied "No." 1.99% of respondents did not answer, however none were tagged "Not displayed." This value is low.

This question is crucial to understanding how restricted financial resources affect winter home heating, a key aspect of energy poverty. The positive replies show that many participants struggle to heat their houses, which can affect health, well-being, and quality of life. To minimize energy poverty and provide adequate living circumstances for all people, tailored measures must address the root causes of financial constraints, such as income disparity or energy inefficiency. This will enable better solutions.

*Table 15Response of struggling to keep home warm, own work*

| Answer | Count | Percentage |
|---|---|---|
| Yes (Y) | 85 | 42.29% |
| No (N) | 112 | 55.72% |
| No answer | 4 | 1.99% |
| Not displayed | 0 | 0.00% |

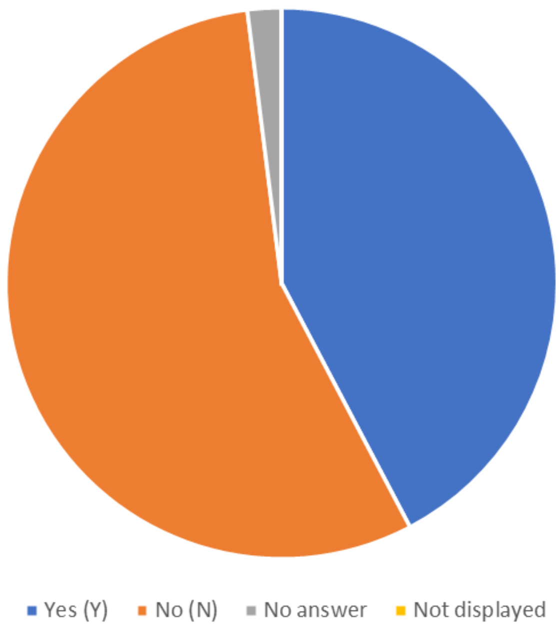


*Figure 13: Response of struggling to keep home warm, own work*

## 10.10 Have you or a close family member ever experienced health problems as a result of living in a cold, poorly heated home?

According to the findings, 45.77 percent of those who participated in the survey or members of their immediate family have experienced health problems as a direct result of staying in a home that was too cold or did not have sufficient heating. On the other hand, 51.74 percent of respondents selected "No," and 2.49 percent of respondents chose not to provide any response at all.

*Table 16Data on experiencing health problems, own work*

| Answer | Count | Percentage |
|---|---|---|
| Yes (Y) | 92 | 45.77% |
| No (N) | 104 | 51.74% |
| No answer | 5 | 2.49% |
| Not displayed | 0 | 0.00% |

This topic draws attention to the effects that poor heating and a lack of access to affordable energy have on individuals. The responses that are in the positive emphasize the relevance of addressing both the financial and health components of energy poverty by drawing attention to the potential adverse health impacts that are associated with living conditions that are below standard. Because of the information, there is a solid foundation for supporting laws and other activities that strive to improve heating conditions in order to safeguard people's health and the health of their families.

### 10.11 Have you received any financial assistance or subsidies from the government or other organizations for energy-related expenses?

15.9% of those who answered said they got money or grants from the government or other organisation to pay for energy-related costs. On the other hand, a large 81.59% said they had not gotten such support. Two and a half percent (2.49%) did not respond. This question is very important for figuring out how well and how easy it is to get help with paying for energy-related costs through current financial aid programmes. The positive responses show how much help is out there, while the majority of "No" responses show that these efforts may not be reaching as many people as they could be. The information in this report helps lawmakers improve and grow assistance programmes so they can better help people who are having trouble paying for energy.

*Table 17Response to receiving financial assistance from government or other organization, own work*

| Answer | Count | Percentage |
|---|---|---|
| Yes (Y) | 32 | 15.92% |
| No (N) | 164 | 81.59% |
| No answer | 5 | 2.49% |
| Not displayed | 0 | 0.00% |

### 10.12 Are you aware of any government programs or initiatives aimed at addressing energy poverty in Hungary?

32.84% of those who answered said they knew about government programs or projects in Hungary that aim to help people who are poor in energy. On the other hand, 64.68% said they didn't know about such programs. Two and a half percent (2.49%) did not respond. The answer to this question shows how much the people being surveyed know about the government's attempts to fight energy poverty. Some respondents are aware of these efforts, but the large number of "No" answers suggests that there may be a problem with how they are communicated or seen. This information shows how important it is to improve communication methods to make people more aware of issues and make sure that people who need them know about government programs that can help them deal with energy poverty.

### 10.13 What type of heating system do you use in your home?

The results show the types of heating systems that respondents used in their homes:

Central heating- 38.81%

Electric heating- 23.88%

Gas convector heating- 18.91%

Gas boiler heating- 16.42%

Wood-burning stove-6.97%

Fuel boiler-2.99%

To deal with energy efficiency and the possibility of energy poverty, it's important to know how common different heating methods are. The type of heating device used can have a big effect on how much energy is used, how much it costs, and how much of an impact it has on the environment. By looking at these answers, we can find ways to promote heating solutions that are more environmentally friendly and last longer. This helps save energy and money at the same time.

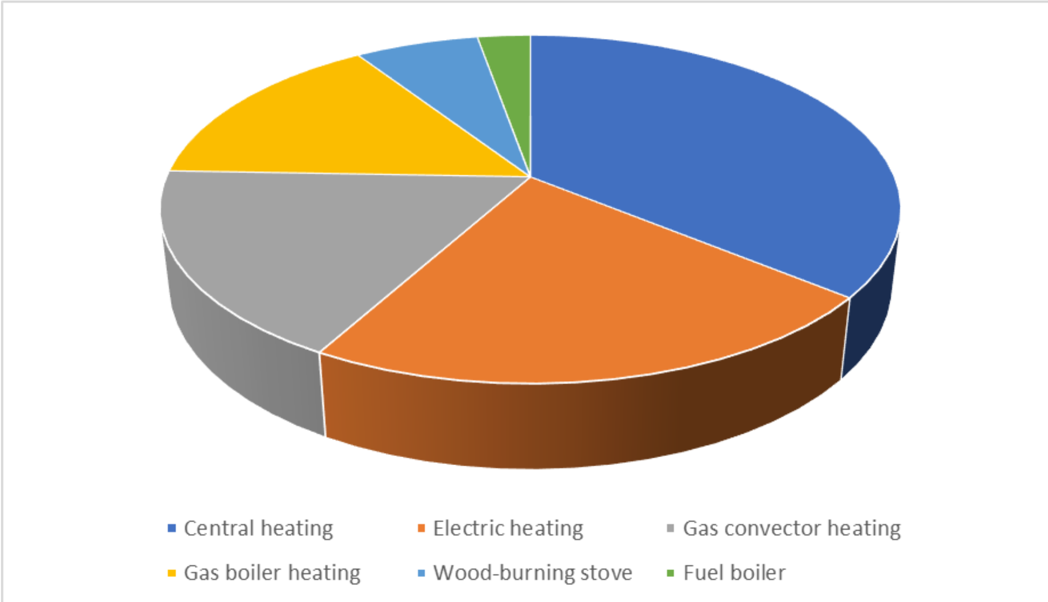


*Figure 14Type of heating system in household, own work.*

### 10.14 How would you rate the energy efficiency of your heating system on a scale from 1 to 5 (1 being very inefficient, 5 being very efficient)?

The response to the question of rating the energy efficiency of their heating system effectiveness on a scale from 1 to 5, 1 being very inefficient to 5 being very efficient is represented below

*Table 18Rating of effectiveness of the heating systems, own work*

| Answer | Count | Percentage |
|---|---|---|
| 1 (1) | 7 | 3.61% |
| 2 (2) | 26 | 13.40% |
| 3 (3) | 76 | 39.18% |
| 4 (4) | 51 | 26.29% |
| 5 (5) | 34 | 17.53% |
| No Answer | 7 | 3.48% |

The participants' perceptions of the energy efficiency of the various heating systems were rated using these scales, which provide useful information. The majority of respondents fell within the middle range (3), which indicates a judgement of efficiency that is moderate. The data reveals a varied range of perspectives, which highlights the necessity for individualized tactics to enhance energy efficiency based on the distinctive qualities of various types of heating systems. Changing these attitudes can help direct efforts to improve energy efficiency and encourage the use of heating solutions that are less harmful to the environment.

### 10.15 Have you made any energy-efficient improvements to your home, such as insulation, double glazing, or energy-efficient appliances?

44.78% of those who participated in the survey said that they had made energy-efficient changes to their homes, such as installing insulation or double-paned windows or using equipment that were more energy-efficient. On the other hand, 51.24 percent of respondents said "No," and a minor percentage, 3.98%, did not submit a comment.

*Table 19Responses to energy efficient improvements initiatives taken by households, own work*

| Answer | Count | Percentage |
|---|---|---|
| Yes (Y) | 90 | 44.78% |
| No (N) | 103 | 51.24% |
| No answer | 8 | 3.98% |
| Not displayed | 0 | 0.00% |

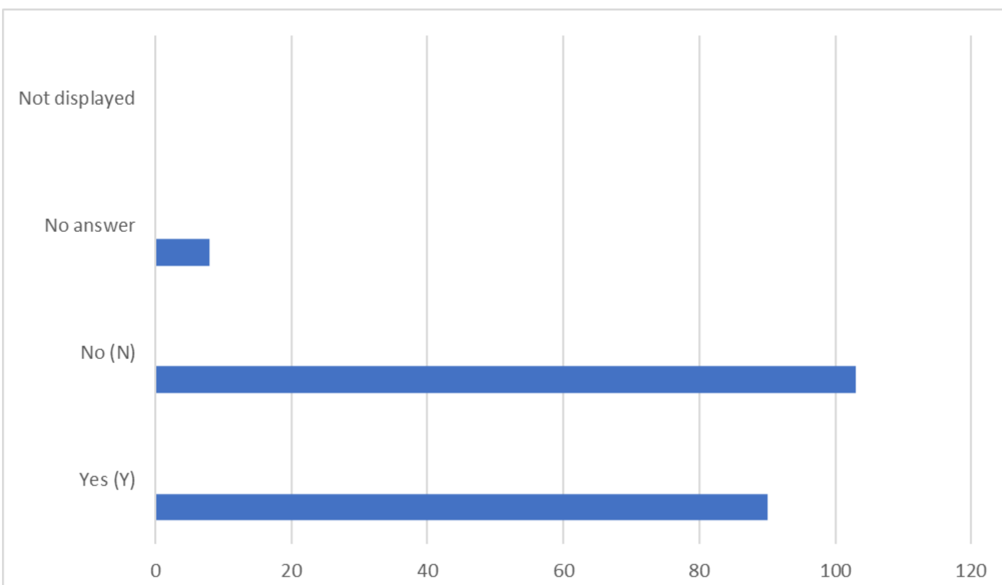


*Figure 15Responses to energy efficient improvements initiatives taken by households, own work*

The answer to this question dives into the preventative steps that people take to improve the energy efficiency of their living areas. The replies that were positive highlight the fact that some of the participants are actively contributing to sustainable practices. The analysis of these replies provides significant insights into the elements that influence the decision-making process regarding renovations that are more energy efficient and informs initiatives to encourage the wider adoption of environmentally friendly practices in residential settings.

### 10.16 Approximately, what percentage of your monthly income is spent on maintaining your home, including energy costs (heating, electricity, gas)?

The specific query is of greatest significance within the context of the survey since it is used as an essential factor in estimating the financial consequences of maintaining households. More specifically, it is used to determine how much money is spent on energy-related expenses like heating, electricity, and gas. The responses to this query are essential for determining the prevalence of energy poverty, which will be operationalized in this context as the allocation of 10–20% of one's income toward the upkeep of their home.

*Table 20Percentage of income spent on maintain home (heating, electricity, gas), own work*

| Count | Percentage |
|---|---|
| 45 | 15% |
| 40 | 14% |
| 30 | 13% |
| 25 | 12% |
| 15 | 18% |
| 10 | 20% |
| 8 | 19% |
| 5 | 17% |
| 20 | 16% |
| 15 | 25% |
| 10 | 30% |

After examining the data, it became clear that a sizeable demographic, which accounts for around 70 percent of the people who participated in the poll, falls within the 10–20 percent range that was specified. This conclusion demonstrates that a sizeable portion of the population that was questioned is contending with the possibility of living in poverty due to a lack of access to electricity. As a result, there is an urgent need for targeted interventions and policy considerations. It is absolutely necessary, in order to create a living environment that is more sustainable and equitable for these individuals and families, to address the financial restraints that are associated with the expenses related to the home.

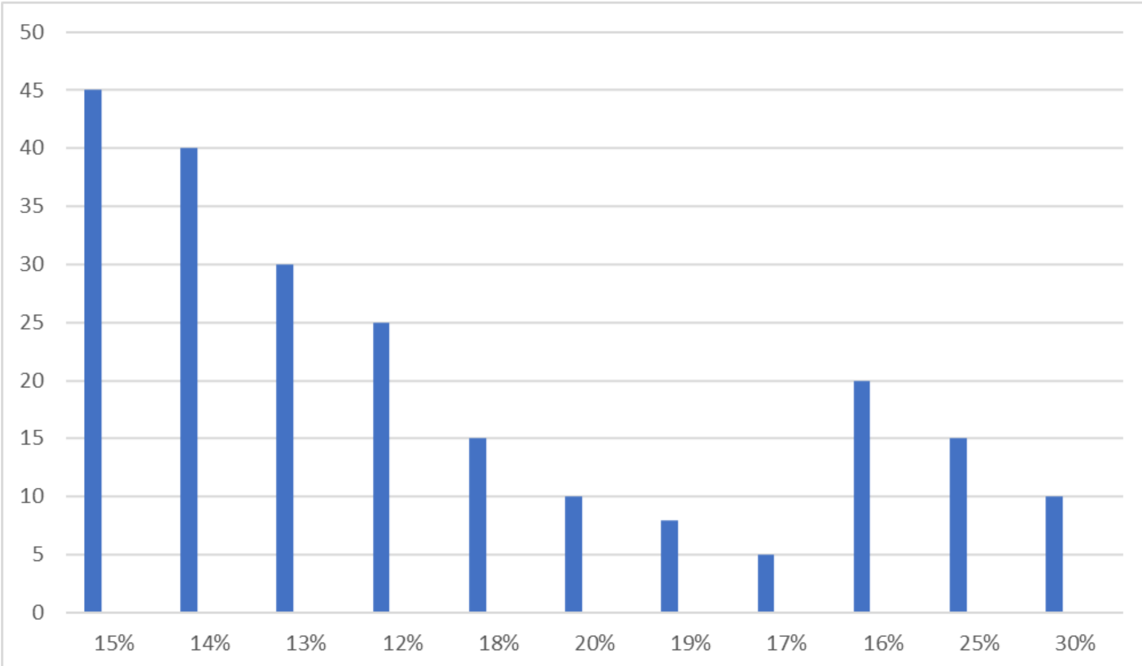


*Figure 16Percentage of income spent on maintain home (heating, electricity, gas), own work.*

## 10.17 Percentage of income spent on maintain home (heating, electricity, gas)

*Table 21Response to noticing increase of income in past years, own work*

| Answer | Count | Percentage |
|---|---|---|
| Yes (Y) | 164 | 81.59% |
| No (N) | 21 | 10.45% |
| No answer | 16 | 7.96% |
| Not displayed | 0 | 0.00% |

According to the findings of the survey, an overwhelming majority of respondents, around 81.59%, have observed an increase in the cost of living over the course of the previous five years, notably with regard to the prices of housing and energy.

On the other hand, 10.45 % of respondents said "No," and 7.96 % did not provide a comment. There was not a single response that was indicated to be "Not displayed."

This topic is extremely important for understanding the perceived trends in the costs of living, as it sheds light on the financial issues that individuals confront, particularly in relation to housing and energy. The affirmative responses demonstrate the broad knowledge of the rising cost of living, offering vital insights for policymakers and stakeholders who need to address the changing economic landscape and implement measures to reduce the financial difficulties connected with housing and energy bills.

### 10.18 Have you ever sought information or assistance from government agencies or non-governmental organizations regarding housing and energy-related issues?

According to the findings, 32.34% of respondents had sought information or support about housing and energy-related concerns from government agencies or non-governmental organizations. This is indicated by the statistics. On the other hand, 63.18 percent of respondents said "No," and a somewhat smaller amount, 4.48%, did not submit a comment. There was not a single response that was indicated to be "Not displayed."

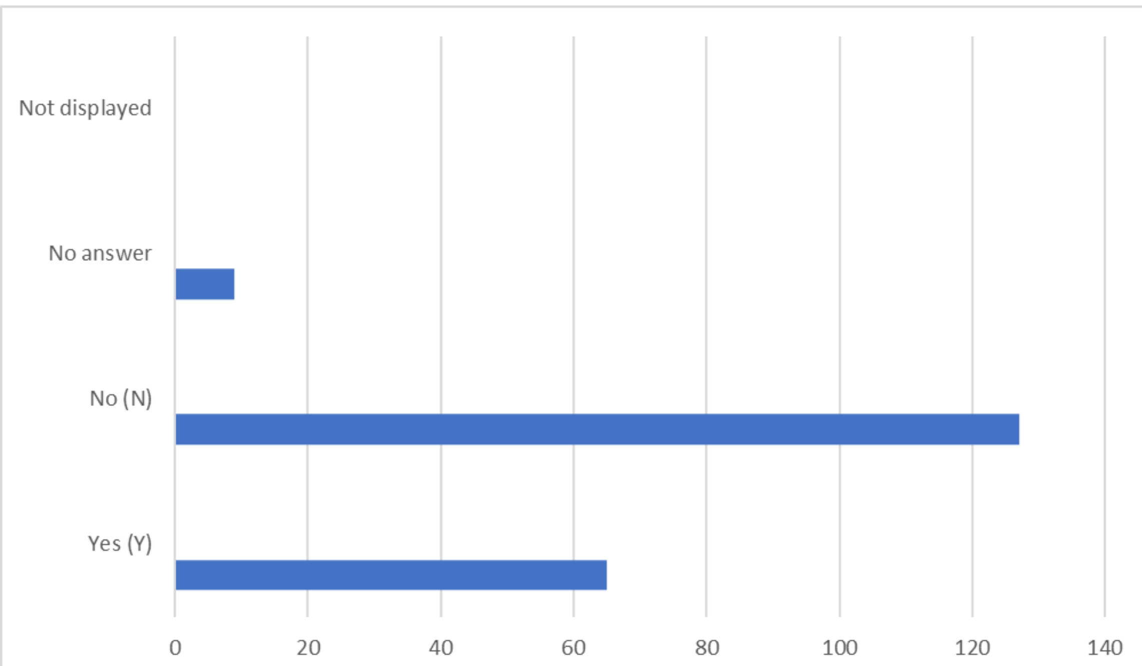


*Figure 17Responses to seeking information from government/non-government organization, own work.*

The response to this question is critical for determining the extent to which individuals actively seek guidance or support from relevant authorities or groups about housing and energy-related concerns. The responses shed light on the prevalent patterns of engagement with the various resources and services that are now available. The analysis of these data can give policymakers and service providers with information on the efficiency of the informative and support mechanisms that are currently in place. This can guide efforts to improve accessibility and awareness among individuals who are experiencing difficulties linked to housing and energy.

### 10.19 How would you rate the government's efforts in addressing energy poverty and improving housing conditions in Hungary on a scale from 1 to 5 (1 being very ineffective, 5 being very effective)?

On a scale running from 1 to 5, the following is how the respondents rated the efforts of the Hungarian government to alleviate energy poverty and improve housing conditions:

*Table 22Response to rating government's effort addressing energy poverty, own work*

| Answer | Count | Percentage |
|---|---|---|
| 1 (1) | 18 | 9.73% |
| 2 (2) | 55 | 29.73% |
| 3 (3) | 80 | 43.24% |
| 4 (4) | 19 | 10.27% |
| 5 (5) | 13 | 7.03% |
| No answer | 16 | 7.96% |

The findings show a variety of perspectives regarding the efficiency of government programs in reducing energy poverty and improving housing conditions. The majority of people have an opinion that falls within the middle range (3), indicating that they have a mixed impression of the efforts made by the government. The distribution demonstrates how important it is to conduct additional research into the particular facets of government policies and initiatives that lead to these viewpoints. The examination of these statistics can provide guidance to policymakers in the process of refining policies and addressing specific concerns to boost the overall effectiveness of activities targeted at improving housing conditions and the energy poverty that exists in Hungary.

### 10.20 Are you aware of energy conservation practices or programs in your community, such as energy-efficient lighting or appliances?

According to the findings, 59.20% of respondents are aware of energy conservation measures or programs that are available in their town. These practices or programs may include energy-efficient lighting or appliances. On the other hand, 36.32 percent of respondents said "No," and a relatively tiny minority, 4.48%, did not submit a response. There was not a single response that was indicated to be "Not displayed."

*Table 23Response on awareness of energy conservation practices, own work*

| Answer | Count | Percentage |
|---|---|---|
| Yes (Y) | 119 | 59.20% |
| No (N) | 73 | 36.32% |
| No answer | 9 | 4.48% |
| Not displayed | 0 | 0.00% |

This question is quite helpful in determining the level of awareness that exists among the population that was polled with regard to energy saving measures that are taking place within their neighborhood. The replies that were positive imply that a considerable majority of the participants are aware of such practices, which highlights the potential for community-driven activities to promote energy efficiency. This data can be analyzed to provide community leaders and groups with guidance on how to modify communication methods to increase knowledge of energy conservation initiatives and participation in those programs, so cultivating a community that is more sustainable and environmentally conscious.

### 10.21 Have you personally taken any steps to conserve energy in your daily life, such as reducing energy consumption, turning off lights, or using energy-efficient appliances?

According to the findings of the survey, an overwhelming majority of respondents, or around 76.62%, have taken personal actions to reduce their energy use in their day-to-day life. This include actions like as decreasing energy usage, switching to energy-efficient appliances, and turning off lights when they are not in use. On the other hand, 18.91% of respondents said "No," and a smaller minority (4.48%) chose not to submit a comment. There was not a single response that was indicated to be "Not displayed."

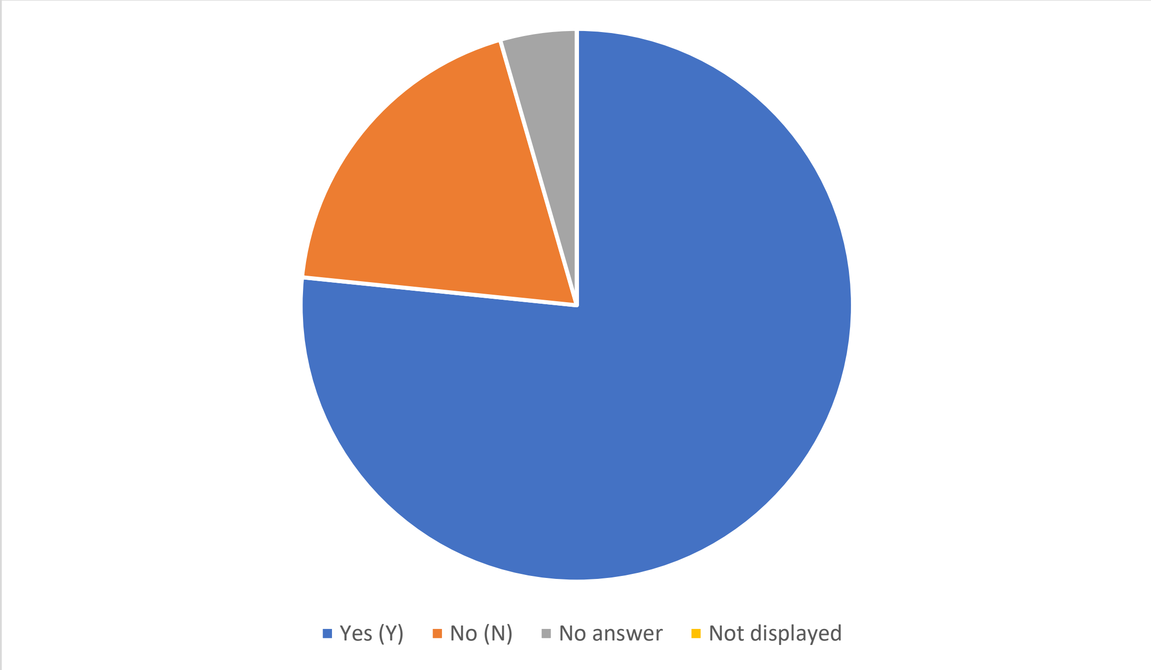


*Figure 18Response on personal steps on conserving energy, own work.*

The response to this question is critical to gaining an insight of the individual commitment to energy saving activities within the group that was questioned. The comments that were positive demonstrate that a widespread awareness and engagement in personal initiatives to increase energy efficiency already exists. The analysis of these data not only provides insights into the performance of individual efforts, but also reveals the potential for greater community-level impacts through maintained energy conservation habits.

### 10.22 Do you believe that adopting more energy-efficient practices and technologies can help reduce energy poverty in Hungary?

According to the results of the poll, there is a significant consensus among respondents, with 84.58 percent of respondents expressing the idea that adopting more energy-efficient practices and technology can contribute to alleviating energy poverty in Hungary. On the other hand, 10.45% of respondents held a contradictory opinion, while 4.98% did not submit a comment. This question acts as a barometer of how the general public perceives the possible influence of energy-efficient measures on the reduction of energy poverty.

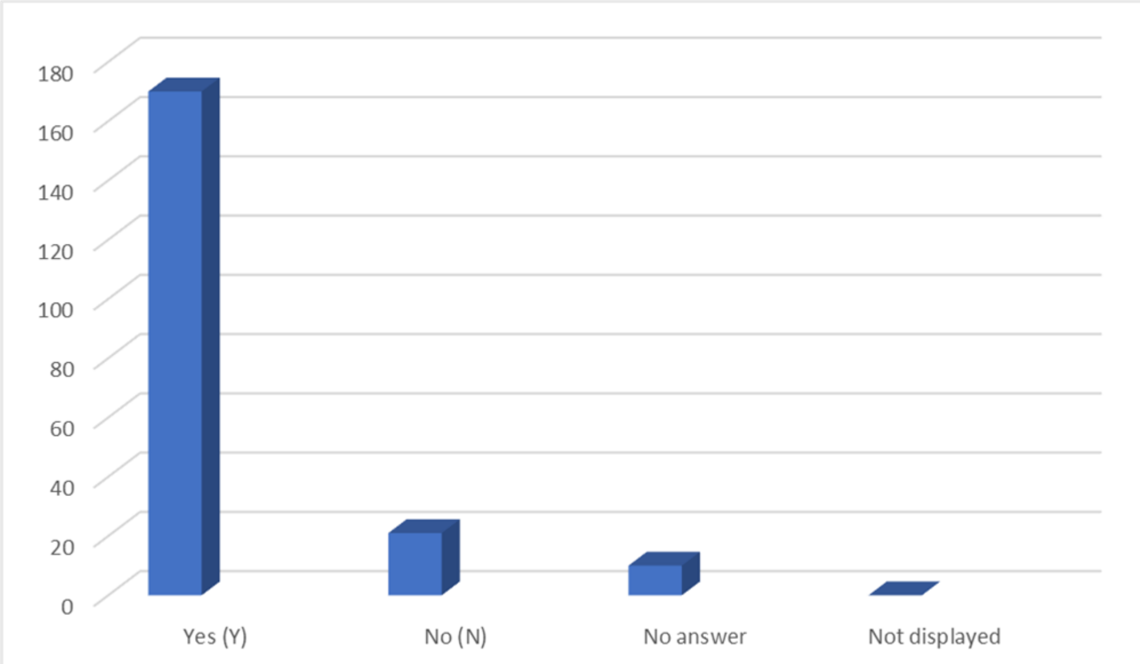


*Figure 19Response on the adoption of practicing energy efficient practices to reduce energy poverty, own work.*

The overwhelmingly positive reaction is indicative of a widespread realization that the implementation of energy-efficient techniques is an effective means of tackling the issues that are connected with energy poverty. This emotion brings to light an opportunity for politicians, communities, and organizations to collaborate on an initiative to leverage and promote sustainable behaviors, which will ultimately contribute to the alleviation of energy poverty in Hungary.

### 10.23 How much money are you willing to spend on renovations in your house for energy-efficient practices (in HUF)?

The results of the study point to a wide range of financial commitments on the part of respondents with relation to the amount they are willing to invest in home improvements that will improve their homes' energy efficiency. The willingness to spend can vary greatly, with respondents falling into the following categories according to their budgets.

*Table 24Amount of money people willing to pay to renovate houses, own work*

| **Amount in HUF** | **Count** |
|---|---|
| 0-49,999 | 70 |
| 50,000-99,999 | 50 |
| 100,000-149,999 | 40 |
| 150,000-199,999 | 20 |
| 200,000-249,999 | 15 |
| 250,000-299,999 | 6 |

The respondents' willingness to invest, on average, amounts to 94,650.77 HUF (Hungarian Forints). The vast majority of responders do, in fact, fall into the lower budget categories; nevertheless, there is also a sizeable representation in the spectrum between the two extremes. When it comes to implementing energy-efficient techniques in their houses, the participants' diverse financial considerations and objectives are brought to light by the statistics. This information is helpful for decision-makers, enterprises, and service providers because it allows them to customize their products and support systems to fit with the varied financial capacities that are present among the population that was surveyed.

# 11 CONCLUSION

## 11.1 Summary of key findings and contributions to addressing energy poverty in Hungarian buildings

At the end of this thesis, which investigated the interplay of legal, economic, and engineering aspects in the realm of climate protection and energy efficiency in Hungarian buildings, a comprehensive panorama emerges, which is marked by nuanced insights into the perceptions, behaviors, and challenges experienced by respondents. This thesis was written as part of a larger project that investigated the interplay of legal, economic, and engineering aspects in the realm of climate protection and energy efficiency in Hungarian buildings.

**Demographic and Housing Dynamics**

The investigation of demographic particulars, most notably age, serves as a foundational pillar because of its far-reaching effects on income, adaptability to environmental limits, and knowledge acquisition. This is because of the fact that age is one of the most important demographic details. The accompanying analysis of different forms of housing and their characteristics provides a sophisticated lens through which to observe the energy-related factors that are involved in a variety of different living arrangements.

**Energy Poverty and Dwelling Characteristics**

A Crucial Revelation A crucial discovery lies in the split of housing kinds, ranging from apartments to homes, along with a detailed investigation of their specific properties. This was done in order to shed light on the relationship between energy poverty and dwelling characteristics. The categorization of flats according to the materials used in their construction contributes to a deeper comprehension of the ways in which the characteristics of a residence are intertwined with issues pertaining to energy efficiency.

**Spatial Distribution and the Different Types of Settlement**

The geographic distribution of respondents across the different types of settled areas provides important insights into the potential regional variances in energy-related concerns and solutions. The thesis's applicability and relevance are improved as a result of this spatial understanding, which focuses on the broader regional energy dynamics.

**Economic Strata and the Realities of Income**

The economic landscape can be better understood by an in-depth analysis of the distribution of income in conjunction with the various forms of settlements. The identification of energy poverty, in particular when viewed through the lens of the percentage of income dedicated to housing-related costs, highlights the financial difficulties that a considerable portion of the population of respondents is currently experiencing.

**Patterns of energy consumption and efficiency**

A thorough understanding of energy consumption patterns can be attained through the accumulation of information regarding common heating systems, the efficiency of those systems, and the proactive steps taken by respondents for improving the energy efficiency of their homes. A positive leaning toward environmentally responsible behaviors is indicated by a readiness to make investments in the modernization of a building to improve its energy efficiency.

**The Obstacles of Governmental Initiatives:**

The recognition of the obstacles that are posed by an increase in the cost of living, namely in housing and energy bills, highlights the economic pressures that are present among the population that was polled. The assessment of the efforts made by the government displays a spectrum of attitudes, which represent varied degrees of pleasure and concern about the situation.

**Awareness at the Community Level and Individual Commitment**

The investigation of awareness at the community level and individual commitment to energy conservation methods reveals the active role that citizens play in the process. The potential for holistic approaches to enhance sustainability is highlighted by the combination of personal activities with community-level consciousness.

**views and Collective Perceptions**

The closing section debunks the collective views on the usefulness of energy-efficient activities in alleviating energy poverty. These ideas are discussed in more detail in the previous section. The fact that all of the respondents came to the same conclusion demonstrates that there is a widespread comprehension of the transformative role that sustainable efforts may play in the solution of energy-related problems.

Overall Concluding Statements In the broader context of this thesis, a rich tapestry of interconnected elements emerges, revealing the intricate dance between legal frameworks, economic realities, and engineering considerations in the pursuit of climate protection and energy efficiency within Hungarian buildings. The findings provide policymakers, community leaders, and organizations with a comprehensive resource that can offer actionable insights to inform targeted interventions, promote sustainable practices, and address the multifaceted challenges that are inherent in the pursuit of energy efficiency in Hungarian communities.

## 11.2 Future Recommendation to Lower Energy Poverty in Hungarian Buildings

The report examines various approaches to tackling the energy issue in Hungary. These thoughts arise due to the inherent complexity of the problem.

Based on the analysis of the survey results, it can be concluded that there is a need for income alleviation among individuals in order to cope with the rising energy costs. Comprehensive dissemination of knowledge on energy efficiency and appropriate energy utilization is vital, reaching every corner through individual or collaborative efforts. The government should establish regulations and enforce their required compliance in all households. Another approach that might be pursued is the introduction of technologies pertaining to energy efficiency and lighting.

Authorities should devise and provide targeted financial assistance to low-income households for their energy needs. These programs could include subsidies for energy-efficient house modifications, reduced energy service pricing, and funding to enhance energy resilience among low-income families.

Given that economic inequality directly results in energy poverty, it is imperative to advocate for equitable distribution of income. In order to reduce energy expenses for individuals with limited financial means, it is imperative to address and rectify these inequitable circumstances.

Individuals can acquire knowledge about energy conservation, eco-friendly practices, and energy-efficient products by participating in workshops, community education programs, and outreach initiatives.

Scientific and technological advancements provide incentives and subsidies to individuals who utilize energy-saving gadgets. We should prioritize the adoption of energy-efficient products, promote the use of renewable energy sources, and incentivize consumers to purchase energy-saving home appliances.

Optimal effectiveness of energy poverty reduction initiatives necessitates close collaboration between the government and non-governmental organizations (NGOs). Collaboratively, they can undertake significant initiatives aimed at assisting economically disadvantaged individuals by addressing technological, social, and economic challenges in the realm of energy.

Regular policy application audits and reviews can identify and rectify inefficiencies. Government initiatives must be closely monitored to ensure they effectively reach the intended recipients and adequately address their evolving requirements.

To change society, stress the economic and social benefits of living in an energy-efficient way.

When teaching about smart energy, the long-term benefits of eco-friendly habits should be emphasized.

Support new research and development projects that aim to make energy-efficient building systems. Help make housing cheaper and more long-lasting, and back technology that saves energy. Community needs and program success can be found through regular surveys. Feedback from the community helps programs have the most effect and last the longest.

International cooperation is needed to end energy poverty, and each country can learn from the successes of others. These cooperative solutions can help Hungary's energy poor people by letting them share knowledge, resources, and experiences.

These ideas could change neighborhood programs and laws if they are put into action. It would encourage fair and sustainable decisions regarding energy for Hungarian residential buildings.

## 11.3 Limitations of this study

To better understand the energy poverty of Hungarian residential buildings, a total of 23 questionnaires were surveyed in addition to other literature reviews. Because of the traits and personalities of the respondents, the survey's outcome could not be ideal. The geographical distribution was not uniform because of the researcher accommodation. Also, due to the researcher's language problem, the poll was not able to contact respondents of all ages or households in Hungary. Thus, these were the restrictions that applied to the investigation.

# 12 REFERENCES

Aguilar, J., Garces-Jimenez, A., R-Moreno, M.D. and García, R. (2021). A systematic literature review on the use of artificial intelligence in energy self-management in smart buildings. *Renewable and Sustainable Energy Reviews*, 151, p.111530. doi:https://doi.org/10.1016/j.rser.2021.111530.

Amaral, R.E.C., Brito, J., Buckman, M., Drake, E., Ilatova, E., Rice, P., Sabbagh, C., Voronkin, S. and Abraham, Y.S. (2020). Waste Management and Operational Energy for Sustainable Buildings: A Review. *Sustainability*, [online] 12(13), p.5337. doi:https://doi.org/10.3390/su12135337.

Analytical Brief on Energy Sufficiency in the National Context: Hungary. (n.d.). Available at: https://cactus-energy-sufficiency.eu/wp-content/uploads/2021/03/2021-03-18_Analytical_brief_HUNGARY_final.pdf.

Anna Zsófia Bajomi, Nóra Feldmár and Kőszeghy, L. (2020). Trapped in politics. *Routledge eBooks*, pp.25–54. doi:https://doi.org/10.4324/9781003000976-3.

Article 14(1) of Directive 2012/27/EU: A comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling in Demark. (2015). Available at: https://energy.ec.europa.eu/system/files/2016-03/En%2520versionreportDenmark_0.pdf [Accessed 7 Nov. 2023].

Assessment of Hungary's recovery and resilience plan Key points. (2021). Available at: https://bankwatch.org/wp-content/uploads/2021/04/2021-04-29_Hungary-RRF-assessment_final.pdf [Accessed 8 Nov. 2023].

Atsu, D., Seres, I. and Farkas, I. (2021). The state of solar PV and performance analysis of different PV technologies grid-connected installations in Hungary. *Renewable and Sustainable Energy Reviews*, 141, p.110808. doi:https://doi.org/10.1016/j.rser.2021.110808.

Authors, Jenei, D., Matolcsy, K. and Tóth, P. (n.d.). *I m p l e m e n t a t i o n o f t h e E P B D H u n g a r y Status in 2020*. [online] Available at: https://epbd-ca.eu/wp-content/uploads/2022/10/Implementation-of-the-EPBD-in-Hungary-2020.pdf [Accessed 7 Nov. 2023].

Bajomi, A.Z., Feldmár, N. and Tirado-Herrero, S. (2021). Will Plans to Ease Energy Poverty Go Up in Smoke? Assessing the Hungarian NECP through the Lens of Solid Fuel Users' Vulnerabilities. *Sustainability*, 13(23), p.13047. doi:https://doi.org/10.3390/su132313047.

Bankwatch. (n.d.). *Analysis of biomass in NECPs*. [online] Available at: https://bankwatch.org/publication/analysis-of-biomass-in-necps [Accessed 8 Nov. 2023].

Barbara, B. (2021). *Encouraging deep renovation of residential buildings is necessary and worthwhile*. [online] MEHI. Available at: https://mehi.hu/en/reports/hungarian-renovation-wave/ [Accessed 8 Nov. 2023].

Bart, I., Csernus, D. and Sáfián, F. (2018). *ANALYSIS OF CLIMATE- ENERGY POLICIES & IMPLEMENTATION IN HUNGARY*. [online] Available at: https://eko-unia.org.pl/wp-content/uploads/2018/06/mini-report-1_Hungary.pdf [Accessed 8 Nov. 2023].

bloomsbury.com (2013). *Energy Justice in a Changing Climate*. [online] Bloomsbury. Available at: https://www.bloomsbury.com/uk/energy-justice-in-a-changing-climate-9781780325767/ [Accessed 7 Nov. 2023].

Boardman, B. (2013). *Fixing Fuel Poverty*. Routledge. doi:https://doi.org/10.4324/9781849774482.

Bouzarovski, S. and Petrova, S. (2015). A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary. *Energy Research & Social Science*, 10, pp.31–40. doi:https://doi.org/10.1016/j.erss.2015.06.007.

Bouzarovski, S. and Tirado Herrero, S. (2016). Geographies of injustice: the socio-spatial determinants of energy poverty in Poland, the Czech Republic and Hungary. *Post-Communist Economies*, 29(1), pp.27–50. doi:https://doi.org/10.1080/14631377.2016.1242257.

Bouzarovski, S., Tirado Herrero, S., Petrova, S. and Ürge-Vorsatz, D. (2015a). Unpacking the spaces and politics of energy poverty: path-dependencies, deprivation and fuel switching in post-communist Hungary. *Local Environment*, 21(9), pp.1151–1170. doi:https://doi.org/10.1080/13549839.2015.1075480.

Bouzarovski, S., Tirado Herrero, S., Petrova, S. and Ürge-Vorsatz, D. (2015b). Unpacking the spaces and politics of energy poverty: path-dependencies, deprivation and fuel switching in post-communist Hungary. *Local Environment*, 21(9), pp.1151–1170. doi:https://doi.org/10.1080/13549839.2015.1075480.

Cascone, S. (2019). Green Roof Design: State of the Art on Technology and Materials. *Sustainability*, 11(11), p.3020. doi:https://doi.org/10.3390/su11113020.

CORDIS | European Commission. (n.d.). *Integrated Services to Boost Energy Renovation in Hungarian Homes | RenoHUb Project | Fact Sheet | H2020*. [online] Available at: https://cordis.europa.eu/project/id/845652 [Accessed 8 Nov. 2023].

Csoknyai, T., Hrabovszky-Horváth, S., Georgiev, Z., Jovanovic-Popovic, M., Stankovic, B., Villatoro, O. and Szendrő, G. (2016a). Building stock characteristics and energy performance of residential buildings in Eastern-European countries. *Energy and Buildings*, 132, pp.39–52. doi:https://doi.org/10.1016/j.enbuild.2016.06.062.

Csoknyai, T., Hrabovszky-Horváth, S., Georgiev, Z., Jovanovic-Popovic, M., Stankovic, B., Villatoro, O. and Szendrő, G. (2016b). Building stock characteristics and energy performance of residential buildings in Eastern-European countries. *Energy and Buildings*, 132, pp.39–52. doi:https://doi.org/10.1016/j.enbuild.2016.06.062.

Directorate-General for Energy (European Commission) (2020). *Member state reports on energy poverty 2019*. [online] *Publications Office of the European Union*. LU: Publications Office of the European Union. Available at: https://op.europa.eu/en/publication-detail/-/publication/b9a25ba4-9ef6-11ea-9d2d-01aa75ed71a1/language-en.

Dong, Y., Kong, J., Mousavi, S., Rismanchi, B. and Yap, P.-S. (2023). Wall Insulation Materials in Different Climate Zones: A Review on Challenges and Opportunities of Available Alternatives. *Thermo*, 3(1), pp.38–65. doi:https://doi.org/10.3390/thermo3010003.

Dubois, H. and Nivakoski, S. (2023). *Unaffordable and inadequate housing in Europe Living conditions and quality of life*. [online] Available at:

https://www.eurofound.europa.eu/system/files/2023-05/ef22024en.pdf [Accessed 7 Nov. 2023].

ec.europa.eu. (n.d.). *Key figures on Europe — Statistics visualised — 2019 edition*. [online] Available at: https://ec.europa.eu/eurostat/web/products-interactive-publications/-/ks-02-19-677 [Accessed 7 Nov. 2023].

energiaklub.hu. (2019). *RenoHUb - Integrated Services to Boost Energy Renovation in Hungarian Homes | ENERGIAKLUB*. [online] Available at: https://energiaklub.hu/en/project/renohub-integrated-services-to-boost-energy-renovation-in-hungarian-homes-4775 [Accessed 8 Nov. 2023].

energiaklub.hu. (2023). *Buildings | ENERGIAKLUB*. [online] Available at: https://energiaklub.hu/en/topics/buildings [Accessed 7 Nov. 2023].

energy.ec.europa.eu. (n.d.). *Renewable energy targets*. [online] Available at: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en#the-2030-targets.

ERRA. (n.d.). *Hungarian Energy and Public Utility Regulatory Authority (MEKH)*. [online] Available at: https://erranet.org/member/mekh-hungary/ [Accessed 7 Nov. 2023].

eur-lex.europa.eu. (n.d.). *EUR-Lex - l27067 - EN - EUR-Lex*. [online] Available at: https://eur-lex.europa.eu/EN/legal-content/summary/an-energy-policy-for-europe.html.

Europa.eu. (2011). *Home - Eurostat*. [online] Available at: https://ec.europa.eu/eurostat/.

Europa.eu. (2020). Available at:https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di04.

European Commission (2018). *Energy performance of buildings directive*. [online] energy.ec.europa.eu. Available at: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en.

Eurostat (2011). *Eurostat*. [online] Europa.eu. Available at: https://ec.europa.eu/eurostat.

Farghali, M., Osman, A.I., Chen, Z., Abdelhaleem, A., Ihara, I., Mohamed, I.M.A., Yap, P.-S. and

Rooney, D.W. (2023). Social, environmental, and economic consequences of integrating renewable energies in the electricity sector: a review. *Environmental Chemistry Letters*, 21(3), pp.1381–1418. doi:https://doi.org/10.1007/s10311-023-01587-1.

Garba, I. and Bellingham, R. (2021). Energy poverty: Estimating the impact of solid cooking fuels on GDP per capita in developing countries - Case of sub-Saharan Africa. *Energy*, 221, p.119770. doi:https://doi.org/10.1016/j.energy.2021.119770.

Gnansounou, E. (2008). Assessing the energy vulnerability: Case of industrialised countries. *Energy Policy*, 36(10), pp.3734–3744. doi:https://doi.org/10.1016/j.enpol.2008.07.004.

Guidance on Energy Efficiency in Public Buildings. (n.d.). Available at: https://www.eib.org/attachments/epec/epec_guidance_on_energy_efficiency_in_public_buildings_en.pdf.

Guillén-Lambea, S., Rodríguez-Soria, B. and Marín, J.M. (2017). Control strategies for Energy Recovery Ventilators in the South of Europe for residential nZEB—Quantitative analysis of the air conditioning demand. *Energy and Buildings*, 146, pp.271–282. doi:https://doi.org/10.1016/j.enbuild.2017.04.058.

Győri, Á., Huszár, Á. and Balogh, K. (2021). Differences in the Domestic Energy Consumption in Hungary: Trends between 2006–2017. *Energies*, [online] 14(20), p.6718. doi:https://doi.org/10.3390/en14206718.

Heves, G. (2021). *SEPlaM-CC -Raising capacity of cross-border public institutions in sustainable energy planning and management and climate change mitigation Analysis of best practice examples in energy refurbishment, renewable energy sources usage and climate change mitigation in Hungary*. [online] Available at: https://www.menea.hr/wp-content/uploads/2022/02/Analysis-of-best-practice-examples_SEPlaM-CC_ZMVA-1.pdf [Accessed 8 Nov. 2023].

Hungary Today. (2022). *Majority of Hungarians Do Not See Significant Increase in Utility Costs*. [online] Available at: https://hungarytoday.hu/majority-of-hungarians-do-not-see-significant-increase-in-utility-costs/ [Accessed 7 Nov. 2023].

IEA. (n.d.). *WEO-2016 Special Report: Energy and Air Pollution – Analysis*. [online] Available at: https://www.iea.org/reports/energy-and-air-pollution [Accessed 15 Jun. 2020].

Joint Research Centre (European Commission) and Menyhért, B. (2023). *Energy poverty: new insights and analysis for improved measurement and policy : evidence from unique joint HBS SILC microdata from Hungary*. [online] *Publications Office of the European Union*. LU: Publications Office of the European Union. Available at: https://op.europa.eu/en/publication-detail/-/publication/47f0c0e0-1627-11ee-806b-01aa75ed71a1/language-en [Accessed 8 Nov. 2023].

Kökény, Dr.M., Süli, Dr.O. and Ujhelyi, Dr.I. (2021). *How could the European Health Union help the Hungarian healthcare to catch-up?* [online] Foundation for European Progressive Studies. Available at: https://feps-europe.eu/publication/804-how-could-the-european-health-union-help-the-hungarian-healthcare-to-ca [Accessed 8 Nov. 2023].

Kumar, B., Szepesi, G., Čonka, Z., Kolcun, M., Péter, Z., Berényi, L. and Szamosi, Z. (2021). Trendline Assessment of Solar Energy Potential in Hungary and Current Scenario of Renewable Energy in the Visegrád Countries for Future Sustainability. *Sustainability*, 13(10), p.5462. doi:https://doi.org/10.3390/su13105462.

Leal-Arcas, R., Filis, A., Peykova, M. and Greger, M. (2019). *Towards a Carbon-Free, Decentralized, and Democratized System of Energy Generation*. [online] Social Science Research Network. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3460007 [Accessed 8 Nov. 2023].

Martey, E., Etwire, P.M., Atinga, D. and Yevu, M. (2021). Household energy choice for cooking among the time and consumption poor in Ghana. *Energy*, 226, p.120408. doi:https://doi.org/10.1016/j.energy.2021.120408.

Maxim, A., Mihai, C., Apostoaie, C.-M., Popescu, C., Istrate, C. and Bostan, I. (2016). Implications and Measurement of Energy Poverty across the European Union. *Sustainability*, [online] 8(5), p.483. doi:https://doi.org/10.3390/su8050483.

MEHI. (n.d.). *Energy efficiency in Hungary*. [online] Available at: https://mehi.hu/en/energy-efficiency-in-hungary/ [Accessed 7 Nov. 2023].

MÉRŐ, B., BORSOS, A., HOSSZÚ, Z., OLÁH, Z. and VÁGÓ, N. (2022). *A HIGH RESOLUTION AGENT-BASED MODEL OF THE HUNGARIAN HOUSING MARKET*. [online] Available at: https://www.mnb.hu/letoltes/mnb-wp-2022-7-final-1.pdf.

Mirza, B. and Szirmai, A. (2010). Towards a new measurement of energy poverty : a cross-community analysis of rural Pakistan. *RePEc: Research Papers in Economics*, (024).

National Energy and Climate Plan. (n.d.). Available at: https://energy.ec.europa.eu/system/files/2022-08/hu_final_necp_main_en.pdf.

NATIONAL ENERGY STRATEGY 2030. (n.d.). Available at: https://2010-2014.kormany.hu/download/7/d7/70000/Hungarian%20Energy%20Strategy%202030.pdf.

NATIONAL FRAMEWORK STRATEGY ON SUSTAINABLE DEVELOPMENT OF HUNGARY. (2013). Available at: https://www.nfft.hu/documents/127649/1361679/NFFT-ENG-web.pdf/f692c792-424d-4f5a-9f9d-9e6200303148#:~:text=The%20Framework%20Strategy%20intends%20to.

national-policies.eacea.ec.europa.eu. (2023). *7. Health and Well-Being*. [online] Available at: https://national-policies.eacea.ec.europa.eu/youthwiki/chapters/hungary/7-health-and-well-being [Accessed 8 Nov. 2023].

Népszámlálás 2022. (n.d.). *Népszámlálás 2022*. [online] Available at: https://nepszamlalas2022.ksh.hu/ [Accessed 9 Nov. 2023].

Oberthür, S. (2019). Hard or Soft Governance? The EU's Climate and Energy Policy Framework for 2030. *Politics and Governance*, 7(1), p.17. doi:https://doi.org/10.17645/pag.v7i1.1796.

Odyssee-mure.eu. (2021). Available at: https://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/hungary-country-profile-english.pdf [Accessed 7 Nov. 2023].

Overview report on the energy poverty concept Energy poverty in the privately-owned, multi-family environment. (n.d.). Available at: https://www.bpie.eu/wp-content/uploads/2021/05/ComAct-D1.1_Overview-report-on-the-energy-poverty-concept_Final-version_UPDATED-1.pdf.

PALYAZAT and .gov.hu (no date) PALYAZAT. Available at: https://archive.palyazat.gov.hu/evaluation (Accessed: 12 November 2023)

powerpoor.eu. (n.d.). *Hungary | POWERPOOR*. [online] Available at: https://powerpoor.eu/about/locations/hungary [Accessed 7 Nov. 2023].

Ref and Ares (2015). *National Building Energy Performance Strategy*. [online] Available at: https://energy.ec.europa.eu/system/files/2015-07/2014_article4_hungary_en%2520translation_0.pdf [Accessed 7 Nov. 2023].

Renátó Ritter*: Making homes more energy efficient is key to Hungary's energy independence. (1990). Available at: https://www.mnb.hu/letoltes/renato-ritter-making-homes-more-energy-efficient-is-key-to-hungary-s-energy-independence.pdf [Accessed 8 Nov. 2023].

Shafigh, P., Asadi, I. and Mahyuddin, N.B. (2018). Concrete as a thermal mass material for building applications - A review. *Journal of Building Engineering*, 19, pp.14–25. doi:https://doi.org/10.1016/j.jobe.2018.04.021.

Simcock, N., Walker, G. and Day, R. (2016). Fuel poverty in the UK: beyond heating? *People Place and Policy Online*, 10(1), pp.25–41. doi:https://doi.org/10.3351/ppp.0010.0001.0003.

Springford, A., Eadie, G.M. and Thomson, D.J. (2020). Improving the Lomb–Scargle Periodogram with the Thomson Multitaper. *The Astronomical Journal*, 159(5), p.205. doi:https://doi.org/10.3847/1538-3881/ab7fa1.

Szlavik, J. and Csete, M. (2012). Climate and Energy Policy in Hungary. *Energies*, 5(2), pp.494–517. doi:https://doi.org/10.3390/en5020494.

Tatai, Z., Bódi-Nagy, A., Orosz, I., Becsák, P., Pető , Z. and Szabó , K. (2021). *BUDAPEST CLIMATE STRATEGY AND SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN 1*. [online] Available at: https://budapest.hu/sites/english/documents/BP_klimastrategia_SECAP_EN_final.pdf.

Tirado Herrero, S. and Ürge-Vorsatz, D. (2010). *Energiaszegénység Magyarországon: első értékelés (Fuel poverty in Hungary: a first assessment)*. Budapest: Center for Climate Change and Sustainable Energy Policy at Central European University and Védegylet. Center for Climate Change and Sustainable Energy Policy (3CSEP).

Tirado, S. and Diana Ürge-Vorsatz, H. (n.d.). *FUEL POVERTY IN HUNGARY A first assessment*. [online] Available at: http://3csep.ceu.hu/sites/default/files/field_attachment/project/node-3347/englishreportfuelpoverty.pdf [Accessed 7 Nov. 2023].

Toth, N. and Péter Tamás Szemes (2013). Investigation of the energy poverty risk with building mechatronics. *International Review of Applied Sciences and Engineering*, 4(2), pp.177–184. doi:https://doi.org/10.1556/irase.4.2013.2.13.

Trotta, G., Spangenberg, J. and Lorek, S. (2018a). Energy efficiency in the residential sector: identification of promising policy instruments and private initiatives among selected European countries. *Energy Efficiency*, 11(8), pp.2111–2135. doi:https://doi.org/10.1007/s12053-018-9739-0.

Turai , E., chmatzberger, S.S. and Broer, R. (2021). *Overview report on the energy poverty concept Energy poverty in the privately-owned, multi-family environment*. [online] Available at: https://www.bpie.eu/wp-content/uploads/2021/05/ComAct-D1.1_Overview-report-on-the-energy-poverty-concept_Final-version_UPDATED-1.pdf.

www.atozglazing.com. (n.d.). *Importance of Quality Glazing for Energy Efficiency - A to Z Glazing*. [online] Available at: https://www.atozglazing.com/~/articles/importance-of-energy-efficiency [Accessed 7 Nov. 2023].

Www.emi.hu. (2023). *ÉMI Nyitólap*. [online] Available at: http://www.emi.hu.

www.emi.hu. (2023). *Status Quo Analysis on education and training of building professionals-skills needed to achieve the 2030 energyefficiency and climate targets - 2023 06*. [online] Available at: https://emi.hu/EMI/web.nsf/Pub/ISSJ6X/ [Accessed 1 Oct. 2023].

www.ksh.hu. (n.d.). *Hungarian Central Statistical Office*. [online] Available at: https://www.ksh.hu/official_statistical_service [Accessed 7 Nov. 2023].

www.odyssee-mure.eu. (n.d.). *Hungary energy efficiency & Trends policies | Hungary profile | ODYSSEE-MURE*. [online] Available at: https://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/hungary.html#buildings [Accessed 7 Nov. 2023].

# 13 DECLARATION

**DECLARATION**

**the public access and authenticity of the thesis/dissertation/portfolio[1]**

| | |
|---|---|
| Student's name: | Shahria Tanzil |
| Student's Neptun code: | A2T5YS |
| Title of thesis: | Master's Thesis |
| Year of publication: | 2023 |
| Name of the consultant's institute: | Institute of Agricultural and food Economics |
| Name of consultant's department: | Environmental Engineering |

I declare that the final thesis/thesis/dissertation/portfolio submitted by me is an individual, original work of my own intellectual creation. I have clearly indicated the parts of my thesis or dissertation which I have taken from other authors' work and have included them in the bibliography.

If the above statement is untrue, I understand that I will be disqualified from the final examination by the final examination board and that I will have to take the final examination after writing a new thesis.

I do not allow editing of the submitted thesis, but I allow the viewing and printing, which is a PDF document.

I acknowledge that the use and exploitation of my thesis as an intellectual work is governed by the intellectual property management regulations of the Hungarian University of Agricultural and Life Sciences.

I acknowledge that the electronic version of my thesis will be uploaded to the library repository of the Hungarian University of Agricultural and Life Sciences. I acknowledge that the defended and

- not confidential thesis after the defence
- confidential thesis 5 years after the submission

will be available publicly and can be searched in the repository system of the University.

Date: 2023 year 11 month 11 day

Shahria Tanzil

______________________

Student's signature

# DECLARATI0N

Tibor László Csegődi, dr. as a thesis insider consultant of Shahria Tanzil (NEPTUN code: A2T5YS) declare that I have reviewed the final thesis and that I have informed the student of the requirements, legal and ethical rules for the correct handling of literary sources.

I recommend the final thesis to be defended in the final examination.

The thesis contains a state or official secret: yes **<u>no</u>**

Date: Gödöllő, 2023. year November month 11. day

Dr. Csegődi Tibor László, tanársegéd

insider consultant