DISSERTATION / DOCTORAL THESIS

Titel der Dissertation /Title of the Doctoral Thesis

Revealing the Hidden Link
Energy Poverty and Self-Restricted Energy Use in Austria

verfasst von / submitted by

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angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Doktorin der Philosophie (Dr. Phil.)

Wien, 2023 / Vienna 2023

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	A 796310122
Dissertationsgebiet lt. Studienblatt / field of study as it appears on the student record sheet:	Soziologie
Betreut von / Supervisor:	Univ.-Prof. Yuri Albert Kyrill Kazepov, PhD

Acknowledgements

Support is key to completing a dissertation and this one is no exception. Although these acknowledgments are insufficient to truly recognize their importance in this journey, I hope they will provide a glimpse into my deep gratitude.

My heartfelt thanks go to my supervisor, Yuri, who played an instrumental role in making this dissertation possible. From the outset, Yuri provided me with invaluable scientific advice, guidance, and feedback that helped me refine my research question and topic, and ultimately allowed me to finalize this work. Yuri challenged me to grow as a scientist and as a person, and for that, I will always be thankful. Moreover, Yuri's mentoring and advocacy extended beyond the dissertation itself. Through team trips to Italy and Slovakia, his wonderful dinners, and his positive energy, he created a supportive and collaborative environment that allowed me to learn from some of the kindest, funniest and most brilliant researchers. I treasure the lunch and coffee breaks, the gatherings and parties, and the time spent working together with Tatjana Bozy, Mirjam Pot, Byeongsun Ahn, Ruggero Cefalo, Lena Seewann, Michael Friesenecker, Margareta Wolf, Maria Schlechter, Katharina Litschauer, and Xenia Piskunova. It has been an honor and a pleasure.

I would like to express my gratitude to Sebastian Seebauer for providing me the opportunity to work and learn alongside him. I am thankful for his support and companionship, and to be a part of the BALANCE project, which inspired the topic of my dissertation.

This work would not have been possible without financial support from Literar Mechana - Wahrnehmungsgesellschaft für Urheberrechte GesmbH, the Department of Sociology, and the Vienna Doctoral School of Social Sciences.

I would like to express my heartfelt thanks to my friends, who provided a much-needed source of laughter, support, and for being the incredible loving people you are. Special thanks go to Jule Berens, Kristina Zimbelmann, Sandra Kosmala, Eike Neugebauer, Katharina Hatzogiannis, Arne Wolf, and Ines Ewerszumrode for being such loyal friends.

To my love Paulo: Cê acredita?! I am grateful for your constant motivation to persist, your unwavering emotional support, your patience, and your assistance in every step of the way.

To my dearest Babula who from an early age inspired me to pursue my interests in science: спасибо за то, что ты была моей опорой на протяжении всего этого путешествия. ты всегда верил в меня! большое спасибо!

Finally, but most importantly, to my parents and my brother David for their infinite love and support who have always been by my side no matter the distance. Mama und Papa diese Arbeit ist euch gewidmet.

This dissertation marks the culmination of a remarkable journey filled with both challenges and triumphs, and I am excited to take on whatever the future holds with newfound strength and resilience.

Hakuna Matata

DANKE – СПАСИБО - THANK YOU - OBRIGADA - GRAZIE

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List of Abbreviations

Abbreviations	English [German translation]
ABGB	Austrian Civil Law Code [Allgemeines bürgerliches Gesetzbuch]
AROPE	At Risk of Poverty or Social Exclusion
Art.	Article
BGBl.	Federal Law Gazette [Bundesgesetzblatt]
CAR	Climate Action Regulation
CFA	Confirmatory Factor Analysis
CO_2	Carbon Dioxide [Kohlestoffdioxid]
EC	European Commission
ECHP	European Community Household Panel
EED	Energy Efficiency Directive
EEffG	Energy Efficiency Law [Energieeffizienzgesetz]
EEOS	Energy Efficiency Obligation Schemes
EPBD	Energy Performance of Buildings Directive
EPOV	Energy Poverty Observatory
EU	European Union [Europäische Union]
GHG	Greenhouse Gas Emissions
GWh	Gigawatt-hour
IEA	International Energy Agency
LCA	Latent Class Analysis
LIHC	Low Income - High Cost
LTRS	Long-Term Building Renovation Strategy
LTS	Long-Term Strategy
MEPI	Multidimensional Energy Poverty Indicator
ML	Maximum Likelihood
MRG	Tenancy Law [Mietrechtsgesetz]
MS	Member States
n.s.	Not significant
NECP	National Energy and Climate Plans
NGO	Non-Governmental Organization
nZEB	Nearly Zero-Energy Buildings
OECD	Organization for Economic Cooperation and Development
OR	Odds ratio
OSCE	Organization for Security and Co-operation in Europe
ÖVP	The Austrian People's Party [Österreichische Volkspartei]
p.a.	Per annum
PJ	Petajoules
RED	Renewable Energy Directive
SEM	Structural Equation Model(ling)
TFEU	Treaty on the Functioning of the European Union
TWh	Terawatt-hour
UK	United Kingdom
UN	United Nations
WEG	Residential Property Law [Wohnungseigentumsgesetz]
WGG	Limited Profit Housing Act [Wohngemeinnützigkeitsgesetz]

1. Topic Statement

1.1 Introduction

In winter 2022 (3rd quarter), indicated by the inability to keep home adequately warm, 11,3% of Austrian population were considered energy poor. In Vienna alone, the situation is worse, with 16,2% of the population suffering from energy poverty in the 3rd quarter of 2022 (Statistik Austria, 2023). Energy poverty is characterised by three key dimensions: affordability and price of energy, household income, and energy (in)efficiency of the dwelling. Predominantly affecting low-income groups, energy poverty results from living in older, deteriorating homes with inadequate heating and cooling facilities, and a housing tenure system that cannot encourage energy-efficient upgrades. The situation is compounded by a lack of resources and knowledge to support improvements and retrofits. Despite the high number of people affected, it remains a neglected policy issue and a "blind spot" in the Austrian political arena, with policymakers often overlooking the urgent need for action. However, this is gradually changing, as, due to inflation and high energy prices, energy poverty is becoming increasingly salient.

The Clean Energy for all Europeans Package is a key regulatory framework that addresses energy poverty, in which the European Commission outlined stricter Directives and Regulations to combat energy poverty and increase energy efficiency in buildings. The comprehensive approach to energy poverty in the EU is driven by public support, as 90% of respondents in a Special Eurobarometer poll agree it is the EU's responsibility to address energy poverty and ensure a fair energy transition for all citizens and regions “so that no citizen or region is left behind” (European Commission, 2019f). The high level of public acceptability for energy poverty policies calls for sustainable solutions and legislative actions to combat the issue.

The world is facing a growing crisis in energy consumption and climate change, and buildings play a significant role in this issue. Relying on “never ending” fossil fuels and on technological advances is not sufficient to decrease greenhouse gas (“GHG”) emissions and maintain our planet liveable in the long run. In the EU, the residential building sector is responsible for 43% of the final energy consumption and 60% of the electricity use in the EU-28 (Rousselot et al., 2020). Two-thirds of this energy consumption is accounted by residential buildings: EU-wide, it represents the second largest consuming sector after transport (Eurostat, 2020c).

Approximately 75% of the overall EU's residential stock is energy inefficient (Rousselot et al., 2020), and most consumed energy, approximately 64%, in the residential sector is used for space heating (Eurostat, 2020a). This thesis aims to examine energy poverty in the EU and Austria, focusing on its causes and the effects of energy policy on vulnerable households. This research seeks to provide insights into how the EU's efforts to achieve a low-carbon society by 2050 must also consider the impacts on energy poverty and inequalities in society.

A driver of energy poverty is high energy prices, which increased overall in the EU in the last decade, and particularly skyrocketing in 2022 due to the war of aggression on Ukraine. Predictions indicate a further increase in the coming decade because of the EU energy transition. Vulnerable households are particularly affected by such increases because they typically live in inefficient homes that require more energy to achieve a decent indoor temperature; a condition that may amplify existing inequalities in society (IEA, 2017; Longo et al., 2020). As societal transitions produce "losers" and "winners", this dissertation offers insights that show how achieving a low-carbon society by 2050 in the EU must also contend with aspects pertaining to energy. Existing inequalities could be exacerbated, and it is not farfetched to consider energy poverty and the outcomes of the energy transition as new social risk (Ranci et al., 2014) arising as a result of climate change.

> *"Climate change is the most intractable collective action challenge in human history, being inherently global, extremely long term, technologically demanding, and replete with distributional difficulties, among countries, people, and generations" (Wolf, 2012, p. 777).*

Prioritising energy efficiency in buildings where energy poor households live brings several benefits, including reduced GHG emissions and energy bills, improved quality of life and health, reduced vulnerability to income and energy price fluctuations, and the ability to avoid cutting back on energy or other necessities. This decade will be perilous in relation to climate action and the European Commission (2020d, p. 2) recognised that

> *"[t]he rising trend in energy-related expenses as a proportion of income is expected to peak around 2025-2030, after which this share is expected to decline, as the benefits of the energy transition materialise in full."*

The energy transition must be designed in a socially acceptable manner that considers the impact on energy poor households. Discussions about energy awareness and behavioral change must be critically evaluated, as further skimping on energy use could worsen the quality of life for energy poor households.

Rationale for Austria and Vienna

Austria, a country of 8.8 million people with 1.9 million living in its largest city Vienna, is part of the "Green Growth Group" (UN Environment Program, 2020) aiming for global warming limit to 1.5°C but lags behind other EU countries to reduce GHG emissions (Ollier et al., 2020). Its GHG emissions even increased by 1.8% compared to 1990 levels and the retrofitting rate was low at 1.4% (Amann et al., 2020b). The current government has set an ambitious goal of achieving climate neutrality by 2040, which is even more ambitious than the EU goal of doing the same by 2050 (European Commission, 2021g), and increasing the share of domestic renewable energy sources in electricity consumption to 100% by 2030. This requires coordinated effort between and within governmental levels and ministries, as Austria has met none of its EU 2020 climate commitments.

Austria is a federal country with large competences for federal states in climate policy areas, including building policies, where national emission reductions and energy poverty rates will be reflected. There are interdependencies between national and federal state-level objectives and policies. Vienna, a municipality and a federal state, has the potential to pass innovative climate policies, but its retrofitting rate is the lowest among the federal states at only 1% per annum, which must be doubled or tripled to meet outlined targets. This increase would also bring households out of energy poverty if targeted properly. Compared to other federal states, Viennas reduction efforts have not (yet) been successful in achieving the goals for key climate indicators and GHG emission statistics.

Personal contribution, aims and objectives of the PhD research

This thesis brings together two issues that are pertinent to both research and policy agenda, but have rarely been considered hand in hand. First, it sheds light on the role of housing and climate policies in the EU, Austria, and Vienna, and, second, it examines the reasons behind energy poverty in Austria and, specifically in the residential setting of social housing residents in Vienna. For this endeavor, a concurrent triangulation design, comprising qualitative and quantitative methods, is utilised. Alongside the three main drivers of energy poverty -household income, high energy prices, and decrepit housing- this thesis suggests that underestimating, and failing to account for households' self-restricting energy behaviour conceals the current energy poverty rates. To address this shortcoming in quantitative energy poverty research, this study develops energy poverty indicators that incorporate this aspect. It is recommended that future research analyze energy self-restrictions and monitor energy poverty to better capture hidden energy poverty. The research objectives of this thesis therefore are to:

- compare various energy poverty definitions;
- offer new ways to identify those who suffer from energy poverty to optimise policy design;
- determine the current climate, energy and social housing policies to ease energy poverty;
- critically evaluate existing policies and explore possible pitfalls of the policy design;
- analyse data on social housing energy-related behaviour;
- determine whether impacts of a retrofit influence energy behaviour and identify core determinants of energy restriction behaviours.

This thesis makes an original contribution to energy poverty research in three key ways. *First*, it introduces a household-level composite indicator based on Austrian EU-SILC survey micro data from 2019 to understand where energy poor typically live and who they are. *Second*, the study proposes a novel approach to measure hidden energy poverty based on consensual-based data and uses it to examine the case study of social housing residents in Vienna.[1] Consequently, a multidimensional energy poverty index is utilised following Alkire and Forster method (2011) that combines energy poverty indicators. The strength of the index is the consideration of at least two forms of deprivation. *Third*, from a multilevel governance perspective, an in-depth analysis of current policies and instruments to achieve EU set climate goals and decrease energy poverty is employed in terms of their ability to tackle energy poverty and effectiveness.

The latest developments

Energy poverty in the EU and Austria has worsened in the last two years: in 2020/2021 the COVID-19 pandemic is expected to have exacerbated energy poverty as lockdowns and financial limitations have caused an increase in energy usage as people spend more time at home (e.g. increase in remote work and online learning practices). In 2022, the current energy crisis, the war in Ukraine, and soaring inflation has put more households under greater financial pressure. Due to the crises, rising energy prices, and the nation's reliance on imported energy, it is now more difficult for low-income people to pay their energy bills. Price increases have a different impact on the various strata of the population as households with lower incomes spend a higher proportion of their income on housing, clothing, and food compared to higher income households.

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1 Data gathering was realized within the research project BALANCE "Balancing climate and social housing policies in the transformation to a low carbon society: Designing integrated policy mixes for Austria". This research received financial support from the Austrian Climate and Energy Fund and was carried out within the Austrian Climate Research Program (funding no. B769944).

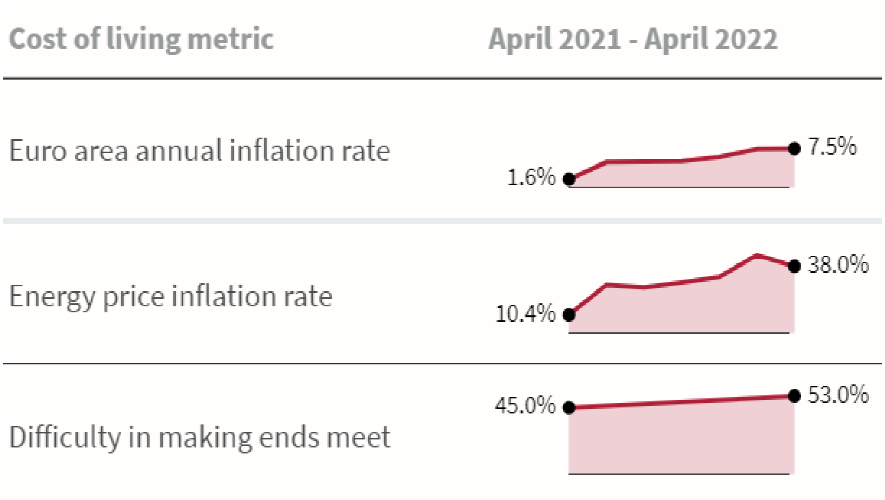

Figure 1 Euroindicators. More People Are Struggling to Make Ends Meet (Source: Eurofund (2022) Based on Eurostat 2022)

1.2 Research Questions

The central research question of this thesis is threefold and reads as such:

(R1): Which household types experience energy poverty in Austria?

(R2): What are the reasons behind energy poverty in Austria?

(R3): What policies aim to decrease energy poverty and are current policies in Austria successful in reducing energy poverty?

The following sub-research questions are formulated to address the problem statement for this thesis:

- What are the key drivers of energy poverty in Austria and in Vienna?
- What is the extent of energy poverty in Austria and social housings in Vienna?
- Do households use self-restricting energy strategies that make them hidden energy poor?
- What factors (e.g. building-related and psychological) determine how dwellers in social housings in Vienna behave energetically?
- To what extent are current EU, Austrian, and Vienna’s policies able to remedy energy poverty?

1.3 Research Design - The Pragmatic Philosophical Perspective

Like every human being, researchers have a specific understanding of reality and their role in society within their field of research. When research is conducted, it is important for researchers to be aware of their position relative to the four main philosophical worldviews in research as they affect the practice of research: post-positivism, social constructivism, advocacy/ participatory, and pragmatism (Creswell, 2009; Hanson et al., 2005). These worldviews, or paradigms, shape how research is conducted and interpreted. It is important for researchers to be transparent about their purpose and role in their research. Paradigms are scientific worldviews that influence how we interpret the world, design, conduct, and interpret our research. Figure 2 illustrates briefly the four paradigms ontology, epistemology, methodology, and axiology.

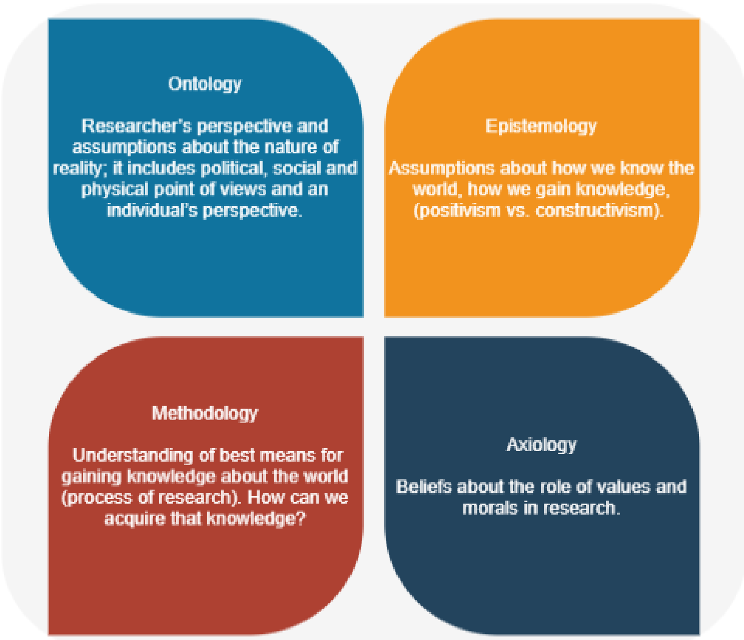

Figure 2 Four Philosophical Traditions (Source: Own Visualization).

This thesis is led by the philosophical tradition of *pragmatism*. The pragmatist tradition applies predominantly in mixed-methods (quantitative and qualitative) research by embracing a plurality of methods. The pragmatic philosophical tradition emphasises that no matter which method, either quantitative or qualitative or both, a method that can answer the research question is an excellent method (Zou et al., 2018). Hence, researchers ought to use the methods or philosophical approaches that suits best to the research problem that is being investigated (Tashakkori and Teddlie, 1998). This philosophical approach acknowledges multiple truths that are unique to human experiences that are open to empirical inquiry and understands that *"actions cannot be separated from the situations and contexts in which they occur" (Morgan 2014: p. 26).*

Pragmatist philosophy rejects the traditional separation of 'objectivity' and 'subjectivity' (Biesta, 2010) and thus overcomes the "forced dichotomy" of positivism and constructivism (Creswell and Plano Clark, 2011). Tashakkor and Teddlie (2003, p. 713) define pragmatism as

"a deconstructive paradigm that debunks concepts such as "truth" and "reality" and focuses instead on "what works" as the truth regarding the research questions under investigation. Pragmatism rejects the either/or choices associated with the paradigm wars, advocates for the use of mixed methods in research, and acknowledges that the values of the researcher play a large role in interpretation of results".

Taken together, these shortly presented pragmatic philosophical characteristics offer a solid entry point and a strong link between theory that is used in the thesis, and the way data is analysed. It is open to mixed methods design that is chosen in this thesis.

1.4 Mixed Methods Research - The Concurrent Triangulation Design

The fundamental principle of mixed method research is the combination of quantitative and qualitative approaches in the same project or study, which provides a better understanding of the problem than either approach can achieve alone (Creswell and Plano Clark, 2011). Hence, recognising that quantitative and qualitative methods have both limitations and strengths, triangulation emphasises the strength of each method and tries to overcome its limitations. Triangulation, per se, seeks convergence, corroboration, and correspondence of results from different methods (Greene et al., 1989). Within the *Journal of Mixed Methods Research*, the most used definition is provided by Johnson et al. (2007, p. 123):

"Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g. use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration."

There are only a few studies conducted in energy social science research that employ a mixed methods design (Ambrose and Marchand, 2017; O'Sullivan and Howden-Chapman, 2017). Zou et al. (2018) report that, within energy behaviour literature, most studies (83.48%) apply quantitative methods, followed by mixed methods (5.22%) and qualitative methods (0.87%). O'Sullivan and Howden-Chapman (2017, p. 1009) advise that researchers in the field of energy poverty should utilise mixed methods more often as they offer

> *"opportunities for drawing on varied sources of evidence to better capture the multi-dimensional experiences and outcomes, as well as, antecedents of fuel poverty within communities and potential solutions to resolve household energy vulnerability."*

A mixed methods research design will be applied in this thesis to analyse energy poverty, climate, and housing policies in the EU, Austria and Vienna. In more detail, this research project applies a ***concurrent triangulation design*** (Creswell, 2010). The main advantage of adopting this approach lies in its ability to reveal and contend with different perspectives on a social phenomenon.

Building upon predominantly qualitative findings on the experiences of energy poor households from previous studies, this thesis acknowledges the difficulties in identifying vulnerable households that are potentially energy poor (Anderson et al., 2010b; Brunner et al., 2012; Chard and Walker, 2016). This study is therefore informed by insights leaned from previous qualitative energy poverty studies based on lived experiences of affected energy poor households. Specifically, the findings of Brunner et al. (2017; 2012) qualitative study on energy poverty in Vienna shaped the quantitative questionnaire design. The policy analysis gives meaning and provides information on the *status quo* of energy poverty and policies connected to a just transition in the EU, Austria, and Vienna.
In mixed method studies[2], some key questions have to be addressed and answered before research is conducted:

- Are the methods equally weighted, or is one method prioritised over the other?
- What sequence will qualitative and quantitative data collection implement?
- What is the time ordering of qualitative and quantitative phases?

Three general strategies exist how data can be collected: *sequentially, transformative* or *concurrently.* Sequentially means that one data collection follows the other. Transformative relates to a particular theoretical lens that is employed thorough the study that guides the research. In concurrent designs, data is gathered more or less at the same time in the research process. In the notation of Morse (1991), concurrence is indicated by a '+', whereas sequential design is indicated by a '→' between research components. Creswell et al. (2003) distinguish between three main concurrent approaches:

2 There are several mixed methods research designs (approx. 40) and Creswell and Plano Clark give examples of the main 15 unique designs and classifications that can be clearly distinguished from each other (Creswell and Plano Clark, 2018).

1. concurrent triangulation design
2. concurrent nested design
3. concurrent transformative design

The concurrent triangulation design is one where qualitative and quantitative data are collected and analysed separately but subsequently merged or compared in a discussion section. Usually, one form of analysis plays a more important role than the other, which instead serves a supportive purpose (Caracelli and & Greene, 1997). This thesis employs the **concurrent mixed methods** approach. Specificlly, the study adopts a **QUAN + qual** deductive-simultaneous research design where the data collection is conducted simultaneously for both components. [3] The analysis relied primarily on quantitative data analysis and an auxiliary, supporting role is instead played by qualitative data analysis (Zou et al., 2018).

Point of integration

The point of integration is a crucial step in research, where the results from both quantitative and qualitative methods are combined and integrated. This is when the two methods are "mixed" and the results are combined to provide a more comprehensive understanding of the research question. The point of integration can occur at different stages in the research process, and in this thesis, it will take place in the discussion chapter, using the "results point of integration" approach (Morse and Niehaus, 2009).

1.5 Outline of the Research Process

Following the line of a concurrent triangulation design, the research process took place in six concurrent steps: (1) document analysis of (legal) strategy documents, (2) semi-structured interviews with experts and in-depth analysis of policy instruments, (3) secondary data analysis of EU-SILC data, (4) analysing critical intersections between climate and (social) housing policy, (5) primary survey data analysis, and (6) integration of results across the methods. These six steps consecutively inform each other. The data was analysed separately but then specific findings were compared, cross validated, and synthesised to answer the research questions. The six steps of the research process are outlined in the next paragraphs.

3 The use of capital letters implicates that the quantitative component in the same design is prioritized and the lower-case letters indicate secondary or supplemental priority of the qualitative analysis.

1.5.1 Step One – Document Analysis

In the first stage, a document analysis of the national legislative architecture was conducted. Legally binding and legally non-binding Austrian climate and (social) housing policy targets were identified that explicitly addressed the housing sector, specific population groups and building segments. For the thesis, document analysis[4] presents the first starting point to get an overview of the regulations and policy frameworks that exist in the EU, in Austria and in Vienna. The rationale for reviewing and evaluating the documents was to provide context, generate questions, identify relevant categories of analysis and to understand why governments enact certain policies and their potential effects on certain groups (Mogalakwe, 2009). The selected documents comprise EU and federal (state) laws, regulations, directives, party programs, coalition agreements, and major programs from national administrations, as well as, policy documents from non-governmental organisations. This approach recognises emerging themes which become the categories for analysis (Fereday and Muir-Cochrane, 2006). Some pre-defined codes were used based on the research question. The documents were screened focusing on the codes energy poverty, vulnerable groups, energy justice, and proposed mitigation approaches. The document analysis was guided by the following questions:

- What kind of climate, building, and social targets exist in the EU and Austria?
- How is energy poverty addressed in the EU legal frameworks, in Austria and in Vienna?
- From a multilevel policy analysis, what energy poverty policies and instruments exist?
- How do energy poverty instruments in Austria target vulnerable households?
- Are institutional interactions between ministries/ magistrates or governmental departments taking place to ease energy poverty?

1.5.2 Step Two – Expert Interviews

The policy document analysis was complemented with expert interviews with representatives from governments, NGO's and energy service providers in order to decrease bias and to understand if important social and climate targets in the EU and Austria are left out by the researcher. The second step serves to evaluate, cross-validate, confirm, or contradict the results from mapping the policy targets and detect possible misalignments between the climate and

4 Document analysis involved scanning through the documents, a careful reading and examination of upcoming themes and topics, and interpretation.

social sphere in the Austrian institutional setting. Qualitative expert interviews with key actors were conducted to gain insights into governance practices regarding gaps, barriers or overlaps between both policy spheres. Bogner and Menz (2009) developed a typology of three forms of expert interviews: exploratory, systematising, and theory-generating expert interviews.

(1) The exploratory expert interview serves to establish a guiding way into a poorly investigated field of research and to develop a clear idea of the problem. It serves as an explorative tool to gain a first orientation into a new field and to better structure the problem.
(2) Systematising expert interviews see experts as a source to obtain systematic and complete information on the topic of investigation. Experts have special knowledge and are not the object of the investigation, but function more like informants. Experts in this case are persons who are responsible for the development, implementation or control of solutions or policies. Moreover, experts generally have privileged access to information about groups of people and decision processes, or who have an exclusive position.
(3) Theory generating interviews focus on subjective aspects of expert knowledge and try to reconstruct implicit knowledge of action and interpretation. Often, this technique relates to the function of experts and less on their knowledge. Hence, these interviews emphasise motives, beliefs, and routines during work.

The **systematising expert interviews** are most suitable given the research questions for the thesis since the knowledge gained from step one will be used to evaluate, confirm, or contradict the policy analysis.

Selection of experts

A preliminary search was carried out to identify experts in the climate and social policy sphere in Austria who have specific technical knowledge of details concerning "*how things work*" regarding coordination and integration of social and/or climate policy fields. Experts were selected for their knowledge and experience in relevant topics and laws (e.g. intersections of housing laws and retrofitting) and their firsthand understanding of the governance structures and barriers in policy implementation. They were chosen for their insight into routines and interactions between hierarchical structures and possible pitfalls in the implementation process. They serve as key informants in identifying barriers in climate change and social housing policies. The interviews were conducted face-to-face in Vienna and Graz (between 2018-

2020).[5] They lasted about an hour each (a full list of interviewees and questions is provided in Appendix A in Table 40). In total, 15 key actors affiliated with federal and regional authorities, NGOs, academia and energy utility companies were interviewed. Following a semi-structured interview technique, respondents were presented with a set of pre-defined questions while allowing certain themes to be explored in greater depth depending on their specific interests, expertise and points raised. The sequence of the questions was adopted throughout the interview situation, depending on the area of expertise.

Interview topics focused on social and climate-related characteristics of housing segments, conflicts of climate and social policy goals, matters of policy integration and cross-sphere policy impacts. A policy matrix was used to open and stimulate the interviews (see Appendix Figure 46). The experts were asked whether the matrix exhaustively covers all main climate and social targets; what indicators, measures, and evaluations are implemented to pursue these targets; which population segments are (not) reached; the distribution of competences and jurisdictions; coordination of social and climate policies; and conflicts of interests. Direct translated quotes from the expert interviews will be used in the results section of this thesis to understand current developments. The interviews served to supplement and validate the findings from the document analysis. Both methods, therefore, complemented and informed each other following the means of triangulation (Denzin, 2017).

1.5.3 Step Three – Energy Poverty Analysis in Austria with EU-SILC Data

In the third step, secondary data analysis of EU-SILC data (year 2019) was utilised. The aims were twofold:

- to quantify and differentiate between predominant definitions of income and energy poverty in Austria to understand the multidimensionality of energy poverty
- to determine energy poverty intersections with structural building characteristics (e.g. legal status, construction period, housing segments), housing conditions (e.g. housing/ heating costs, heating system), and socio-demographics of vulnerable groups.

The secondary EU-SILC data analysis seeks to answer the following questions:

5 Experts were contacted via e-mail with a description of the research project, its major goals, content and the motivation behind the research. After confirmation or interest, the interview guide was sent attached in an e-mail. Prior to each interview, all experts agreed to be audio recorded and signed a confidentiality agreement. All interviews were conducted in German.

- Who and how various households are affected by energy poverty in Austria?
- Which building segments are most affected be energy poverty?
- What socio-economic/ socio-demographic groups are energy poor in Austria?

1.5.4 Step Four – Primary Data Analysis of Social Housing Residents

S*tep four* builds the core of the thesis, namely collecting, analysing and interpreting primary survey data. Insights from the document analysis and expert interviews provided the researcher with contextual information to conduct the primary data analysis and the selection of the case study area. The study employed a non-experimental, cross-sectional design. It is the point where the data of the social housing survey in Vienna is gathered and analysed to assess how households differ depending if they had a retrofit or not, and weather households make use of self-restrictions reflecting hidden energy poverty. The survey is analysed by following the research questions:

- Do households use self-restricting energy behaviours in social housings in Vienna? Who is hidden energy poor in the case study?
- Might energy self-restrictions help to overcome and complement identification issues of energy poor households in Austria?
- Do building characteristics, socio-demographics, -economics influence self-restricting energy behaviours?
- Do attitudes, social norms, perceived behavioural control, and habits influence the intention to restrict energy?

1.5.5 Step Five – Multilevel Governance Policy Analysis

From a multilevel governance perspective (EU, federal, and federal states level), step *five* foresees the analysis of current policy instruments to ease energy poverty. The policy analysis is based on the matrix of policy targets and the interviewee inputs. Expert quotes provide the assessment of policy pitfalls and deeper insights into the governance structure. The Clean Energy for All Europeans Package (European Commission, 2019a) is presented, including its major Directives and Regulations related to energy poverty. This is followed by current programs, laws, and housing subsidies in Austria that are connected to energy poverty. The policy analysis is theoretically grounded in the policy coherence and integration framework using a multilevel governance perspective (Benz, 2021; Corfee-Morlot et al., 2009; Kazepov, 2010; Mickwitz, 2009). The policy analysis followed a specific set of guiding questions and tasks to assess the impact of the policies and measures tackling energy poverty (evaluation follows Schumacher et al., 2015):

- What policies currently exist to tackle energy poverty in the EU and Austria?
- Is the target group clearly defined and do policy instruments reach energy poor households?
- Does the measure tackle energy poverty in a short or long term?
- From an intersectional perspective, are some households left behind, overburdened or neglected in the contemporary policy frameworks?

1.5.6 Step Six – Mixing of Qualitative and Quantitative Results

After the analysis of quantitative and qualitative data, the last step brings the results together in the discussion chapter and evaluates the relevance of the research results in a wider research context. It is the part where mixed methods integration occurs. The two domains may yield potentially converging, complementing, conflicting or diverging results.

1.6 Outline of the Thesis Structure

The thesis is composed of 14 themed chapters. Following this *introductory* chapter, the *second* chapter will examine existing definitions of energy poverty and then illustrate the research gap. It will link self-restriction to previous research on hidden energy poverty, underconsumption, and energy use. Chapter *three* explains energy behaviours and links them to energy poverty research. The *fourth* chapter is concerned with the methods used in this thesis and provides justification for conducting research in social housing in Vienna. The *fifth* chapter presents and analyses the goals and instruments connected to energy poverty through a multilevel governance lens. The *sixth* chapter presents the findings of the policy analysis in Austria and focuses on whether climate policy can cushion social inequalities in Austria. Chapter *seven* explains housing policies, and identifies barriers to retrofitting activities in Austria. In chapter *eight*, Vienna's mitigation measures against climate change and energy poverty are discussed. Chapter *nine* delves into the quantitative part of the thesis by analysing current energy poverty trends in the EU and Austria using EU-SILC aggregated and micro-data. The quantitative case study results of social housing residents in Vienna are presented in chapter *ten*. Chapter *eleven* identifies the determinants of multidimensional energy poverty and assesses its extent among social housing residents in Vienna. In chapter *twelve*, structural equation models are estimated to understand energy use, identify key factors that predict energy restriction and rebound behaviours, and examine the connections between psychological factors and these behaviours. The findings are assembled in chapter *thirteen*, which provides a synthesised discussion of insights into the thesis. Lastly, chapter *fourteen* lays out how these findings inform research and knowledge on energy poverty, and the contributions this thesis makes to the field of energy poverty research. An overview of prominent topics of this thesis is visualised in Figure 3.

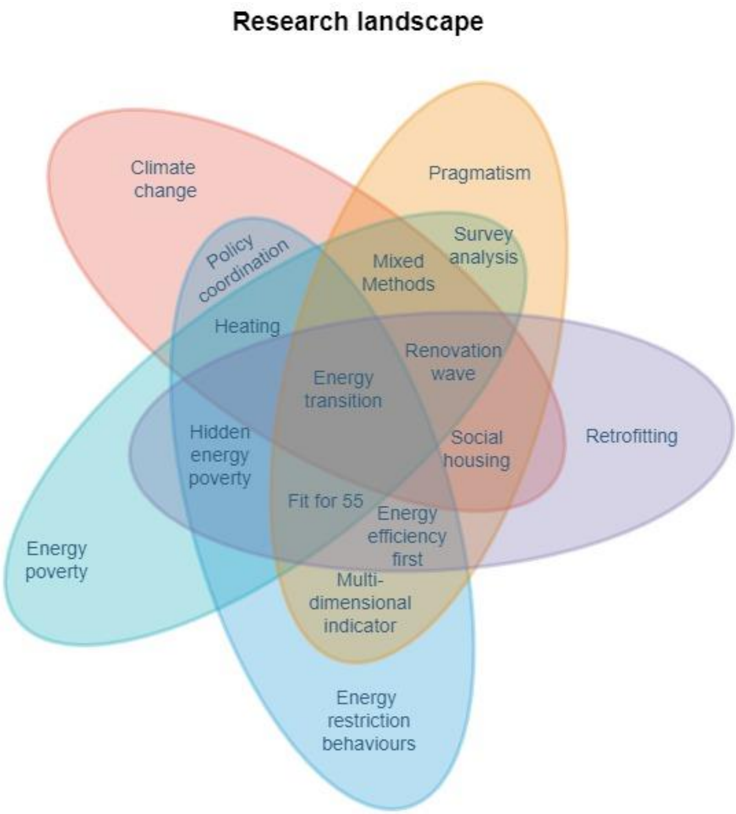

Figure 3 Research Landscape of the Thesis (Source: Own Visualization)

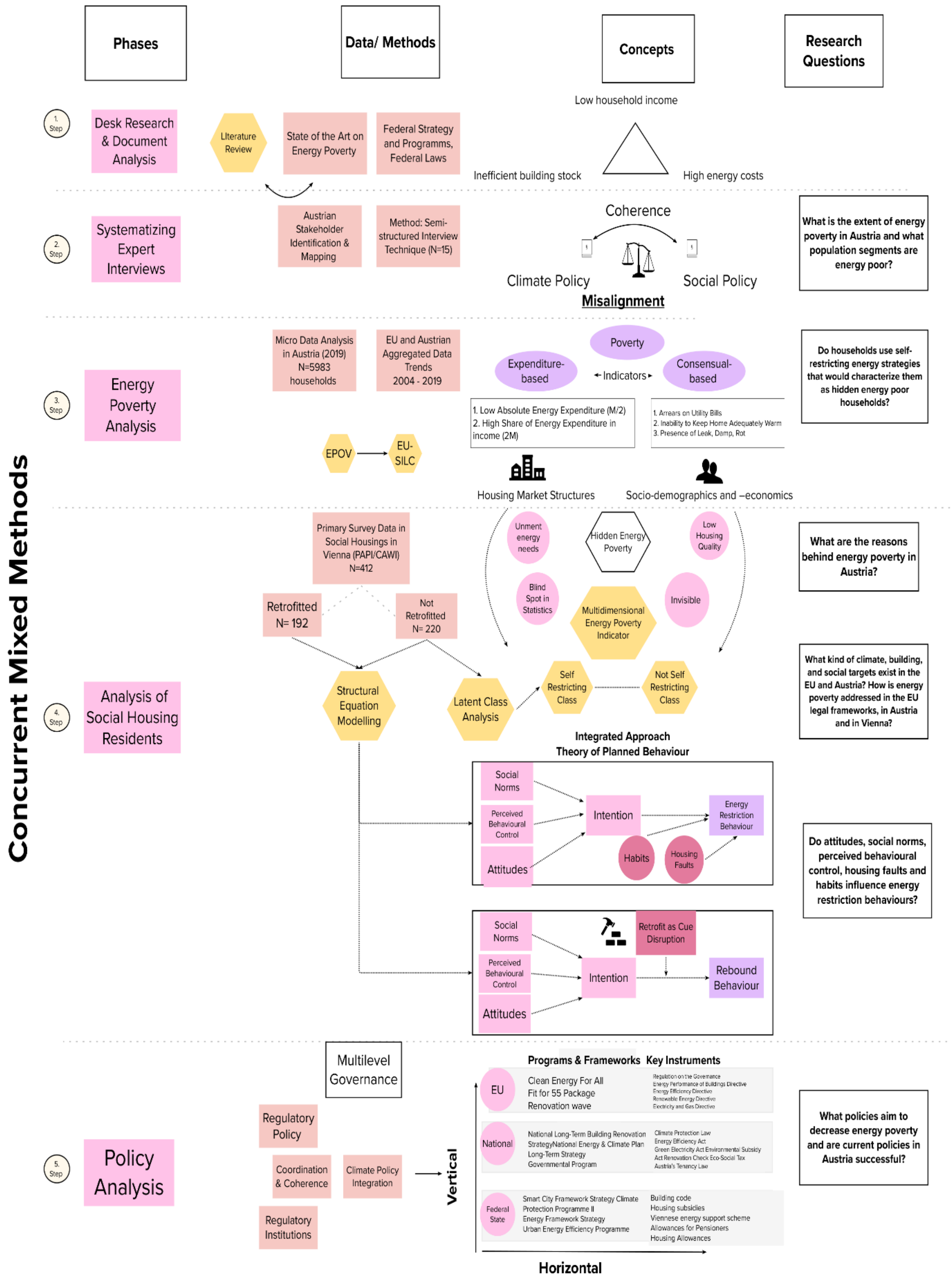

Figure 4 Analytical Framework of the Dissertation (Source: Own Visualization)

2. Theories and Causes of Energy Poverty: Setting the Scene for a Comprehensive Understanding

The chapter lays down the foundation for analysing energy poverty in the EU and Austria. A profound body of scientific literature recognises the importance of addressing energy poverty, and in recent years, there has been considerable debates taken place on how to approach, analyse and tackle the issue. The international groups of researchers studying energy poverty are multidisciplinary, spanning from sociology, engineering, public health, geography, architecture and planning, environmental studies, economics to industry. Each of these disciplines takes a unique approach to understand energy poverty, inspired by the prevalent methodological and conceptual underpinnings and research trends in each respective field. Several ways to operationalize energy poverty have been proposed, and the appropriateness of the selected metrics and methods has been debated heavily. Energy poverty is not only identified as a societal problem in academic literature, but it is a relevant topic in political debates in the EU and its member states connected to climate and social policies. This chapter enters the scientific debate around the various definitions of energy poverty and ways of approaching it theoretically and empirically. Specifically, it will illustrate a research gap in the way energy poverty has been conceptualised so far, and it will shed light on an aspect that received less attention in the current scientific work: self-restricting energy behaviours that points to hidden energy poverty. The chapter will then critically examine why hidden energy poverty is a crucial aspect that can improve the identification of energy poor households. It will also explore how this understanding can inform the formulation of future policies and adequate programs to address the phenomenon.. Finally, this chapter shows that excluding self-restrictions from the understanding of energy poverty implies overlooking households at risk and potentially incurring misidentification in policy strategies.

The objective of the chapter is to develop a novel approach to understand, target and analyse energy poverty in Austria. To this end, critical implications of various energy poverty definitions will be discussed and examined. It will be argued that energy poverty is a multidimensional construct that presents various consensual and expenditure-based dimensions. Because the choice of definitions has an important impact in shaping policy responses, different drivers, definitions and causes are presented to provide various ways to investigate energy poverty. To argue why it is important to employ various definitions of energy poverty, critical limitations of the prominent indicators will present the rationale for using a multidimensional energy poverty indicator. Hence, next to a bear description, significant challenges in the application of the measurements will complement the chapter. Problems of identifying hidden energy poor households will be discussed and an alternative way will be proposed. A working definition of energy poverty will be presented in the concluding section that synthesises the presented literature. Overall, this chapter seeks to answer the following questions:

- What is energy poverty, and how can we measure energy poverty?
- What are the drivers affecting the risk of being energy poor?
- What are the key features (in terms of description, analysis, evaluation) of distinct sets of energy poverty indicators?
- What is hidden energy poverty?
- How can hidden energy poverty be operationalized besides the current indicators?

This chapter has been organised around ten sub-chapters: sub-chapter *one* opens with the general definition of poverty and moves on in the *second* sub-chapter to explain energy poverty. Three drivers of energy poverty are outlined in sub-chapter *three*. Having defined poverty at the beginning of this chapter, the *fourth* sub-chapter distinguishes shortly between income poverty and energy poverty. Sub-chapter *five* offers multiple ways to operationalize energy poverty. This chapter also presents areas of controversy about energy poverty measurements. Sub-chapter *six* outlines the European Energy Poverty Observatory and its four main energy poverty indicators. Sub-chapter *seven* provides some concluding remarks on the typically employed energy poverty measurements. Sub-chapter *eight* is concerned with the state-of-the art to pinpoint the current research gap in the energy poverty literature. Sub-chapter *nine* links hidden energy poverty to self-restricting energy behaviour, underconsumption, and occupant behaviour. Sub-chapter *ten* ends with a conclusion and a proposal to consider self-restricting energy behaviour complementary to existing formalised energy poverty indicators and to direct to future research.

2.1 What is Poverty?

Before delving into the energy poverty discussion, it is necessary to clarify common definitions of poverty and social exclusion, and its application in EU research debates. The necessity to explain the concept lies in the circumstance that energy poverty indicators predominantly employ commonly used poverty measures. The EU definition of poverty strongly differs from other definitions in other parts of the world (e.g. the US definition relies on an absolute measurement) leading to very particular policy implications and measurements to combat poverty. From a general perspective, poverty characterises the inability to meet the basic needs for survival. The EU's working definition of poverty is taken from the 2003 joint report of the European Council and the Council of the EU:

> *"People are said to be living in poverty if their income and resources are so inadequate as to preclude them from having a standard of living considered acceptable in the society in which they live. Because of their poverty they may experience multiple disadvantages through unemployment, low income, poor housing, inadequate health care and barriers to lifelong learning, culture, sport and recreation. They are often excluded and marginalized from participating in activities (economic, social and cultural) that are the norm for other people and their access to fundamental rights may be restricted" (Council of European Union, 2003).*

This definition shows that poverty is associated with a lack of resources and it is a situation of individuals or households who got into difficulties by no fault of them. The concept also addresses multiple deprivations next to a lack of money, such as opportunities, services, and experiences that are accepted as normal in a society. It pinpoints to the fact that participation in economic, social and cultural activities is key in society for a minimum acceptable way of life. Hence, the assessment of poverty contains a multidimensional perspective to account for various factors of human deprivation as it became widely accepted that traditional income-based measures do not adequately target the most vulnerable groups (Ballon and Krishnakumar, 2011; Nolan and Whelan, 2011). That is why the lack of resources does not necessarily relate to income or wealth alone but is defined as having less in terms of a specific aspect, like health or education, compared to other members of a country.

How do we measure poverty? Monetary poverty is the most-employed measurement of poverty. Thereby, *relative* rather than *absolute* measurements are utilised in the EU as poverty is measured in relation to the distribution of income in each Member State ("MS") using a *relative income poverty line*. It is calculated as the income relative to the average or median household income within a country, adjusted for household size and composition (i.e. how many children or adults live in the household). Equivalence scales are used to adjust for differing household compositions.[6] The poverty threshold in the 28 EU MS refers to people that are falling below 60% of the country's median equivalised disposable income (after social transfers). A household is considered being poor if its income and resources are worse than what is thought

6 It is standard practice in empirical poverty research to use the so-called modified equivalence OECD scale ((Eurostat, 2018b), which assigns a value of 1 to the household head, 0.5 to each additional adult member (aged 14 and over) and 0.3 to each child (aged under 14). This equivalence scale is also employed in the results section of the thesis.

to be adequate or socially acceptable in the society/ country in which the person/ household lives.

Using median income as a measurement has several advantages over the use of mean income. First, it is not affected by extreme values (outliers) and is therefore a more accurate representation of the population. Second, it is less sensitive to sampling errors (Atkinson et al., 2002). However, determining what is adequate, socially acceptable is often left to experts or political decision-makers. To achieve a social consensus, it is important to evaluate and regularly reassess these standards. One limitation of using relative poverty lines is that monitoring progress over time and space is not always useful, as there will always be a bottom, for instance, 40% of the population living in poverty. The standard of living (e.g. living space in m^2), however, could have risen over the time, as impressively witnessed in the 1960ies in the EU (Beck, 1986).

Eurostat compiles statistical EU comparative data on relative-income poverty rates (European Commission, 2020p).[7] To monitor poverty related progress, the Employment, Social Policy, Health and Consumer Affairs' Council of Ministers agreed on an ‘at risk of poverty or social exclusion’ indicator. This indicator is the benchmark indicator in the EU typically utilised in official EU poverty statistics. The prefix ‘at-risk-of’ signals a person’s or household’s likelihood of becoming poor or, in other words, being vulnerable to becoming poor (Decancq and Lugo, 2013). In fact, also millionaires can be ‘at-risk-of poverty’ although the likelihood is not high. Eurostat glossary indicates that:

> *“this indicator does not measure wealth or poverty, but low income in comparison to other residents in that country, which does not necessarily imply a low standard of living” (Eurostat, 2018a).*

The measurement does not consider assets, properties, and capital. This seems rather odd because a person identified as (income) poor may live an opulent lifestyle and may maintain a high consumption level. Pertinent literature indicates that capital is more unevenly distributed than incomes, particularly in Austria, with the highest concentration of net wealth distribution (Lara, 2015).

7 EU-SILC replaced the European Community Household Panel (ECHP) in 2004 as the common European source for data on income and social inclusion. To avoid quality problems, low response rate and incomplete geographical coverage as in the ECHP, EU-SILC pays particular attention to the sample design, internationally harmonized income definitions, and EU-wide coverage (Clemenceau and Museux, 2007). The EU-SILC database is an EU milestone as Member States are mandated by law to deliver harmonized data to the EU.

The EU at risk of poverty and/ or social exclusion indicator comprises a combination of three key dimensions and constitutes a multidimensional approach to identify a poor population (Eurostat, 2019a). It includes the total number of people that fall into one or more of these three categories:

1. *At risk of poverty* concerns monetary poverty and refers to people with a disposable household income below 60% of the national median equivalised disposable income.
2. *Severe material deprivation* is a measured with an index of nine items connected to a lack of ordinary necessities, which would indicate decent living standards in a society. All persons living in a household which, at the moment of the interview, are deprived of at least four out of nine items are considered severely materially deprived (see Table 1).
3. Living in a household with very *low work intensity* reflects the share of population aged 18 to 59 years living in households where the working age inhabitants worked less than 20% of their total work potential during the past year.

This at-risk-of-poverty approach is robust, data is harmonised and provided annually in the EU. The at-risk-of-poverty indicator is classified as an objective measure as it uses information collected with a high degree of 'objectivity', namely households income and expenditures. It can, however, be critically argued that this indicator does not measure the concept of poverty per se but resembles more *income* inequality since in extreme cases in a country with a rather equal income distribution the 'at-risk-of-poverty' indicator could take the value zero, even if the majority was poor. Taking Luxembourg as an example: people below the 60% of the Luxembourgish median income have much higher living standards and would indicate a rather large spread of the income distribution (Darvas, 2019). Hence, interpreting the indicator can be misleading as it measures relative income poverty, more precisely, income inequality *within* a country and not *between* countries (Darvas, 2019). Interestingly, EU goals and recommendations aim to reduce social exclusion and poverty but not explicitly income inequality, which -at its core- this indicator actually measures. An additional indicator that considers the distribution of income, assets or capital in the EU would offer a more nuanced picture of poverty.

Item	The household…
1	… has been in arrears on mortgage, rent payments, utility bills, hire purchase instalments or the loan payments over the last months.
2	… does not have the capacity to afford paying for one-week annual holiday away from home.
3	… does not have the capacity to afford a meal with meat, chicken, fish or vegetarian equivalent every second day.
4	… does not have the capacity to face unexpected financial expenses equal to the at-risk-of-poverty threshold (monthly average) estimated on the basis of EU-SILC of two years ago.
5	… cannot afford to keep the home adequately warm.
6	… does not have a telephone because it cannot afford it.
7	… does not have a color TV because it cannot afford it.
8	… does not have a washing machine because it cannot afford it.
9	… does not have a car because it cannot afford it.

Table 1 Poverty as Material Deprivation of Nine Binary Indicators (Source: Eurostat, 2019b).

Since the at-risk-of-poverty rate is a relative measure, that is inherently country specific, the threshold differs across countries in terms of the purchasing power they represent. For that reason, EU country comparisons are risky to utilise and cautiousness is advised before making country conclusions. Consequently, this holds also true for country comparisons that employ energy poverty measurements that include the 'at-risk-of-poverty rates'. A further critical issue, which requires a thoughtful discussion, concerns normative assumptions of the 60% median income cutoff thresholds.

> *"All poverty lines will retain an element of arbitrariness, and a convincing analysis of poverty is built on a whole sequence of steps with the poverty line being just one of them (Lanjouw, 2001)."*

Delving shortly into the predominant EU poverty definition was essential to understand its application, pitfalls and particularities, also because commonly applied energy poverty indicators include the 'at-risk-of-poverty' and/ or social exclusion indicator. This chapter argued that this indicator has a limitation as it does not include assets, savings, and capital. This, however, is an important determinant of whether a household is poor, because this is a major determinant of whether a household can face unexpected events (e.g. investments to increase energy efficiency), which can remedy and lift households out of energy poverty. These wealth-related questions, however, are considered as a sensitive and private topic difficult to ask in surveys, as respondents are less willing to answer them due to confidentiality issues (OECD, 2013).

2.2 What is Energy Poverty?

Between 50 and 125 million people cannot afford proper indoor thermal comfort in the EU (European Commission, 2021b). This constitutes a major problem, inter alia, for health, as well as, for quality of life of the dwellers (Atanasiu et al., 2014). The number of people unable to afford proper indoor thermal comfort in the EU is likely to have increased because of high inflation and energy prices, which exacerbates energy poverty and its negative effects on health and quality of life of dwellers. The large spread indicated of affected energy poor households[8] in the EU results from a variety of energy poverty indicators and definitions that exist in the scientific and political sphere. The academic literature and EU MS provide various definitions to quantify energy poverty and a common European definition is still pending. Some EU countries have officially defined the concept of energy poverty.[9]

Energy poverty is related to several EU priorities predominantly concerning energy efficiency (European Commission's "Clean Energy for All Europeans" package), poverty, and healthcare. As it constitutes an intersectoral policy matter, there is no 'one size fits all' approach. The pertinent scientific discussion subsumes it as a particular form of environmental inequality[10] and as an unacceptable feature in contemporary society (Sovacool, 2015; Walker and Day, 2012; Wilkinson et al., 2007). The prevalence of energy poverty has firstly been recognised in the UK and the Republic of Ireland in a social policy context. In both countries, there is a rich body of scientific literature, starting from the mid-1970s due to a rapid increase of domestic energy prices following the Oil Crisis. In the last decades, scientific and policy debates around energy poverty spread and expanded with a wide range to the rest of the EU but also to most highly industrialised countries and it became the subject of new political awareness (Bouzarovski, 2018b; Bouzarovski and Petrova, 2015).

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8 The terms "energy poverty" and "fuel poverty" are often used interchangeably in the scientific community, as well as in EU policy documents. In an EU legislative piece, Member States shall define vulnerable consumers with reference to "energy poverty". In her PhD thesis, Thomson (2014) illustrated that out of 187 (policy) documents, 132 (70.59%) use the term energy poverty over fuel poverty. This thesis will use the term "energy poverty" as it has become more common in recent EU documents and scientific contributions.

9 See Rademeakers et al. (2016) for an extended list of countries individual definitions of energy poverty.

10 Environmental inequality refers to "results from the unequal distribution of the risks and benefits that stem from interactions with our environment" (Ganzleben and Kazmierczak, 2020, p. 3).

Essentially, after the financial crisis in 2008, the phenomenon gained more public and policy attention as austerity policies implemented by governments across Europe have contributed to cuts in welfare spending, which led to the increased likelihood of households experiencing and falling into energy poverty (e.g. Greece). The amplified scientific attention can also be assessed on the number of publications dedicated to energy poverty. Figure 5 shows the number or publications in “Elsevier Science Direct” utilising the keywords “energy poverty” and “fuel poverty” that gained momentum after 2008.

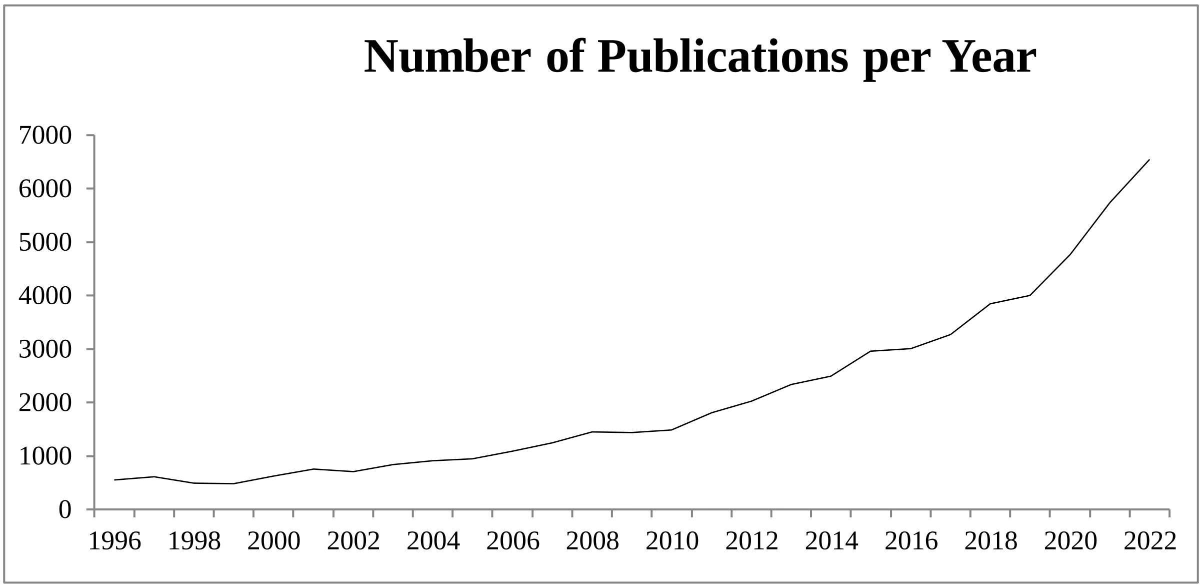

Figure 5 Number of Publications per Year in “Elsevier Science Direct” with the Key Word “Energy Poverty” or “Fuel Poverty”(Source: Own Calculation Based on Elsevier).

2.3 Main Drivers of Energy Poverty?

Energy poverty occurs at the nexus of (1) low household income, (2) high energy prices, and (3) energy inefficient building stock. Measures to combat energy poverty can be divided into four major policy areas (Kyprianou et al., 2019):

1. consumer protection (e.g. tariffs through regulated energy prices, disconnection protection),
2. direct financial interventions/ support (e.g. heating allowances or social assistance),
3. energy savings measures, including energy efficiency and renewable energy sources schemes (RES) (e.g. soft loans or subsidy schemes),
4. information provision/ awareness-building and energy counselling (e.g. awareness campaigns, energy saving tips) to lower energy consumption.

Figure 6 visualises the predominant causes and solutions to mitigate energy poverty. The two measures stated above (income increase and fuel price regulation/ fuel subsidies) typically refer to short-term remedies as they tend not to tackle the cause of the problem but rather reinforce to maintain the *status quo* because only one of the three indicated problems is eliminated.

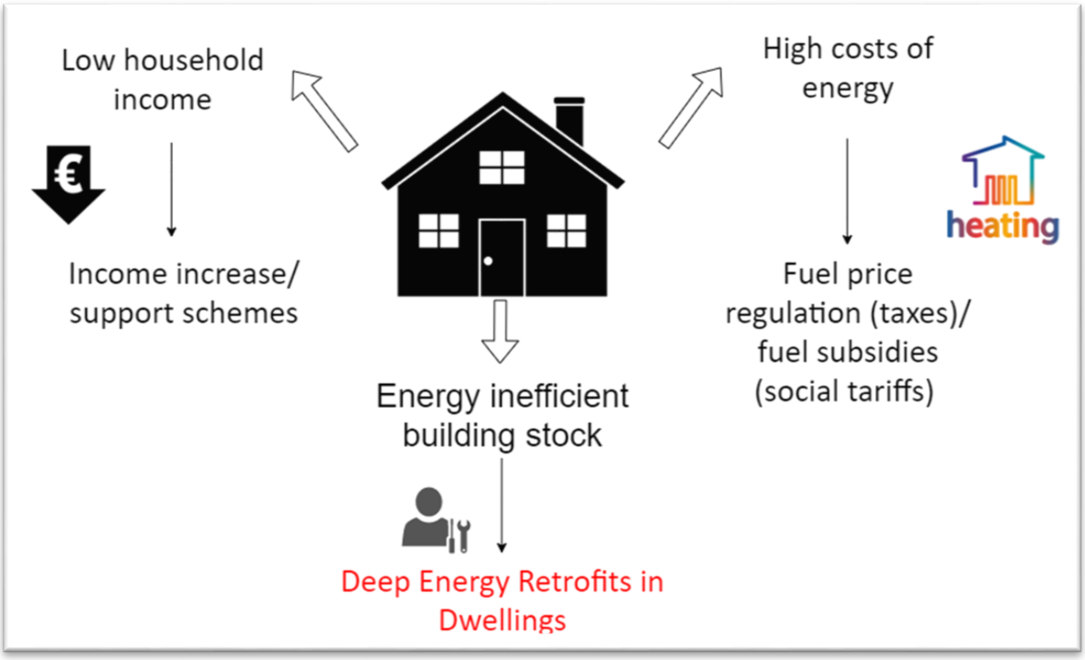

Figure 6 Energy Poverty – Causes and Solutions (Source: Own Visualization).

The provision of social tariffs, prolonging consumer debts to pay energy bills, discounts to vulnerable households or disconnection prohibitions do not provide sustainable remedies of energy poverty as they are palliative solutions (Schumacher et al., 2015). Improving energy efficiency is a more sustainable approach as it reduces greenhouse gas emissions while also providing a long-term solution to vulnerable groups. This is because addressing the underlying causes of energy poverty ensures that the problem will not persist even if tenants move out of an energy inefficient home, ensuring that the next tenant will not be affected. A majority of energy efficiency ("EE") measures (e.g. exchanging heating systems) are, therefore, win-win situations as they allow people to heat their homes up to comfort temperatures by using less energy. This (if no rebound-effect occurs) reduces GHG emissions, energy costs, energy consumption and, in return, increases available household income. Therefore, EE measures are not only effective in reducing energy poverty, but they also have additional benefits, such as improving the quality of life for affected households. Retrofitting homes to increase energy efficiency often provides greater benefits than the costs of the measures, extending beyond just environmental benefits. The following major advantages and co-benefits are linked to EE measures. These points, however, should not be considered exhaustive:

Economic

EE improvements decrease energy demand and utility bills. Lower energy bills provide increased disposable income for households, which offer remedy to afford other critical services and needs (e.g. ease choice decisions, e.g. “heat or eat”). From the supply side perspective, retrofitting activities create green jobs (European Commission, 2020m; Yearwood Travezan et al., 2013). It lowers the dependency of imported fuels and mitigates energy security. From the building owner's perspective, it corresponds to increased property values and landlords' profit from long-term rentability (Heffner and Campbell, 2011). From the macro-economic perspective, EE results in improved grid stability, reduced network losses, and reduced costs for system upgrades and increases GDP (European Commission, 2015).

Environmental

From a climate change perspective, EE gains decrease carbon intensity of households and lowers GHG emissions and other pollutants (Boardman, 2010). A direct effect is the reduced primary and final energy consumption (Ugarte et al., 2016).

Health

The inability of households keeping their dwelling warm constitutes a significant public health problem (Bosch et al., 2019; Oliveras et al., 2020; Thomson et al., 2017b). Research has found that EE measures, such as insulation, district heating and double glazing, have positive effects on health and well-being (Bosch et al., 2019; Curl and Kearns, 2017; Marí-Dell'Olmo et al., 2017; Thomson et al., 2009). Health benefits are larger for children, elderly people, people with chronic diseases and for low income (Howden-Chapman et al., 2011; Maidment et al., 2014). Moreover, EE measures lead to an increase in average mean temperature indoors, leading to more comfort and an enhancement of quality of life (Heyman et al., 2011). Other positive health impacts of energy efficiency measures include the reduction of mortality, symptoms of respiratory and cardiovascular conditions, rheumatism, arthritis and allergies, as well as fewer injuries (IEA, 2014). Also, respiratory tract infections, Chronic Obstructive Pulmonary Disease, and the risk of heart attacks or strokes because of raised blood pressure can be lowered if cold and damp housing is improved (Fisk et al., 2007). EE improvements can lower stress (Gilbertson et al., 2012), and a study found that the incidence of anxiety or depression was halved after EE measures (Green and Gilbertson, 2008).

Braubach et al. (2011) showed that 30% of excess winter mortality is attributed to poor housing conditions and energy inefficient housing. Excess winter deaths are not only a northern and eastern European problem, but concerns also southern countries, like Portugal, Spain and Cyprus (Recalde et al., 2019). A meta-analyses of health effects of dampness and mould indicates an increased risk of 30-50% of a variety of respiratory and asthma-related health outcomes (Richardson and Eick, 2006). EE improvements lower the risk to have mould and improve indoor air quality (Kelemen et al., 2015). In total, 84 million Europeans live in damp or mouldy dwellings, and 2.2 million have asthma as a direct result of living in damp or mouldy buildings (Grün and Urlaub, 2016). Furthermore, cold homes have negative effects on mental health like being anxious or depressed (Anderson et al., 2010a). This is linked to stressors, such as financial insecurity, inability to control the temperature and to social isolation (Liddell and Guiney, 2015; Thomson et al., 2013). Moreover, energy poor households face the heat or eat dilemma, which is described as the choice decision between reduced food expenditure or self-restricting energy behaviours (Frank et al., 2006; UCL Institute of Health Equity, 2014).

Social welfare, urban livelihood and quality of life

EE measures address social problems connected to energy inefficient housings. Energy poor households can be isolated and feel embarrassed by their uncomfortable housing condition that can even be expressed by avoiding to accept visitors (Bashir et al., 2013). Children's education could suffer if only one room is heated, leaving no place for undistracted studying (Richardson and Eick, 2006). From the other point of view, a co-benefit connected to people's well-being after a retrofit is the improved appearance of the building and the increased community pride and social cohesion (Bisello, 2020; Dempsey et al., 2011). It may also lead to positive educational outcomes if inhabitants have a better understanding of the topic and becoming "semi-experts" by getting involved in topics, such as climate change.

2.4 Distinguishing Energy Poverty from Income Poverty

The beginning of this chapter introduced the EU definition of poverty and it revealed that poverty is operationalized through income poverty, which utilises a relative poverty threshold. There is a controversial debate about how to delineate energy poverty from income poverty. EE is the key dimension to differentiate both concepts from each other. Research results highlighted that measures that target income poverty also decrease energy poverty because two key drivers of energy poverty, namely low incomes and high energy bills, contribute to general poverty and overlap. This circumstance is likelyHowever, it's important to note that energy poverty cannot be equated solely with income poverty. Even if income poverty were eliminated, energy poverty could still persist:

> *"There is a factual statement which is that energy poverty is very different from poverty because of the role of capital investment. Capital investment is endemic whenever you talk about energy, so as soon as you bring energy into the equation you are looking at something very different from poverty" (Bordman in Liddell, 2012, p. 15).*

The rate of energy poverty is not only sensitive to changes in energy prices, but this quote refers to necessary capital investment that is a prerequisite to upgrade the living area to lower energy bills. The capital component is also linked to purchasing electrical appliances that have a high energy rating (Scott et al., 2008). Hence, increasing income of vulnerable households will most probably lead households out of poverty in the short term but not necessarily directly out of energy poverty as a faulty dwelling situation would remain unchanged until sufficient capital is saved to afford a retrofit or easy accessible loans are offered.

An important consideration is determining who will bear the financial burden of implementing EE measures, as the decision to retrofit does not occur in a vacuum and is influenced by factors such as housing ownership and tenure status. While EE measures and upgrades in own houses can be organised independently, the situation differs strongly for tenants living in f.i. multifamily buildings, as renovations are typically initiated, managed and organised by property owners (Eisfeld, 2022b)**.** Other research results indicate that renters are less likely to invest in retrofitting measures (Gillingham et al., 2012; Krishnamurthy and Kristrm, 2015). For energy poor or low-income households, lack of access to initial investment capital and risk aversion are major barriers to invest in EE measures in private households (Marchand et al., 2015; Schleich et al., 2019). The intention to invest in EE measures may also be denied by banks to access loans because of a lack of enough private assets. Schleich et al. (2021) found that debt aversion reduces the adoption of retrofit and request low-interest loans. Schmitz and Madlener (2021) research results indicate that the initial investment cost is the largest deterrent of supporting retrofitting measures in non-owned accommodations in Austria. A further complication is the decision making in multi-storey buildings with diverse owners (mixture of owners and tenants) as housing laws may hinder single landlords to retrofit a whole building. Often, tenants face the circumstance that they cannot motivate the property owner to retrofit. This is because of several reasons (Eisfeld, 2022a):

- lack of awareness, interest knowledge of EE,
- energy issues are usually not on top of the primary concerns,

- imperfect information on EE opportunities or the energy performance of technologies,
- homeowners' age influences their EE behaviour (Nair et al., 2010): older homeowners/ landlords are less likely to adopt EE investment measures,
- unavailability of targeted financial instruments and subsidies.

A prominent barrier to retrofit is called the tenant-landlord dilemma (known as split-incentive). It describes the conflicting situation in which the landlord/ owner of the property making the initial investment to increase the energy efficiency of the dwelling/ apartment (decision-maker) is not the same person who benefits from the positive effects (e.g. reduced energy costs) (Weber and Wolff, 2018). Retrofitting comes potentially with cost losses for the landlord (Ástmarsson et al., 2013). Because they do not see financial gains, landlords may become reluctant to make investments in energy efficiency. However, landlords/ property owners can be compensated for their large-scaled investments by increasing rents and the increased value of the building (Ástmarsson et al., 2013; Brown et al., 2019).

Often short-termed economic considerations and minor necessary measurements are prioritised by the landlord before EE measures (Palm and Reindl, 2018).[11] Without delving deep into the discussion on the various ways to overcome this dilemma, one solution for funding EE measures is an on-bill payment system, where the costs of renovation are repaid through utility bills by withholding cost savings from the energy bill, called *housing cost neutrality* (Ástmarsson et al., 2013; Bird and Hernández, 2012; Brown et al., 2019; Castellazzi et al., 2019). This means the bills will be equal or lower than before the retrofit, but higher than the actual post-retrofit consumption. The person who paid for the retrofit will receive the difference in energy savings (Zygierewicz, 2016).

To sum up, energy poverty differs from general poverty as it contains a capital investment dimension. However, making EE measures work for low-income renters is challenged because of the tenant-landlord-dilemma as rents typically increase and constitute a burden on energy poor households.

11 Depending on the depth of the retrofit, estimates of energy retrofit costs range from €200 to €450 per m2 Artola et al. (2016). Retrofitting costs differ heavily between MS, also due to various labour costs and demand.

2.5 Assessing Energy Poverty: Measuring Techniques and Indicators

The preceding sub-chapters have covered the causes and solutions of energy poverty. This sub-chapter focuses on various indicators to understand measuring techniques of energy poverty. To achieve this, this sub-chapter provides a theoretical overview of the current methods used to measure energy poverty in the EU, drawing on relevant literature from energy poverty research, official policy documents, and EU institutions (such as EU documents). The sub-chapter is organized around four key approaches to measuring energy poverty that have been consistently identified in the reviewed literature.

<u>Expenditure-based approach:</u> based on information about the household's expenditure on energy and often compared it to the household's income.

<u>Consensual/ subjective qualitative approach</u>: utilises self-reported assessments by affected households of indoor housing conditions, and the ability to reach, access and afford basic energy services (e.g. thermal discomfort).

<u>Objective non-expenditure-based indicators:</u> direct measurement of the level of energy services (internal room temperature in C°) achieved at home compared to a set standard.

<u>Outcome-based approach:</u> focuses on structural outcomes associated with energy poverty (e.g. cold-related mortality).

<u>a. Expenditure-Based Approach</u>

Expenditure-based approaches capture the affordability of adequate energy services for households with low income. This approach typically utilises various thresholds to employ an analysis. Expenditure-based approaches can be grouped into three overall categories (Rademeakers et al., 2016):

1. detecting households with excessive energy burden or energy expenditure (high share of energy costs): when energy (heating and electricity) or fuel costs lie above a certain threshold;
2. households whose residual income is below a monetary poverty line if its domestic energy expenses have been deducted;
3. households with very low actual energy consumption that indicates hidden energy poverty. This metric compares the minimum required energy consumption level that is necessary for a household with actual energy expenditure.

A closer look into these three categories shows that when the expenditure-based approach is applied, several essential considerations must be addressed prior to data analysis: a decision whether to apply an absolute or relative expenditure threshold, how to quantify energy demand and spending, and how to calculate household's income. Choosing the appropriate threshold for expenditure-based measurements is crucial and must be done with consideration of factors like data quality, availability, and scope of analysis. Each of the three strategies has its own limitations and strengths.

Boardman's 10% threshold

In the UK, the definition and measurement of energy poverty are well-developed and have a history dating back over four decades, with significant political attention paid to the issue (Isherwood and Hancock, 1979). Activist organisations and the movement for affordable warmth drew attention to increased energy prices following the oil crisis 1973-1974, and the inability of households to heat their dwellings at an appropriate temperature level, leading to high incidences of winter mortality (Fizaine and Kahouli, 2019). The most ground-breaking energy poverty definition arises from Boardman's pioneering PhD thesis "Fuel poverty: from cold homes to affordable warmth", published in 1991, where she defined energy poor households as those households that are "unable to obtain an adequate level of energy services, particularly warmth, for 10% of its income" (Boardman, 1991). In other words, "if a household spends over 10% of its average annual income to keep adequate indoor temperature it will be qualified as fuel poor" (Boardman, 2013).

The 10% threshold is a fixed threshold that constitutes a key indicator for energy poverty analysis in current energy poverty calculations. It originally referred to the *theoretical* amount of energy needed to keep warm (energy costs a household would have to pay), rather than the amount of energy used to keep warm (energy costs a household actually pays). Boardman focused on fuel expenditures of households relative to income. She reports that while average-income households spend approximately 5% on energy, most of low-income households spend a double of that. Hence, this approach considered twice the median (high share of energy expenditure in income) household spend on fuel at the time in the UK. Boardman (2010) explains that the 10% indicator of income was chosen as "affordable" at that time for everyone in the UK. Until now, this threshold remains one of the most popular indicators because it is easy to calculate and to apply.[12] The energy poverty ratio is calculated in the following way:

$$\text{Energy poverty ratio} = \frac{Modelled\ required\ domestic\ fuel\ costs\ (modelled\ consumption\ x\ price)}{Income\ before\ housing\ costs} > 10\%$$

The ratio is obtained by multiplying theoretical required fuel costs (consumption) by fuel price divided by household income. If the ratio is greater than 0.1 (10%) then the household is energy poor. The original indicator utilises the required energy spend for space heating, water heating, lights, appliances, and cooking to ensure that the household achieves the adequate level of warmth. Furthermore, for the analysis the numerator also contains household fuel consumption requirements and the energy efficiency of the household: size of the property, number of people who live in the dwelling, energy efficiency of the household, energy mix usage of each household (Department of Energy and Climate Change, 2010; Thomson et al., 2017a; WHO, 1987). However, theoretical needs vary between households and energy costs depend on the physical characteristics of the specific building. Therefore, typically outside of the UK, *actual* energy costs are utilised, which are more easily available in surveys (Moore, 2012; Thomson et al., 2017a).

In scientific debates on energy poverty, voices got louder to move away from the 10% indicator as this measure suffers from several shortcomings. Criticisms were largely of methodological nature: although that measure is simple to use, straightforward, and data is comparable, a drawback of great magnitude is that households with high incomes are likely to be identified as false positives, because they may have the means to pay for their relatively extensive fuel consumption. This is a circumstance that clearly does not correspond to the definition of energy poverty. Hence, the ratio only measures excessive energy expenditure than energy poverty. A substantial proportion of households are found to be energy poor, when in reality their large fuel expenditures are in line with their high incomes (Hills, 2012b; Legendre, Dorothee Charlier and Berangere, 2019; Moore, 2012).

Another limitation is that it does not consider the energy efficiency of the building. Moreover, it is sensitive to energy price fluctuations in the energy market (Koh et al., 2012), the original contribution does not account for socio-demographic or geographic dimensions, or dwelling characteristics (Heindl and Schuessler, 2015). The household's income is furthermore not

12 This 10% threshold indicator was widely employed in the UK and Ireland to assess energy poverty from 2001 to 2011, with statistical data taken from the English Housing Survey and modelled with utility bills of households.

equivalised to account for varying household size and composition. This measurement has been criticised for being timely inappropriate, as it relies on observations made almost 30 years ago. It seems not suitable in other countries and contexts, as it is based on an out-of-date national-specific threshold of energy expenditure. It is not clear whether energy poor households spend over 10% to achieve and maintain an acceptable room temperature or if they are just paying more because they cannot achieve the room temperature they prefer (Fahmy et al., 2011). And, Rademaekers et al. (2016a, p. 46) argued that "it may not reflect specific characteristics of each country's economy and income distribution". Moreover, the decision to fix the income threshold at 10% seems arbitrary forty years later in the EU (Koh et al., 2012).

Irrespective of the criticism discussed above, the 10% indicator is still widely used in several national contexts and in most published research on energy poverty. It could, however, be revised and adjusted to country-specific thresholds of energy expenditures. The analysis of modelled energy filters out over- or underconsumption of energy. Tirado-Herrero, therefore, highlights that actual energy consumption analysis systematically underestimates the severity of energy poverty, as energy poor- households typically spend less on energy than thermal comfort needs (Tirado-Herrero, 2017).

Low Income- High Cost indicator (above the median share)

Introduced by Hills (2012b), the Low Income High Cost ("LIHC") indicator replaced Boardman's approach and is a relative measurement that employs two expenditure-based thresholds by calculating the overlap between low incomes and high heating costs. In 2011, Hills was commissioned by the British Government to evaluate existing energy poverty definitions. A household is energy-poor when its (modelled/ calculated) energy costs are above the national median level, and after paying for that required amount, its residual income remains below the official poverty line. His classification of energy poor households follows the conventional 60% of the median equalised income poverty threshold after subtracting housing and modelled energy costs. An advantage of this measurement is the possibility of indicating the 'energy poverty gap' (shown by the horizontal arrow in Figure 7):

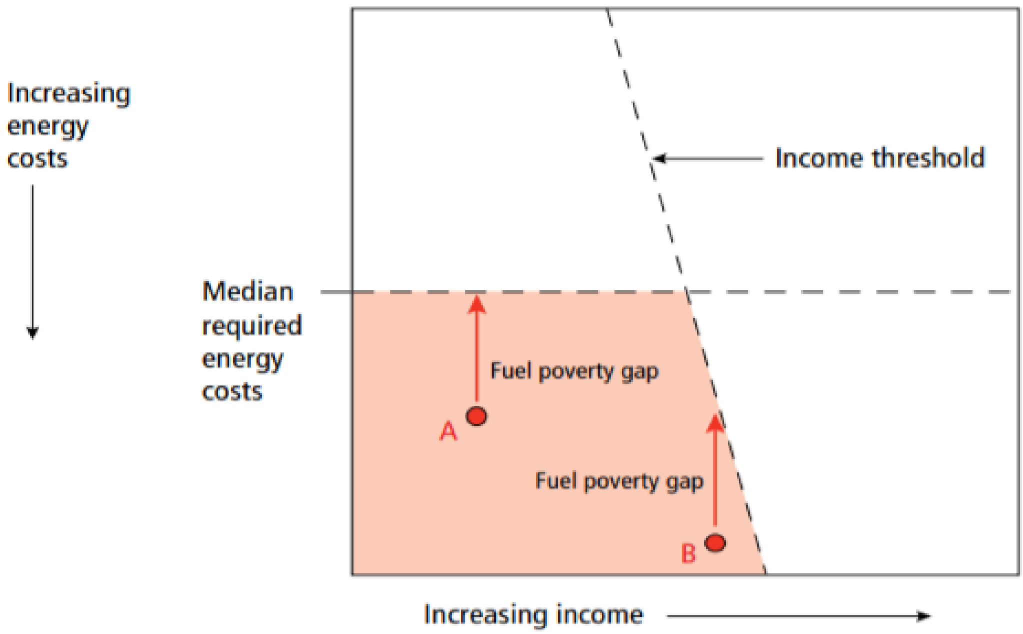

Figure 7 Energy Poverty Measurement with the LIHC Indicator (Source: Hills, 2012b).

it is the difference between the required energy costs for each household and the nearest energy poverty threshold. To put it in other words, it is the gap between what people need and what they can afford. Hence, it is the amount of money needed to reach the non-fuel-poor household threshold to get out of energy poverty (Allison, 2019). Compared to the 10% indicator, the LIHC indicator subsumes, both, the *extent* and *depth* of energy poverty as depicted in Figure 7.

$$\begin{cases} Equalised\ median\ net\ income\ (after\ housing\ costs \leq\ 60\%) \\ \text{Equalised fuel expenditures } \geq \text{required national median fuel expenditures} \end{cases}$$

Currently, this relative measurement is applied in England to assess energy poor households. Moore (2012) criticises the LIHC for being opaque and overly complex. He highlights that the LIHC is vulnerable to fluctuations in energy prices and explains that if prices increase for the entire population also the median increases, which will not capture any *change* in the number of households in energy poverty.[13] Another disadvantage of the indicator is the dependency on a substantial amount of household and property information.[14]

13 Hills (2012b) contradicts and defends his proposed measurement by pointing out that the 10% threshold is sensitive to energy prices because if energy prices increase this makes households increase their spending on energy and this will show an automatic increase in energy poverty rates by the indicator.

14 For the calculation of the LIHC indicator, the following information is required: household's income (equalized after housing costs), household energy requirements: size of the property; number of people living in the dwelling; energy efficiency of the household, and the mix of different fuels, and fuel costs.

The calculation of the relative energy costs component has been criticised by various researchers and consumer organisations. Walker et al. (2014, p. 90) argue that "households in smaller properties, which have lower fuel costs and need a lower income to cover these costs, are less likely to be counted as fuel poor". The major shortcoming is that the LIHC uses *total* rather than *unit* (€/m^2) energy costs. This leads to over-estimation of large, under-occupied housing units, which may lead to eliminate low-income households who disproportionately live in energy inefficient small properties. Belaid (2018), for instance, overcomes this weakness in his energy poverty analysis with an alternative indicator by replacing the total with a unit energy costs threshold set at the national median equalised fuel cost per m^2.

Additionally, the decision should be made whether to use actual or required energy expenditure. Published articles relate to household surveys where actual spending of energy in a specific period was asked. One has to remember that the person who fills out the questionnaire may not know the amount of money they spend on utility bills, as another household member may pay the bills. Another potential circumstance may be that utility bills can be included in the overall rent or paid directly by social services. Not delving deep into discussions on validity and potentially biased results, this indication does not reflect the cause of high or low expenditure levels: *is the low energy expenditure the result of a good energy performance of the building or due to self-restrictions and/or financial constraints?* Asking households directly about their household behaviours and taking the structural building and household characteristics into account could solve the puzzle.

Liddell et al. (2012) proposes to move away from the actual expenditure approach to a *"needs to spend"* approach because some households do not purchase the energy they require maintaining an adequate living. It is unknown whether a household's level of expenditure reflects a bad financial circumstance or a voluntary choice. The authors applied a regional twice the median indicator. The "needs to spend" approach requires standardised building stock information and energy efficiency data[15] to estimate required expenditure of the household; data that is usually unavailable on the EU level (not available in EU-SILC or Eurostat). The only available expenditure-based assessment of energy poverty can be made with the Household Budget Survey ("HBS")(Thomson et al., 2017b). The HBS is implemented in all EU countries and contains information on household's expenditure on goods and services,

15 The MURE database provides the largest and most comprehensive database of energy efficiency policy measures for the EU including impact evaluations (around 2400 measures). It is based on national policy documents such as the National Energy Efficiency Action Plans provided by EU Member States under the EU Energy Efficiency Directive (2012/27/EU; EED).

including household energy. Regrettably, the national datasets are not harmonised across the EU and there are differences in sampling methods and variable design, which poses the risk of providing not reliable information. Moreover, there is a high incidence of non-response, which constitute a major issue (European Commission, 2021d).

From a broader perspective, Middlemiss (2017) criticises that the LIHC approach puts too much emphasis on the technical issues of the efficiency of the building/ apartment detracting it from alternative problems, like a market problem (energy market and its regulation), an inequality problem (distribution of wealth), a tenancy problem (landlord-tenant dilemma), and a health problem. Tirado-Herrero (2017) concludes that

> *"indicators based on the income/expenditure approach are less objective than what is often considered given the substantial transformations they require that entail many decisions left in the hands of data analysts" (p. 1029).*

Based on his review, he opts to employ several energy poverty indicators to capture the full extent of energy poverty. An important issue concerns the energy poverty threshold line to capture specific needs of vulnerable groups: *should it be fixed on an absolute or a relative threshold for each country?* Are these thresholds able to capture differences in household energy needs that arise from different household sizes, age, incomes, or household compositions? Although expenditure-based indicators are considered more 'objective' as they rely on robust data, however, depending on the decisions of the researcher, which variables to consider in the modelling process, the expenditure-based thresholds contain normative assumptions and are subjective in their nature. Reason for this pitfall is that there is no universally accepted basket of basic energy needs/ services to differentiate between energy poor from those who are not. Moreover, while the commonly used threshold may work for the at-risk-of-poverty threshold, they are not directly applicable to energy poverty (e.g. twice median or 60% of the country's median equivalised disposable income after social transfers). A considerable weakness is that the indicator does not reflect the causes of the expenditure levels and it does not reflect self-restriction/ underconsumption of energy. An alternative indicator that directs to the causes of high expenditure levels is discussed in the next chapter.

b. Consensual-Based Approach/ Subjective Measures

The expenditure-based approaches were criticised from various angles, which led researchers like Healy (2004), Thomson and Snell (2013) or Petrova and colleagues (2013) apply *consensual approaches* to quantify energy poverty. Grounded in Townsend's (1979) relative poverty approach, consensual approaches do not focus on income or expenditure, they rather ask households directly about their ability to maintain an adequately warm home, their ability to pay their energy bills on time, as well as, questions about the conditions of the dwelling. These indicators are considered as 'socially perceived necessities' of the society and an absence is regarded as an indication of energy poverty (Healy, 2004; Ürge-Vorsatz and Tirado Herrero, 2012). Healy and Clinch (2002) conducted the first study using consensual parameters.[16] Compared to the expenditure-based approach, the responses to the questions are comparable, as they do not take certain thresholds into account that might conflict with country comparability.

Next seven proxies of the consensual energy poverty indicator are indicated whose absence is "consensually" considered as a necessity by over 95% of the EU population (European Commission, 2010). These attributes tackle both energy affordability (e.g. thermal comfort, and arrears on utility bills) and thermal efficiency (e.g. dwelling, warm, and cool). The researchers developed a composite index using the following harmonised data, which comprises three main (bold), and four additional (ad hoc module) items (these are proxies for consensual energy poverty indicator asked in EU-SILC surveys):

1. **Ability to pay to keep home adequately warm**
2. **Arrears on utility bills within the last 12 month**
3. **Leaking root, damp walls, floors or foundation, or rot in window frames or doors**
4. Dwelling comfortably wem during winter time
5. Dwelling comfortably cool during summer time
6. Dwelling equipped with heating facilities
7. Dwelling equipped with air conditioning facility.

Expenditure-based approaches are called "objective" because spending and earning data is utilised, while consensual approaches are critically regarded as "subjective" because they rely on a household's personal assessment of their own living conditions, pointing to possible validity concerns (Tirado-Herrero, 2017). Notwithstanding these limitations, the strength of the subjective measurement is the less complex collection of data compared to expenditure-based measurements. Also, there is no EU-wide standardised micro-data concerning household fuel

16 The authors employed the following proxies for their analysis to assess energy poverty in fourteen countries of the EU: affordability to heat home adequately, ability to pay utility bills on time, lack of adequate heating facilities, damp walls and/or floors, rotten window frames, and lack of central heating.

expenditure or housing conditions, which is needed for the calculation (Thomson and Snell, 2013).

Subjective indicators are preferred over objective ones as they depict households' actual perceptions of their own situation, as well, as potential pressures and stresses of affording sufficient energy services (Price et al., 2012). Moreover, EU-SILC and its ad hoc housing conditions modules provide EU wide consistent, comparable data which has been consistently utilised by researchers (Bouzarovski and Tirado Herrero, 2015; Dubois and Meier, 2016; Thomson et al., 2016; Thomson and Snell, 2013).[17] It is important to keep in mind that EU-SILC database was not designed to assess energy poverty as Thomson and Snell (2013) correctly emphasize. Consensual-based indices bear the typical risks of survey data:

- Comparability of the answers between the countries is questioned as the same question can be interpreted differently depending on the country context.
- Translated items can cause different interpretations that substantially affect the answers people provide. Does 'adequately warm' mean the same in Portugal, Austria, Sweden and Italy?
- Relying on subjective assessments bears the risk of neglecting the cultural context, meaning that "home normally considered well-lit and warm in one geographical context may not be seen as such in another" (Bouzarovski, 2018b, 2014; Walker and Day, 2012, p. 3; Zhang et al., 2017).
- Social desirability bias might be present as respondents want to present themselves in a positive light and do not want to report, for instance, arrears on utility bills.

Price et al. (2012) have compared the expenditure-based approach with the consensual approach and find discrepancies in the amount of detected energy poor households. The authors conclude that

> *"[m]any households who spend more than 10% of their income on energy do not feel energy poor, and not everyone who feels fuel poor spends more than 10% of their income on fuel" (Price et al., 2012, p. 37).*

This may imply that some energy poor households do not spend an above average amount on heating their houses, instead of self-restricting behaviours may lead to a blind spot that households do not fall into the energy poor category (see chapter 2.9). Moreover, varying indicators may yield opposing or different sub-populations at the highest energy poverty risk, which challenges policy-making (Sokołowski et al., 2019).

17 For an analysis of energy poverty in EU countries with subjective and multidimensional standards, see also Bouzarovski (2014), Buzar (2007a); Healy (2004); Healy and Clinch (2002).

c. Objective Non-Expenditure-Based Indicators

The direct measurement approach reflects adequate levels of warmth. In detail, it compares the level of achieved temperature at home (energy services) versus a pre-defined standard, which commonly is based on the World Health Organization (WHO) benchmark. According to the WHO, 18°C to 24°C temperature range is accepted to protect health, specifically for sedentary people, such as the elderly, infirm or children (Ormandy and Ezratty, 2012). According to WHO standards, a satisfactory heating regime for vulnerable households is 23°C in the living room and 18°C in other rooms, for all other households 21°C and 18°C, respectively. The Chartered Institute of Building Services Engineers refers to 16°C as the lowest temperature for bedrooms and 18°C for all other spaces (Peeters et al., 2009). The objective measurement of energy poverty faces nearly non-existent data, with some few exceptions, like the WHO's "LARES" project (World Health Organization, 2007).[18] The major results of the LARES project are: people spend the major part of their lifetime at home (during working days they spend on average 8.1 hours per day outside and on weekend 7.1 hours per day) and a substantial amount of the respondents reported frequent temperature problems in all seasons. Particularly cold temperatures constitute a fundamental problem in winter and transition periods for approximately 47% of the households. Bad thermal insulation of the dwelling was found as a major reason for cold indoor temperatures (windows, lack of heating regulations, or heating not available at home). A concerning result is the relationship between subjectively perceived thermal comfort-related problems and respiratory problems (e.g. arthritis, asthma prevalence), particularly for children and elderly (World Health Organization, 2007).

Kolokotsa and Santamouris (2015) conducted a wide-ranging review of studies focusing on direct measurements of energy demand and indoor environmental quality of low-income households in Europe. Their review indicated that average indoor temperature for low-income homes could range between 11 - 16°C, which is significantly lower than for average income households. Critchley et al. (2007) pointed to an essential caveat that some householders prefer lower temperatures than the suggested standards. This, however, is not connected to financial constraints, as "many physiological, psychological and environmental variables play a part in humans' perception of thermal comfort" (Healy, 2004). Households may be categorised as energy poor according to this definition although they are in fact not feeling energy poor. This

18 It asked respondents about their perceived thermal comfort with the following question *is there a problem with the temperature in the dwelling during winter, summer, and/or spring/autumn season*. The following response categories were provided: seldom, sometimes, often, or permanently. If a positive response was given an additional question was asked about whether it was because it felt "too warm", "too cold", or "both" (Ormandy, 2009).

weakness clearly points to the need to combine energy poverty indicators and to ask households directly about their perceptions whether the preferred comfort temperature can be reached. Due to the lack of consistent EU-wide and national-level statistical data and application, this approach is scarcely applied. In the future, most probably the missing internal room temperature data will be available due to the installation of "smart homes" and the smart meter rollout across the EU.

d. Outcome-Based Approaches

Health and well-being outcomes such as cold-related illnesses and deaths per income quintile are common proxies for outcome-based approached of energy poverty. Health-based outcomes of energy poverty are assessed through the lens of excess winter deaths and cold-related morbidity (Fabbri, 2019). It has been estimated that energy poverty causes almost 40,000 excess winter deaths in 11 European countries each year that are attributable to cold housing (Braubach et al., 2011). EuroMOMO (European Monitoring of Excess Mortality for Public Health Action) is a joint European project that offers a statistical algorithm-monitoring tool that provides weekly all-cause mortality across European countries including winter excess mortality.[19] Liddell et al. (2016) referred to the EuroMOMO project as a best practice example for standardising the measurement across Europe. This fourth indicator for measuring energy poverty has a major weakness as it only captures outcomes and not the causes, making it difficult to separate the impact of energy poverty from other factors. The assessment of this indicator is also complex because of causality issues as the outcome can result from various factors and energy poverty may be one of many contributing factors (Rademeakers et al., 2016, p. 24). For this reason, the empirical analysis will not employ this measurement, as it is risky to use due to the reverse causality problem of dependent and independent variables.

2.6 Energy Poverty Advisory Hub

Currently, there is no dedicated survey on energy poverty in the EU. Easy accessible harmonised micro-data on energy expenditure, or energy consumption is not available. Researchers depend on different survey sources, but predominantly the EU-SILC and the Household Budget Surveys. Expenditure-based data is not harmonised and represents an inaccurate picture of energy poverty amongst certain groups as households may prioritise other

19 Malta, Portugal, Cyprus, and Spain have the highest number of excess winter deaths. This is known as the "excess winter mortality paradox" (Healy, 2003b).

products and services over achieving adequate levels of energy services, known as the heat or eat dilemma (Hills, 2012b; Lambie-Mumford and Snell, 2015; Thomson et al., 2017b). The European Energy Poverty Advisory Hub (before European Energy Poverty Observatory-EPOV) is the central platform to access aggregated data on energy poverty in Europe. It is the "leading EU initiative aiming to eradicate energy poverty and accelerate the just energy transition of European local governments" (European Commission, 2023b). The interactive ATLAS provides information on local and interactive energy poverty projects around the world. Furthermore, the network seeks to provide a common framework for measuring energy poverty on the EU level (EU Energy Poverty Network 2018).[20] In detail, it provides four key primary indicators for energy poverty, of which two are based on self- reported experiences of limited access to energy services (based on EU-SILC data) and the other two are calculated using household income and/or energy expenditure data (based on households budget survey).[21] Table 2 summarises the main primary indicators.

Variable	**Description**	
Arrears on utility bills	Share of (sub-) population having arrears on utility bills, based on the question "In the last twelve month, has the household been in arrears, i.e. has been unable to pay on time due to financial difficulties for utility bills (e.g. heating, electricity, gas, water, etc.) for the main dwelling?"	Based on self-reported experiences if limited access to energy services (Based on EU-SILC)
Inability to keep home adequately warm	Shar of (sub-) population not able to keep their home adequately warm, based on the question "Can your household afford to keep its home adequately warm?"	
High share of energy expenditure in income (2M)	The 2M indicator presents the proportion of population whose share of energy expenditure in income is more than twice the national median share. Note: where income distributions are more equal, variance in energy expenditure translates to higher 2M shares. High variance in energy/income shares can occur due to structural differences in energy expenditure between household groups, as well as in situations where energy is often, but not exclusively induced in rent.	Calculated using household income and/or energy expenditure data (based on HBS data)
Hidden energy poverty (HEP)	The share of population whose absolute energy expenditure is below half the national median. HEP is a relatively new indicator that has been used in Belgium to complement other expenditure and self-reported indicators. Note: this indicator is influenced by the underlying distribution of absolute energy expenses in the lower half of the population. If the median is relatively high and the distribution below very unequal, the HEP indicator is high.	

Table 2 Primary Energy Poverty Indicators
(Source: Based on EPHA 2023).

20 The selection of the main indicators was based on a (1) screening process of the appropriate literature on the measurement of energy poverty and complementary (2) by the EPOV international advisory board, which comprises 100 energy poverty experts from 25 countries (Vondung and Thema, 2019). Data availability at the European level was one further main criterion.

21 The newly reorganized EPOV indicators contain in total 21 energy poverty indicators. Please see here: EPHA (2022).

2.7 Summary of Current Energy Poverty Definitions

This chapter explored the reasons behind energy poverty and argued that it is separate from income poverty. As a multifaceted issue influenced by various interconnected factors, defining energy poverty can be challenging. It is important to recognize that energy poverty varies across regions and nations due to diverse socioeconomic characteristics, cultural differences, and climatic conditions such as rural-urban or mountains-valley settings. Effective monitoring of energy poverty requires a combination of localized, national, and EU-wide definitions, and the use of context-sensitive information. A precise and distinctive definition of energy poverty should consider both, objective and subjective components, rather than relying solely on monetary indicators. For instance, EU statistics incorporate material deprivation indicators to capture the multidimensional nature of poverty. Essentially, it is suggested to combine energy poverty indicators to assess its extent and to capture the multidimensional nature of the problem.[22] Several authors opted to quantified energy poverty as a multidimensional concept and there have been several attempts to construct a composite energy poverty index.[23] Composite indicators, which combine multiple indicators of energy poverty, offer a solid compromise between subjective and objective measures of energy poverty (Thomson and Snell 2013). Despite the advantages, it is recommended to be cautious whilst interpreting composite energy poverty indices as they may produce oversimplified, reduced data and information. The simplification may fail to capture the unique and complex experiences of energy poverty in different contexts and can lead to misleading interpretations (Fizaine and Kahouli, 2019).

The literature reviewed indicates that there is no universal method or procedure for measuring energy poverty. The approaches vary, and depending on the definition used, energy poverty rates may differ even within a country. Based on the Alkire-foster method (2011), Multidimensional Energy Poverty Indexes are gaining momentum. This method allows to include a minimum number of deprivations and the possibility to account for at least two deprivations (indicators). This approach will be employed in the quantitative part of this thesis.

22 Designing multidimensional measures is popular in poverty research (Alkire and Foster (2011); Atkinson (2003)) and has resulted in various multidimensional indices. The "Handbook on Constructing Composite Indicators" published by the OECD (2008) became a reference report for practitioners constructing composite indicators.

23 The indexes are based on a set of sub-indicators varying from energy prices to energy efficiency of the dwelling or personal judgment (Berry, 2019; Day et al., 2016; Dubois, 2012; Gouveia et al., 2019; Healy and Clinch, 2002a; Heindl and Schüßler, 2019; Llera-Sastresa et al., 2017; Nussbaumer et al., 2012; Okushima, 2017; Pablo et al., 2019; Sokołowski et al., 2020; Thomson et al., 2017b; Thomson and Snell, 2013; Tirado-Herrero, 2017; Yip et al., 2020).

Nevertheless, all the prominent reviewed approaches fail to examine household's self-restricting energy behaviours. The way people use energy to heat their homes determines the overall household demand, as energy behaviours can make a significant difference to lower energy bills. Hence, energy-restricting behaviours of the occupants can lead to energy poverty too, because adequate comfort temperatures cannot be reached. Despite a significant amount of qualitative research on self-restriction and underconsumption, this aspect is not yet combined with quantitative research and is not fully captured in the existing literature. A new approach that includes behavioral aspects is necessary to better understand the extent of energy poverty. The next section will examine who is typically energy poor and introduce a new method of analysing hidden energy poverty based on energy behaviours.

2.8 State of the Art and Research Gap

This sub-chapter highlights groups of people that are at a higher risk of being affected by energy poverty, based on socio-demographic and economic, as well as building-related factors. Researchers have reported above-average rates of energy poverty among older people (Chard and Walker, 2016; Day and Hitchings, 2011; Hills, 2012a; Wright, 2004), families with children (Adam and Monaghan, 2016; Liddell and Morris, 2010; Moore, 2012), households with disabilities, long-term illness, infirmity (Gilbertson et al., 2012; Hernández, 2013; Snell et al., 2015), single-parent families and single households (Delbeke and Meyer), unemployed (Belaïd, 2018; Mashhoodi et al., 2019; Masuma, 2013; Phimister et al., 2015), job instability (Romero et al., 2018), women (Oliveras et al., 2020), and low educational achievement (Healy, 2004; Legendre and Ricci, 2015). These vulnerable groups are more likely to have higher than average energy and heating requirements and are prone to spending longer periods of time indoors, which leads to higher energy needs. Considering the dwelling type, results show that households living in detached properties, followed by households living in semi-detached properties, older properties, dwellings above $50m^2$, and especially dwellings larger than $110m^2$ have the largest odds of being energy poor (Hills, 2012a; Masuma, 2013; Santamouris et al., 2007). Furthermore, households in privately rented accommodation have over twice the odds of being energy poor compared to households in social housing. This is due to better energy efficiency in the social housing stock compared to the private rental market (Charlier et al., 2019). Legendre and Ricci (2015) found that the risk of being energy poor is higher for single-person households living in rented properties, with inefficient roof insulation, with an individual heating system, and using gas for cooking. Belaid (2018) research results indicate different energy poor clusters:

1. Single person, retired, in small size flat group
2. Foreign family, employed in shared building group
3. Family in individual house with gas and individual central heating system group
4. Owner of large sized rural house group.

His results differ from Legendre and Ricci (2015) and Masuma (2013) who both found single-person having a higher risk of energy poverty compared to a higher likelihood for larger families. Romero et al. (2018) found similar results in Spain using the Spanish Household Budget Survey: households with home ownership but no mortgage were less likely to be energy poor than those living rented flats or those with a mortgage. Surprisingly, the authors' findings indicated that families with children and especially those with lower incomes are more likely to be energy poor than households formed by a single person, a couple without children, or large families with high incomes. Another controversial result is that people over 65 have a reduced likelihood of being energy poor. However, the overwhelming amount of other studies report contrary effects, namely that elderly live in larger dwellings, spend more energy to achieve a comfortable level of temperature and are more likely to be energy poor (Liao and Chang, 2002). Elderly often face four problems connected to energy poverty:

1. They have more often lower incomes
2. They typically live in larger dwellings that are poorly insulated
3. Their intentions to invest in energy efficiency measures are low
4. They have different energy needs, are more often longer at home, and move less.

Rehdanz (2007) assessed determinants of household expenditures on space heating using an econometric analysis in Germany. Her research results suggest that household expenditure is significantly lower for owner-occupied accommodation. She gives two reasons why that might be the case: homeowners are more likely to have invested in EE heating and hot water supply systems, while tenants have little control over EE improvements. Similar results reported Meier and Rehdanz (2010), in which the authors indicated a significant difference between property owners and renters and their likelihood of being energy poor. Owners have higher heating expenditures than renters. They reported

> *"differences between owner and renter heating expenditures are mainly due to differences in the types of dwelling. Owners tend to live in detached or semi-detached houses. These have higher levels of heat loss than flats, which are mainly rented" (Meier and Rehdanz, 2010, p. 958).*

These results also illustrate that heating expenditures increase with household size, average age of occupants, and the number of children in a household. A qualitative study concerning energy poverty in Vienna focused on the energy consumption of low-income households (Brunner et al., 2012). The authors analysed how inhabitants deal with poor living conditions due to inappropriate housing, unaffordable heating and electric lighting. Depending on the occupant's way of living and lifestyle, energy expenses ranged between 3.6 to 18.7% of total household income. The study results pointed out that the energy burden was exacerbated because of inefficient windows and low-quality building envelope. Moreover, various coping strategies were observed that lead to lower than average energy bills.

Bouzarovski and Petrova (2015) proposed the energy vulnerability framework in which they differentiate between six main vulnerability factors (access, affordability, flexibility, energy efficiency, needs, and practices). Their framework aims to capture different degrees of exposure to energy poverty, resilience of the household to energy poverty, and capacity to adapt (capability to cope) to changes. Bouzarovski (2018a) also advises to include household's needs in the analysis as energy requirements may differ. Some individuals may spend longer times at home and have higher likelihoods to be affected by energy deprivation as their energy demand is above-average (Wrapson and Devine-Wright, 2014).

Großmann and Kahlheber (2018) applied an intersectional lens to study energy poverty in a case study in Rhineland-Palatinate, Germany. The authors highlighted that people's experiences are affected by intersecting challenges, and, in combination, they may deepen the experience of energy poverty. The authors suggest conceptualising "energy as a field of inequality in which multiple factors merge to form a state of deprivation" (Großmann and Kahlheber, 2018, p. 14). Großmann and Kahlheber (2018) summarise that energy deprivation often coincides with other burdens and life crises. They find that clients who approach a consumer protection consultancy experience energy debts and cut-offs. Households with low income, suffering from illness, single parents, especially single mothers, and people who live alone are most affected. Furthermore, women (with small children) are over-represented, as well as individuals with a migration background who have difficulties to speak German.

The authors emphasized that the intersection of factors such as gender and age can become particularly challenging when combined with significant life changes, such as divorce, childbirth, or job loss. Breaking old established routines at home and difficulties to adapt to new situations might produce misunderstandings, mistakes or constrain coping capacities that can increase a household's vulnerability of becoming energy poor. Research applying an intersectional framework on energy poverty is far from being extensive (Andrews and Nwapi, 2018; Johnson et al., 2020; Sunikka-Blank and Galvin, 2021). In the book *Energy Poverty and Vulnerability*, Simcock et al. (2018, p. 255) summarise

> *"[t]his is where scholarship on energy poverty connects with feminist work on intersectionality, as well as critical theories of precarity and precarisation. We hope, therefore, that the chapters presented here signal the start of a new generation of efforts to study and address energy poverty and vulnerability [...]".*

An intersectional lens offers ways to understand how different factors intersect to shape different outcomes, needs, and interests. Furthermore, the approach offers an entry point to uncover dynamics that can shape vulnerability and resilience, or how particular groups of individuals experience power and inequality.

Problem of Identifying Energy Poor

Dubois (2012) outlines energy poverty policy-making as a three-step process characterised by (1) targeting, (2) identification of households, and (3) implementation of measures. Herby, she refers to the poverty literature and predominantly to the work of Sen (1995). The two steps (1) targeting and (2) identification will be discussed as the core argument that ignoring a substantive proportion of households experiencing energy poverty may hold true in the case of Austria.

Targeting Cost

Identified by Sen (1995), targeting costs implies informational distortion that can lead to two types of errors that are connected to the eligibility of support:

1. *Error of inclusion* (also called leakage) connotes the provision of aid to the non-needy.
2. *Error of exclusion* implies failure to identify households that are energy poor and resulting difficulties in reaching these households. It describes the circumstance when under some energy poverty definitions households do not have high energy bills because, e.g. they self-restrict energy to lower their energy expenditures and live in cold dwellings that are below comfort level. These households are difficult to identify because most common energy poverty instruments help those households with above average energy costs. Dubois (2012) further elaborates that when policies rely on proxies, 'mismatches' between the group of beneficiaries and the households that are actually energy poor may occur.

Disutility and Stigma

This type of cost refers to households who refrain from being recognised and categorised as energy poor. There are several reasons for this: households may voluntarily refuse social assistance as they do not want 'take advantage', although they fulfil the conditions to receive aid (Dubois (2012). Connected to stigmatisation is the *loss of individual privacy* and *autonomy* (Sen, 1995), when bureaucratic investigations to apply for benefits become very invasive. The results of energy poverty may be interpreted by the household as individual failure and self-stigmatisation can occur.

Identification

Dubois (2012) highlights that energy self-restricting households are the most difficult group to identify. In the course of the thesis, these households will be called "hidden energy poor" as they find strategies to cope with high energy bills by underconsuming energy. The reasons for a challenging identification are:

a.) direct indoor temperature data is often not available (Hutchinson et al., 2009), and

b.) households do not pass the eligibility thresholds and fall out of the typically employed energy poverty statistics.

An approximation to identify this hidden group is to assess typical self-restricting behaviours. The EPAH operationalizes hidden energy poverty (HEP) only through expenditure-based metrics and defines hidden energy poverty if a household's energy expenditure is lower than half the national median energy spending. This thesis proposes a new approach to assess hidden energy poverty in Austria. The next chapter explains the hidden energy poverty approach utilised by EPAH and the new proposal to understand it as a consensual indicator of hidden energy poverty.

2.9 Hidden Energy Poverty

For over three decades, energy poverty has been largely studied from an economic angle (Boardman, 1991; Fabbri, 2015; Hills, 2012a; Rademaekers et al., 2016b). Using energy expenditure or costs as a proxy can lead to a blind spot as households may self-restrict their energy consumption to keep their energy bills manageable, i.e. by cutting down on everyday heating. Underconsumption may blur the lines between being classified as energy poor and several researchers have suggested that behavioural aspects connected to energy poverty are under-researched (Legendre and Ricci, 2015; Maxim et al., 2016). Households may restrict their energy consumption to limit expenditure on energy to avoid default of payment or excessive energy bills (Dubois, 2012). This adaption may lead to the discrepancy that these "households [do] not reach the 10% income expenditure line but their lived experience suggests that they are energy poor" (Yip et al., 2020, p. 475). Accepting colder room temperatures to save costs may make a household pass just below the eligibility threshold for receiving support (e.g. winter fuel payments, energy counselling), even though this household does not achieve an adequate level of warmth and comfort temperatures. As these households would fall out of the typically employed energy poverty definition, the phenomenon is therefore underestimated. Previous studies employ three approaches to capture self-restrictions on energy:

First, households with low energy bills are considered hidden energy poor (e.g. Karpinska and Smiech 2020, Betto et al. 2020). This hidden energy poverty indicator aims to capture underconsumption of energy services relative to the national median of energy expenditures (based on absolute expenditures) (Rademaekers et al., 2016a). However, this indicator has several caveats, and one has to interpret cautiously the results as:

a.) Energy costs, or a part of them, can be included in the rent and are not captured separately.
b.) Low energy expenditure of a household may also result from a higher EE levels.
c.) In some countries (e.g. Germany) parts of energy expenditure of low-income households/ unemployed persons is covered by the state (Noka et al., 2019).
d.) If a person/ household commutes or is rarely at home, energy costs can be significantly lower and therefore the empirical results can be biased.

As the EPHA M/2 indicator includes people who live in exceptionally energy efficient buildings, this consequently may overestimate the actual share of hidden energy poor households. Similarly, if energy expenses of low-income households are covered by the state or energy costs are included in the rent, these households may be erroneously classified as being hidden energy poor (Vondung and Thema 2019).

Second, hidden energy poverty is deduced from thermal comfort gaps between actual consumption and theoretically required energy needs (Atsalis et al. 2016; Gouveia et al. 2019; Papada and Kaliampakos 2020). This approach relies on converting energy needs to expected expenditures, which may then be compared to actual energy expenditures (Antepara et al. 2020). A limitation of this approach is that it relies on idealised rather than realistic energy consumption patterns, as it neglects, for instance, low energy demand resulting from people being out of their homes periodically because they are commuting.

Third, in situ direct measurement of indoor temperatures may indicate underconsumption, but automatically metering temperatures in many households is difficult, expensive, and therefore scarcely applied.

To sum up, the EPHA indicator has major shortcomings as it only focuses only on expenditure-based data, leaving subjective assessments, self-restricting behaviours and lived-experiences of households out of the equation. The ways households use energy and reduce their energy consumption is a core yet under-researched aspect of energy poverty and utilising energy expenditures as a proxy can lead to a blind spot as households may self-restrict on energy and under-consume to keep their utility bills down. Expenditure based- approaches do not shine light on the causes of expenditure levels, and they are based on normatively set thresholds (median or mean) to define when a household is or is not energy poor. Due to these limitations, a new -*fourth*- approach is proposed that is informed by predominantly qualitative research results, which highlights the role of household's self-restrictions on energy to bridge the discussion between hidden energy poverty and underconsumption (Eisfeld and Seebauer, 2022).

Self-restricting on energy is as a sufficiency strategy characterised by regular cutting back on everyday energy use (downshifting) below subjectively perceived comfort level to keep energy expenses down. These strategies are applied in response to a constraint or threat when people try to minimise stress. How this strategy manifests in daily cutbacks allows identifying hidden energy poverty. For some households, it represents a challenging and deeply inflicted self-imposed choice between spending (too much) money on energy or suffering from lower thermal comfort. Households may succeed in staying out of energy poverty by maintaining self-restriction behaviours, but this buffering capacity may be overextended if households are subject to increased external pressure, such as an exceptionally cold winter or rising energy or rental costs as it is currently the case. Energy saving behaviours, e.g. heating only selected rooms, which would be reasonable and unproblematic if undertaken voluntarily by households, may add further pressure on already deprived households if they are forced to these behaviours. We can find three main self-restricting energy strategies that fall into the category of hidden energy poverty:

1. Self-rationing of energy (e.g. restricting heating, lighting, use of boiling water) or financial redistribution by making trade-offs between heat and other expenditures on other essential items ("heat or eat"). Rationing is expressed mainly through three forms: i. not heating particular rooms at all; ii. not heating particular rooms at specific times (in the morning,

during working hours); iii. not heating the house at all (Brunner et al., 2012; Doble, 2000; O'Sullivan et al., 2013).

2. Voluntary self-disconnection (often for pre-payment customers) to avoid high energy costs (Doble, 2000; O'Sullivan et al., 2013; Rocha et al., 2019).
3. Getting into debt: This behaviour is more commonly performed by younger households, or parents for whom the warmth of their children is of priority (Harrington et al., 2005; Kempson et al., 2004).

Anderson et al. (2010b) conducted a study using qualitative and quantitative methods to study coping strategies of low-income households. They found firm support for self-restriction strategies: low-income households with highly constrained budgets cut back spending on both food and fuel. Often households described an active engagement with the food market and seeking bargains and comparing prices. Almost 50% of low-income households said that their homes were colder than they wanted it to be. Moreover, heat control issues were named, as well as, other difficulties like dampness or condensation. The authors reported that most of the household's in the study had also other problems to deal with, such as ill health, infirmity and disability, caring responsibilities, poor housing conditions and isolation, signalling intersectional deprivations as outlined by Großmann and Kahlheber (2018).

Terés-Zubiaga et al. (2013) assessed the thermal performance of buildings in Spain. The results indicated that energy consumption of dwellings is lower than expected: they refer to self-lowering of indoor comfort levels and low indoor temperatures in winter. Hirsch et al. (2011) compared actual fuel consumption with fuel needs and found that, on average, households consume only around two-thirds of their theoretical energy 'need'. They concluded that people with low incomes are most likely under-consumers of fuel. Additionally, the authors found that single parents, whose incomes are low, are likely to spend a large part of their incomes keeping warm, which puts pressure on their overall standard of living. Hence, families with children are less likely to underconsume. Harrington et al. (2005) found that most households practice energy self-rationing (including restricted use of space heating). However, parents with children prioritised spending on heating for children over luxuries or holidays. Brunner et al. (2017; 2012) divided coping behaviours into *efficiency* and *sufficiency* strategies, both of which are characterised by low investment costs:

- Increasing the efficiency of the dwelling or appliances (e.g. water-saving tops) by sealing leaky windows and/or covering them with thick protecting curtains, or installing window blinds to preserve the heat.
- All behaviours towards reducing energy consumption through cutbacks and sacrifices are sufficiency strategies (e.g. heating only the major area; heating as little as possible during the seasonal transition periods).

Anderson et al. (2012) conducted a quantitative and qualitative analysis of coping strategies of households with low incomes, cold homes, and limited financial resources in the winter months. The authors established a link between cold homes, worsen physical health problems and experienced social isolation. It was also reported that households who experienced the greatest financial difficulties turned the heating down or off and lived more often in damp homes. Bhattacharya et al. (2003) analysed behavioural trade-offs of poor families in the winter months. They investigated how the additional cost of heating could only be met by reductions in the budget for food, leading to a fall in calorie intake for adults and children at a time of increased need for nutritional energy. Predominantly, qualitative work revealed the following self-restricting energy strategies to avoid high energy costs (Anderson et al., 2012; Chard and Walker, 2016; Harrington et al., 2005; Sovacool, 2015; Wright, 2004):

- Putting on extra clothes, including outdoor clothes and wearing thermal underwear.
- Turning heater on only in one room, which is usually the main living room.
- limiting domestic lives to only one or two rooms.
- Going to bed during the day.
- Closing curtains during the day; lining curtains with thermal lining.
- Using hot-water bottles.
- Sitting next to the heater.
- Staying together in one room.
- Wrapping up in blankets or quilts / slipping under the covers.
- Using the heating in transition periods as less as possible.
- Turning the heater off, if it is not needed.
- Using radiator intermittently or only when it is most needed.
- Turning heater off, although a warmer indoor temperature is preferred.
- Being in certain rooms at specific daytimes and only heating those rooms.
- Heating times connected to specific daytimes and rooms or only when having guests.
- Using an electrical radiator in addition if warmth is needed quickly.
- If rooms are chilly, first putting on more cloth or a blanket, instead turning the heating on.
- Go to sleep/ bed earlier if it is cold and sharing a bed.
- Drinking warm beverages (tea) if it is cold.
- Turning on the heater in the morning and going back to bed until the apartment is warm enough.

A range of negative consequences of self-imposed austerity in heating is reported: social isolation if friends are no longer invited in the cold home, rejecting heating cost support or energy consulting because of self-stigmatisations, feeling embarrassed or humiliated because of less material affordability than others, worry and anxiety caused by high energy costs, increased rates of chronic respiratory disease, even excess winter mortality or facing a heat-or-eat dilemma. Thus, self-restricting heating may yield the paradox outcome that the behaviours which were intended as a remedy rather worse experienced energy poverty (Chard and Walker, 2016; Clancy et al., 2017; Harrington et al., 2005; Middlemiss and Gillard, 2015; Willand and Horne, 2018).

The self-restricting focus on how people deal with energy deprivation highlights energy poverty not as a static condition, but as a dynamic process shaped by adaptive capacity (Middlemiss and Gillard, 2015). The notion of energy poverty as processual and varying rather than fixed circumstance is supported by the Kearns et al. (2019) panel study where one third of households transitioned in or out of energy poverty over ten years. Similar results are found in Germany, where Dresche and Janzen (2021) showed that energy poverty is a transitory state with 78% of the energy poor households only temporarily face energy poverty.

Self-imposed energy restrictions are not yet firmly established in energy poverty debates and inter-linkages of daily realities of households living in substandard housing conditions are not addressed to their full potential and constitute a research gap (Besagni and Borgarello, 2018; D’Oca et al., 2018; Delzendeh et al., 2017; Kearns et al., 2019). This calls for an in-depth analysis that is based on previous qualitative work. Therefore, this thesis opts to advance the understanding of self-restriction behaviours to identify hidden energy poverty in Austria and asks “*do households use self-restricting energy strategies that make them invisible to the energy poverty indicators*”.

As a concluding remark, it must be highlighted that self-restriction behaviours are only short-term remedies to stay out of energy poverty to avoid excessive energy costs. The aim to focus on self-restrictions in this research is to shed light on practices households carry out and to help identify energy poor households that typically are invisible in prominent indicators. Although reducing energy consumption to limit climate change is a critical policy priority, it's important to consider the ethical implications of these efforts. Not all individuals consume energy in the same way, and it's essential to understand self-restricting energy behaviours and the reasons for unequal energy consumption and its consequences. While energy-saving behaviors and "living well on less" can be beneficial when they are *voluntary* decisions that do not compromise basic needs, it's important to acknowledge that for some households, particularly those experiencing energy poverty, the decision to skimp on energy can have detrimental consequences on their health and well-being. Therefore, it's crucial to analyze the impact of energy poverty and the reasons behind it, in order to develop effective and inclusive policies that address energy poverty while also reducing energy consumption and mitigating climate change.

2.10 Conclusion

This chapter addressed the question of what the key drivers of energy poverty are, namely low income, high energy costs and energy inefficiency of housing. This chapter challenged traditional energy poverty definitions by reflecting on the various ways to approach and identify energy poor households. As we have learned, energy poverty has changed over the course of the past decades, from a mere single statistical indicator (10% of disposable household income spent on energy as proposed by Boardman in 1991) to an important research field interrelating social, housing and climate policy. Energy poverty can manifest through buildings in need of repair and renovation, a lack of means to afford energy and a range of different self-rationing heating behaviours. It poses a challenging task to operationalize and classify energy poor households, as it was stressed that energy poverty is a multidimensional concept that requires an intersectional analysis. To identify energy poor households, typically expenditure-based and consensual indicators are required for an assessment. The complexity and multidimensionality of energy poverty is widely recognised, but there is no agreed-upon definition at the EU level and there is ongoing debate among academics and policymakers about which dimensions and thresholds should be used to measure it (Lowans et al., 2021; Siksnelyte-Butkiene, 2021).

Given the research gap, it is proposed to include self-restriction in the analysis to monitor energy poverty as further means of capturing hidden energy poverty. Cultural patterns play an important role in the explanation of energy poverty as ‘normal’, and ‘adequate’ comfort levels, and temperatures may differ between regions and individuals: for example, while it is normal to feel cold at home and wear thick jackets in the winter months in Portugal -one of the EU's highest energy poverty incidences- this may be unlikely in Austria (Rodrigues et al., 2020). Even countries within the same temperature zones indicate significant differences in satisfaction with thermal comfort (Robinson et al., 2018b). Hence, a cultural and context-sensitive approach must be considered in future energy poverty debates. Next to the main three drivers of energy poverty, structural dimensions (e.g. building-related variables: tenure, dwelling age, housing faults) and socio-demographic determinants (e.g. elderly, households with children, women) are identified as proxies that systematically increase the risk to be energy poor. Based on the presented literature, the following working definition for energy poverty is provided:

> Energy poverty shall be understood as a lack of choice (as according to Sen 1999, 1995) in achieving comfortable and adequate indoor temperatures, which is caused by insufficient financial resources or inadequate energy efficiency in the home (Bouzarovski, 2014). This results in reduced quality of life for affected households. The concept of energy poverty considers the different needs and temperature preferences of households, which makes reaching adequate comfort levels context-dependent. Energy poverty can also be expressed as an everyday challenge for households to meet basic energy needs, which can cause either higher or lower energy consumption due to self-restriction (Eisfeld and Seebauer, 2022). In addition, energy poverty includes the lack of access to affordable and adequate energy services and the inability to maintain comfortable indoor temperatures.

3. Building Bridges - The Nexus between Energy Behaviour and Hidden Energy Poverty

The European Union ("EU") strives to make Europe the first carbon-neutral continent by 2050. Alongside retrofitting programs, households and their heating behaviours are therefore considered important areas to achieve this policy goal. The lighthouse project "European Green Deal" focuses on increasing energy efficiency of the housing stock but also renovating social housing and helping households who struggle to pay their energy bills. Energy behaviour is a determinant to lower household energy consumption and potentially reduce the energy bills of energy poor households. Identifying and understanding self-restricting energy behaviours stands at the core of the chapter by unpacking the black box of its main determinants, as energy poverty research has not yet established the link between behavioural-based explanations and energy poverty.[24] This chapter analytically unpacks the main determinants behind self-restriction behaviours adopted by certain deprived households.

Due to the emergence of several extensions to existing behavioural models, it is challenging to synthesise all the relevant dimensions and constructs that explain energy behaviour. Various disciplines offer distinct yet complementary entry points, such as economics (maximising utility and minimising costs), environmental and social psychology, engineering, sociology of habits, along with social contexts and practices. For instance, social scientists have analysed individual and contextual factors to explain energy behaviour, whilst often neglecting how the surrounding environment might influence behaviours. From another perspective, building engineers or energy econometricians estimate energy demand and energy consumption based on building characteristics, but neglect social characteristics and household behaviour, leading them to biased estimates stemming from "prebound" and "rebound effects" that are found predominantly in social housing with low household income (Galvin and Sunikka-Blank, 2016; Giuliani et al., 2016). Each of the disciplines and approaches has unquestionable value to explain energy behaviours or energy consumption. This chapter is situated at the crossroads between social science and energy research, and places particular emphasis on the behaviour-oriented and not the economic paradigm of environmental psychology. Zhou and Yang (2016) termed this interdisciplinary stream of research '**energy social science**'. This integrative

24 It must be emphasized that behavioural changes must not exacerbate existing deprivations and households who already skimp on energy. Therefore, efforts in this sphere must be examined critically without overlooking potentially detrimental effects of policies for vulnerable households and their quality of life.

literature[25] review (Torraco, 2016) shall give a valuable contribution to household energy behaviour by reviewing, discussing strengths and weaknesses, and synthesising core literature in an integrated way. This synthesis provides the starting point to generate a combined framework, based on the Theory of Planned Behaviour ("TPB") and the Dual Process approach, that offers new insights for energy poverty research. Specifically, this chapter exploits literature predominantly from environmental psychology and energy consumption to explain self-restriction behaviours and its determinants to help shed light on energy behaviours of hidden energy poor households.

The aim of this chapter is to present carefully selected sociological and psychological behaviour theories that will be subsequently applied in the empirical chapters to examine the case of retrofitted and not-retrofitted social housing in Vienna. The TPB is extended with the concept of habits, as the major focus lies on understanding how behavioural change occurs, what the main determinants of energy behaviour are and how these are related to energy efficient upgrades. The theoretical approach should not be exhaustive but one that combines energy poverty and energy behaviour. The focus on predominantly psychological explanations stems from the recognition that the discipline offers a larger set of convincing frameworks for understanding energy use and behavioural change. Hence, the overarching objectives of this chapter are:

- To build the bridge between energy behaviour and hidden energy poverty
- To examine the roles of reason-based planned processes of the TPB and habit-based automatic processes to engage in self-restricting behaviours
- Propose an integrated theoretical framework
- Discuss socio-demographic, psychological and structural drivers that influence self-restricting energy behaviour that explains hidden energy poverty and behavioural change after a retrofit.

The following questions will be answered in this chapter:

- What are the key predictors of energy behaviour among households?
- How does the concept apply to pro-environmental behavior and what are the contributing factors?
- How is the concept hidden energy poverty linked to energy behavior among households?

25 The integrative literature review "is a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated" (Torraco, 2016, 356).

- What are the key social-demographic, structural and contextual factors that influence energy skimping among social housing residents?

This chapter is structured around six sub-chapters. The *first* sub-chapter begins by addressing what environmental behaviour is and how it can be changed. As well as examining the term ‘energy behaviour’, this section explores the missing link between positive attitudes towards the environment and corresponding actions. It will also present the theoretical model of planned behaviour and discuss its limitations. The *second* sub-chapter will suggest habits and the disruption of environmental cues to change behaviour. The notion of windows of opportunities is discussed in sub-chapter *three* as frames within which behavioural changes can take place, as they can create new opportunities in novel context. The state-of-the art on physical building characteristics is addressed in sub-chapter *four* and socio-demographic and socio-economic determinants are examined in sub-chapter *five*. The concluding *sixth* sub-chapter ends by advancing a theoretical framework.

3.1 Environmental Behaviour

Historically, in social sciences and environmental psychology, the link between behaviour and environment has been investigated since the early 1970, as researchers gained greater awareness of the negative human impact on the nature (Craik, 1973; Hines et al., 1987; Kollmuss and Agyeman, 2002). The first Earth Day in 1970 was a catalytic event that was quickly followed by the Oil Crisis in the same decade, which attracted research interest in the areas of energy consumption behaviour (Uri, 1982; Yates and Aronson, 1983). The prevailing opinion at the time was that environmental knowledge increases environmental awareness and that, in turn, facilitates pro-environmental behaviour (Kollmuss and Agyeman, 2002). The anticipated link was of a linear nature and is generally referred to as the linear progression or information deficit model (Bulkeley, 2000; Burgess et al., 1998; Suldovsky, 2016).

Figure 8 Linear Progression Model (Source: Own Visualization Adapted from Kollmuss and Agyeman 2002).

The linear progression model explains that people do not act environmentally friendly because they lack necessary knowledge (see Figure 8). In order to overcome this deficit, a remedy lies within environmental pedagogical interventions or -so to say- in simple one-way communication of information top-down from ‘experts’ to ‘laymen’. These kinds of interventions are politically and economically easy to transpose with knowledge campaigns.

However, what does literature say about their scientific underpinning?

Environmental awareness information campaigns remain common practice by various agents, interest groups, and policy programs. Nevertheless, among scientist, there is broad consensus that environmental information campaigns have limited capacity for long-lasting behavioural change, as indicated by insignificant effects found in many studies (Kollmuss and Agyeman, 2002; Pickett-Baker and Ozaki, 2008). Abrahamse et al. (2005, p. 278) concluded that there is “*no clear evidence that this results in reductions of energy use”.* In the same vein, Bartiaus (2008) highlighted that neither environmental concern nor knowledge about global warming has a decreasing influence on energy consumption when controlling for household size and income. Similarly, Osbaldiston and Schott (2012) found in a meta-analysis only marginal effects of environmental education campaigns. It is, therefore, questionable whether environmental information campaigns and energy counselling for energy poor households have a long-lasting positive effect on decreased energy consumption and increasing pro-environmental behaviour.

The first meta-analysis by Hines et al. (1987) identified that knowledge about environmental issues, attitudes, commitments, and an individual’s sense of responsibility for the environment are connected to pro-environmental behaviour. However, Diekmann and Preisendörfer (2003), Eckes and Six (1994), found that general environmental awareness could only explain 10% of the variance in behaviour. Other quantitative studies have reported a contested link between attitudes and behaviour (Ajzen, 1991; Ajzen and Fishbein, 2000; Kroesen et al., 2017; Wicker, 1969). As a result, several environmental studies highlighted the importance of the “*attitude/ intention-behaviour gap*” (Blake, 1999; Carrington et al., 2010; Chatzidakis et al., 2007; Kroesen et al., 2017; Vermeir and Verbeke, 2006). This concept captures the discrepancy between positive environmental attitudes/ pro-environmental awareness/ environmental concern and its positive relationship with pro-environmental behaviour. In the case of energy behaviour, while some studies found a positive effect (Gadenne et al., 2011; Sapci and Considine, 2014), others failed to find evidence that environmental attitudes significantly and positively affect energy conservation behaviour (Brandon and Lewis, 1999). Several barriers are proposed to explain this gap. One of the strongest is that individuals believe they lack the capacity of empowerment to take measures that will ‘make a difference' in the fight against climate change (Bickerstaff and Walker, 2002; Norgaard, 2010).

3.1.1 From Pro-Environmental Behavior to Energy Behaviour

While there are multiple definitions and types of pro-environmental behaviour (“PEB”), some of the conceptual ambiguity stems from the use of different synonyms in the academic literature to describe usually the same issue at stake.[26] PEB is distinguished between two types of behaviours that vary according to their *location* and the extent of *visibility* (Stern, 2000): it includes public and private sphere behaviours. The focus of this thesis lies on private sphere behaviours, specifically on heating and energy-related behaviours as an expression of a household’s intention to heat less to decrease energy consumption and bills. Within this, to lower GHG emissions in the private sphere, people can undertake two types of actions that are considered energetically fruitful (Gardner and Stern, 2002):

a.) investing in efficient technologies (e.g. photovoltaic panel installation) - *energy efficiency behaviours;*

b.) consuming existing technologies less - *curtailment behaviours (self- restrictions).*[27]

While efficiency behaviours require a purchase or even a larger investment, curtailment behaviours are low or no cost actions to achieve energy savings (see Figure 9). Efficiency behaviours constitute high cost situations (e.g. time) as an active engagement with the matter is required: before exchanging the heating system, energy criteria or prices need to be compared, government subsidy programmes found, and policies, and time plans have to be carefully evaluated. Whereas efficiency behaviours do not require a long-term behavioural change, but a careful choice process (Gardner and Stern, 2008), adjusting curtailment behaviours involves greater individual will, and (intrinsic or extrinsic) motivation as behaviours need to be changed. According to Abrahamse et al. (2005), there is not enough evidence to conclude whether curtailment or efficiency behaviours lead to more energy savings.

26 Such examples are: environmental behaviour (Dunlap and van Liere, 2008), ecological behaviour (Kaiser and Fuhrer, 2003), environmentally responsible behaviour (Thøgersen, 2004), responsible environmental behaviour (Hines et al., 1987), environmentally significant behaviour (Stern, 2000), environmentally related behaviour (Bamberg, 2003).

27 This is similar to the differentiation in sub-chapter 2.9, in which Brunner et al. (2012) distinguishes between efficiency and sufficiency strategies.

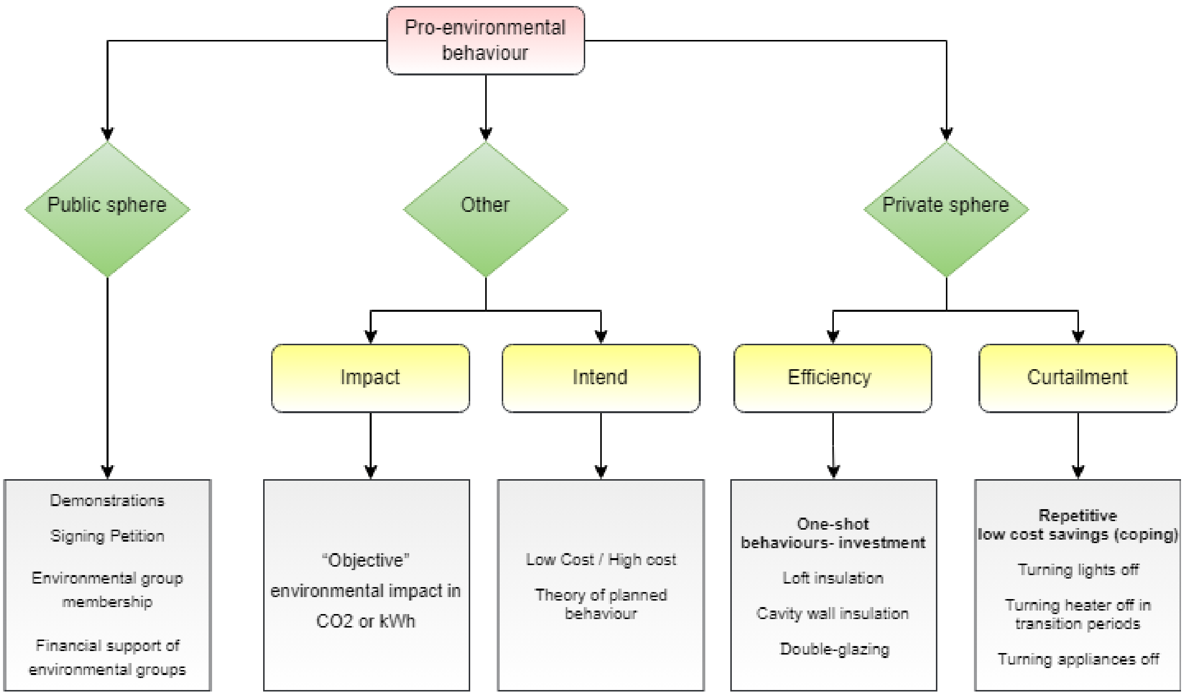

Figure 9 Pro-Environmental Behaviour (Source: Own Visualization Based on Stern 2000).

Masoso and Grobler (2010, p. 174) showed that curtailment behaviours are more effective in their energy saving potential because they produce actual behavioural changes while others find efficiency behaviours more effective in obtaining actual energy savings (in kWh or €). Research on energy efficiency behaviours often relies on field studies and experiments that test the effectiveness of given intervention measures, often through hypothetical scenarios (Hargreaves, 2011; Schmitz and Madlener, 2021). Studies addressing curtailment behaviours engage with theories of behavioural change and establish behavioural drivers for energy use, like intentions to change daily behaviours (Abrahamse and Steg, 2009). Usually, they connect psychological constructs and socio-demographics to explain the intention to change behaviour.

A widely acknowledged definition of PEB is utilised from Kollmuss and Agyemann's (2002). They define PEB as "behaviour that consciously seeks to minimise the negative impact of one's actions on the natural and built world" (Kollmuss and Agyeman, 2002). For Steg and Vlek (2009, p. 309) PEB refers to "behaviour that harms the environment as little as possible, or even benefits the environment". These definitions accentuate the intention to be more environmentally friendly and to reduce the negative impact individuals have on the environment. Both definitions stress the subjective and motivational standpoint of the individual, which is called the intent-oriented approach, in opposition to the impact-oriented approach (see Figure 9).

The *impact-oriented* approach analyses whether the respective behaviours are associated with a high or low environmental impact (e.g. energy, waste separation, water use). Studies using the impact-oriented approach have reservations about the predictive power of pro-environmental intend-oriented explanations (Moser and Kleinhückelkotten, 2018). They pinpoint to income as the most reliable predictor as CO_2 levels or overall energy consumption (kWh) rises if households have more money to spend compared to consumers with lower incomes (ceteris paribus).[28] According to previous research, high income is the most important driver in the EU that increases GHG emissions (Ivanova et al., 2017).

This differentiation helped us to come closer to the heart of 'the attitude/ behaviour gap'. Let us take another viewpoint on the approach. A rather difficult endeavour is to distinguish whether households perform energy behaviours because they intend to reduce their energy consumption for the sake of the environment, constituting a form of pro-environmental behaviour, or because of other reasons, like saving money to reduce utility bills. Referring to the two proposed definitions, Steg and Vlek's definition differs from Kollmuss an Agyemann's insofar as it includes all behaviours that benefit the environment. Thereof, their definition includes also behaviours that are not necessarily motivated by specific environmental goals. Kollmuss and Agyeman's definition focuses merely on environmentally friendly behaviours and excludes behaviours that are motivated by other goals (Sorell et al., 2018). This inside leads to the question: *is it for the money or for the environment?*

This question touches upon a normative dimension as it addresses the reasons behind the behaviour: while pro-environmental behaviour is related to free choice and the deeply held believe that a certain behaviour is beneficial for the environment, self-restricting energy behaviours -as in the case of energy poverty- can but must not necessarily be motivated by pro-environmental goals. In some cases, such pro-environmental behaviors are driven by necessity and limited choices. Often a faulty housing situation forces households to make use of specific energy restricting behaviours due to low financial capacities, as this quote from qualitative research on energy poverty illustrates:

> *"Jo revealed that a sense of powerlessness to make changes resulted in her adopting this mechanism of coping" (Butler and Sherriff, 2017, p. 976).*

28 See exemplary: Bruderer Enzler and Diekmann (2015); Csutora (2012); Gatersleben et al. (2002); Huddart Kennedy et al. (2015); Keuschnigg and Schubert (2013).

This important differentiation is rather challenging to disentangle analytically and empirically as self-restricting energy behaviours can subsume households who have a reduced energy consumption because, inter alia, of several reasons

- pro-environmental reasons (voluntary and free-choice);
- money saving reasons, for instance, coping with debts, high energy, electricity or rent costs (necessity to self-restrict);
- households learned it that way and internalised frugal behaviours through habitualizations;
- socio-cultural structure within a region/ country etc. (e.g. shared informal norms and established practices);
- legal obligations, governmental incentives (offering economic benefits), levies and taxes, subsidies.

A further important aspect needs to be critically discussed as research signifies that there is no general concept 'of pro-environmental behaviour': a household can behave pro-environmentally in one domain (e.g. buying energy-efficient appliances like a washing machine A++), but acts environmentally 'wasteful' in another domain (e.g. flying frequently), as Bratt (1999) convincingly pointed out. Individuals may be environmentally friendly in one area, they may consider having a "moral licence" to be less environmentally in other areas (Sorell et al., 2018). Extreme examples translated in the energy behaviour context would be people who live alone in large apartments, heat all rooms, or prefer high temperatures (> 23°C) and heat as much as it is comfortable without paying attention to the costs. At the same time, this group can express pro-environmental attitudes and intentions to avoid wasting energy but does not act on them, as outlined in the 'attitude-behaviour gap' concept.

This group is difficult to disentangle because they can hold, but must not act on these positive environmental attitudes or intentions. Depending on the utilised definition, self-restricting energy behaviours in the sense of Kollmuss and Agyeman are strictly seen not PEB as they do not subsume the intention to use less energy because of environmental reasons. However, from the impact side point of view, it is PEB because the harmful contribution to the environment is low. From a methodological perspective, impact-oriented approaches require plenty of information (e.g. kWh, CO_2 emissions as household carbon footprint, energy ratings on household appliances), which is difficult to obtain in empirical studies.

At this point, it must be highlighted that a critical scientific discourse on neo-liberalism and the over-emphasis on individualisation of PEB is little discussed in research, which addresses offloading major environmental issues and responsibilities of the state on the individual (Malier, 2019; Middlemiss, 2014). Literature is more rich in research about labour market policies, particularly labour market activation discourses on self-management, self-determination and personal responsibility in the service of society (Lessenich, 2015; Rose, 1999). Lessenich, for instance, addresses the reversal of the socio-political 'debt relations' driven by its neo-social moral economy, whereby the non-fulfilment of preventive measures and individual duties is socially ostracised and punished (German: "Sozialmissbrauch", "Produktivitätsbremse") (Butterwegge, 2015, p. 21). This activation method puts pressure on all citizens, from the young (PISA-compatible) to the elderly ("retirement fit"): "*in a society where activity has become a panacea for the political woes of the declining welfare state*" (Katz, 2000, p. 147). The activation discourse touches upon PEB as well because individualisation as a neo-liberal concept is present in pro-environmental behaviour: Page- Hayes (2015) analysed scientific publications on PEB and showed that 72.3% of them were individualising and opt to changes in human behaviour. She discusses that sustainable behaviour plays a crucial role in the energy transition, however, wider structural, economic, political, and governmental factors are overlooked and miss a critical discussion within the research context. Middlemiss (2014) pointed out that due to power constellations in societies, possibilities to make significant environmental impacts differ, as wealthier people have other behavioural choices and opportunities. Recognising that income or energy poor might not have the same abilities or are structurally locked-in in e.g. rental or energy utility contracts, or in energy inefficient dwellings and are unwillingly forced to some self-restricting energy behaviours. Feelings of humiliation, shame and own failure of ending up in this situation are one of the frequently reported outcomes (Brunner et al., 2017; Grossmann and Trubina, 2021; Meyer et al., 2018).

3.1.2 The Missing Link

Diekmann and Preisendörfer (2003) affirm that people choose PEB that demand the least costs and have the highest benefits.

> *"Cost in their model is not defined in a strictly economic sense but in a broader psychological sense that includes, among other factors, norms, the time and effort needed to undertake a pro-environmental behaviour" (Kollmuss and Agyeman, 2002).*

The main question behind their approach is why, despite holding positive environmental attitudes in some situations, environmentally friendly behaviour is not carried out. They suggest that the importance of attitudes decreases if situations bear higher costs: people with high levels of environmental awareness might not be willing to make bigger lifestyle sacrifices, but seem to be more willing to accept smaller personal changes that will enhance PEB. Diekmann and

Preisendörfer (2003) used German household environmental behaviour and focused on mobility, recycling, water conservation and energy consumption. Their empirical results indicated that environmental concern decreases as the costs of environmental behaviour increases. Preisendörfer and Diekmann classified recycling, waste separation and shopping behaviour as low-cost domains, and energy consumption as a high-cost domain (Diekmann and Preisendörfer, 2003).[29]

Strongly connected to the low-cost hypothesis is the denial hypothesis of Tyler et al. (1982). The authors showed that when the costs of changing behaviour are high, people suppress their environmental concerns and, in doing so, avoid cognitive dissonance (unpleasant feelings) to strengthen their self-esteem. Hence, energy use can also be explained by cognitive dissonance, which predicts that conflicts between beliefs and behaviour will produce cognitive dissonance. People are keen to reduce this mental discomfort to have a consistently positive self-image.

What is the way out of this dilemma?

People either 1. change their attitudes and beliefs, 2. justify their beliefs and behaviours, or 3. they change behaviour to avoid dissonance (Festinger, 1962). However, when applying this approach to household energy behaviour, harmful effects of household energy consumption are not directly visible (only through utility bills) because detrimental environmental impacts of behaviours are not *experienced*, *perceived* and *seen* (Abrahamse et al., 2005; Jackson, 2005). In comparison, air pollution from driving is more often directly *experienced* (e.g. breathing difficulties/ irritation of the eye caused by NO_2), *perceived* (in the form of unpleasant smell) and *seen* (in form of dust and ashes). Conversely, 'unsustainable' energy behaviours in the private sphere rarely lead to cognitive dissonance (Martiskainen, 2007, p. 77), since, energy use at home is taken for granted and is considered as a social necessity, an 'essential' commodity (Hunt and Ryan, 2014; Sheldrick and Macgill, 1988).

There is a fundamental and important gap of energy household consumption and public perception of energy consumption: compared to the case of traffic pollution, people do not directly experience, perceive, or see the environmental consequences and associations between heating (or cooling) homes and climate change. Burgess and Nye (2008) introduce the term '*doubly invisibility'* of energy, as it is an abstract concept with a hard-to-establish link of the

29 Boudet et al. (2016) critically assessed household energy saving behaviours and suggested to overcome the binary dimensions (e.g. low-impact vs. high-impact, low-cost vs. high-cost). They proposed a clustering of nine attributes: energy savings, cost, frequency of performance, required skill level, observability, locus of decision, household function, home topography, and appliance topography.

amount of energy used and the effect on the environment due to its invisibility and intangible nature (Hafner et al., 2019; Pedersen, 2000). End-users rarely see where energy is produced. It is delivered at home through hidden electrical wiring systems and energy meters are commonly out of sight, sometimes in the cellar (Kendel et al., 2017). The link between energy consumption and consequences on the environment becomes even more abstract if utility bills arrive either in a three months or yearly rhythm and must be paid long after using energy (Frederick et al., 2002).

What kind of conclusion can we draw from this concept?

Energy consumption in the private sphere unlikely produces cognitive dissonance and is hard to change, because the powerful stimulus of visibility to change is absent. In a meta-analysis of intervention studies and various pro-environmental behaviours, Osbalidiston and Schott (2012) showed that interventions focusing on cognitive dissonance (by bringing people's attention to the disparity between their behaviour and their attitudes) are effective. According to Hargreaves (2014), smart meter roll out in the EU is also aimed at making energy more visible to increase consumer's reflectiveness about their consumption through personalised feedbacks. If households realise that their habituated energy behaviour is detrimental to the environment and they experience cognitive dissonance, Diekmann and Preisendörfer's 'low-cost/ high-cost' approach (1998: p.89) can help to understand that people "engage in 'simple and painless' pro-environmental behaviours as means to relieve their mental discomfort, by for instance buying local organic products" (Bamberg and Rees, 2015; Thogersen, 1999).

Within environmental social research, there is an ongoing debate on how to best predict environmental behaviour (and intentions) referring to a multitude of variables ranging from environmental knowledge over beliefs to peer pressure. Theories of behaviour, in comparison to theories of change, give reasons why certain behaviours may have occurred. The idea of a one-dimensional model to explain the roots of PEB is obsolete and we cannot deny that multiple predictors contribute to explain PEB. The next chapter deals with a theoretical model to explain energy behaviour and how it can be changed.

3.1.3 Approaching Theoretical Models of Energy Behaviour

With over 1000 peer-reviewed empirical papers between 1980 and 2010, the TPB is a well-established and popular theory.[30] It dominates approximately 40% of all papers published in environmental psychology (social science) on PEB, and it is the most widely used theoretical framework in this research field. The TPB offers a parsimonious model that has been tested frequently across many social disciplines. It predicts a broad range of pro-environmental behaviours (Aguilar-Luzón et al., 2012; Fielding et al., 2008; Han et al., 2010), including household energy and heating behaviour using quantitative research methods (Abrahamse and Steg, 2009; Botetzagias et al., 2014; Clement et al., 2014; Lopes et al., 2019). The applications of the theory, its acceptance in the scientific community, and its wide influence in social science provide compelling reasons to utilise it in this thesis. The theoretical framework stresses the importance of three conceptually independent constructs that determine the intention to act environmentally friendly (see Figure 10): 1. attitudes, 2. subjective norms and 3. perceived

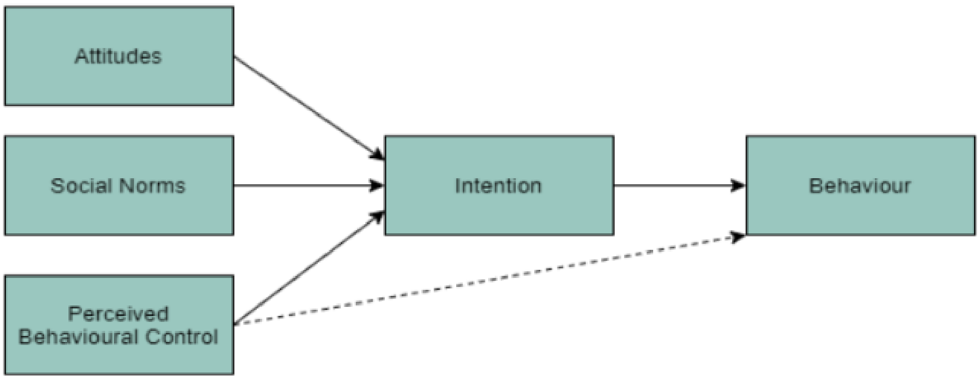

Figure 10 Theory of Planned Behaviour (Source: Based on Ajzen 1991).

behavioural control (PCB). These latent constructs, however, are hypothetical and cannot be directly measured. Items must therefore be formulated (operationalized) from observable responses.

1. Attitudes are an individual's positive or negative beliefs about performing a specific behaviour.

2. Subjective norms refer to the influence of social pressure from friends, family, co-workers, or the close network that is perceived by the individual to perform or not to perform a specific behaviour (Ajzen, 1991). Social norms are

> *"rules and standards that are understood by members of a group and that guide and/or constrain social behaviour without the force of law" (Cialdini and Trost, 1998, p. 152).*

30 See here for a bibliography: Ajzen (2020).

Several studies found that subjective norms have the weakest effect among the TPB constructs. Some studies even report that the effect of subjective norms disappears if other constructs are considered (Abrahamse and Steg, 2009; Chen et al., 2017; Oztekin et al., 2017; Ru et al., 2018).
3. PBC is defined as the individual's belief concerning how easy or difficult performing the behaviour is. The greater the perceived control one has over the respective behaviour, the stronger the person's intention to perform this behaviour. PBC is associated with the ability to control internal (e.g. self-efficacy and personal skills) and external factors, so to say constraining context factors (e.g. being able to control the thermostat) to reach a desired behaviour (Ajzen, 2002; Kidwell and Jewell, 2003). PBC reflects situations in which people may lack volitional control over the behaviour or lack of availability (Ajzen, 2002, p. 678).
Perceived behavioural control can be differentiated between *external* and *internal* perceived behavioural control suggesting whether a behaviour may be perceived as being within an individual's control. External control relates to factors that may act as a barrier or facilitating conditions towards behavioural performance, such as the functioning of the radiator or the presence of a radiator in a room to achieve comfort temperatures.

These four dimensions lead to behavioural intention, which indicates the extent to which an individual will expend effort in order to perform behaviour. Behavioural intention is a direct antecedent of behaviour. According to the theory and a meta-analysis by Hines (1987), a person's intention to perform behaviour is strongly related to the behaviour itself. The theory proposes that intentions mediate the relationship between these predictors and behaviour. Ajzen (2011) emphasizes that his theory is, at its core, concerned with predicting intentions as the intention-behaviour relation depends highly on the individual's actual control over the behaviour.

Armitage and Conner (2001) reviewed 185 articles on pro-environmental behaviour and revealed that the constructs of PEB account for up to 39% of intentions, leading to 27% of the variance of actual behaviour. Other meta-analyses assessing the sufficiency and efficiency of PEB found overall support for the theory (Godin and Kok, 1996; Hagger et al., 2002; Hamilton et al., 2020; McDermott et al., 2015; Notani, 1998; Riebl et al., 2015, 2015; Sutton, 1998). Sheeran's (2002) results indicated a mean overall correlation of 0.53 between intention and behaviour, while in a meta-analysis of health behaviours, McEachan et al. (2011) found 44.3% of explained variance in intention and 19.3% of explained variance of behaviour across studies. Ajzen (2011) assessed his own theory and concluded that intentions do not always provide a substantial predictor of behaviour. Naturally, there is and will always be a proportion of unexplained variance for the behaviour under investigation. As researchers, we can only ask ourselves whether the factors that we have included in the study play a significant enough role to guide the behaviour that is being investigated.

Frequently, the theory was redefined in several ways, and additional constructs were included to explain specific behaviours. Lynch and Martin (2010), Liu et al. (2020), and Webb et al. (2013) employ the TPB to predict household energy saving intentions and behaviours. For instance, van den Broek et al. (2019) showed that objective perceived behavioural control significantly influences energy-saving behaviours (e.g. being able to control the thermostat in the dwelling). Furthermore, Urban and Ščasný (2012) illustrated that even within an energy curtailment cluster, pro-environmental behaviours depend on different predictors. That is why Ajzen (1991) drew attention to construct the items and the predictor variables to be adequate and appropriate for the behaviour that is intended to be predicted. Botetzagias et al. (2015) pointed to this issue by highlighting that different environmental behaviours have different predictors so that the overall effect can be biased, e.g. restricting energy behaviour has different predictors than green shopping behaviour.

3.1.4 Theoretical Limitations

The TPB is a widely tested and robust theory. Nevertheless, like most of all theories in the social sciences, also the TPB cannot escape to be criticised from various angles and profound limitations were shown. Sniehotta et al. (2014) even provocatively announced to retire the TPB as the limitations accounted for the last three decades outweigh the advantages: the explained variance of the behavioural construct accounts on average for 25%, which means that there is 75% unexplained variance. The question arises whether other explanatory factors should be included. While psychological constructs are considered, past behaviour[31] and environmental (household living) context are not considered. Other key factors that motivate households energy behaviours, such as financial savings (Butler et al., 2016), and temperature comfort (Huebner et al., 2013) are overlooked. As it is an intention-based model that assumes that intentions are stable over time, it does not take imperfect volitional control into account. Furthermore, a shortcoming is its rational choice assumption. A substantial body of literature highlighted that our behaviours are often not guided by cognitive deliberation and

31 According to Ajzen, past behaviour is not included on purpose in the theoretical framework because it does not meet the requirement of being a „causal antecedent of intention“ (Ajzen, 2011: p.1120).

consciousness as assumed in the TPB (Dijksterhuis et al., 2005; Verplanken and Aarts, 1999; Verplanken and Wood, 2006). To address this limitation, another approach may step in to solve this drawback.

For repeatedly and habituated behaviours, past behaviour is a strong predictor and intention is rather weak (Ouellette and Wood, 1998a). Intentions are strong predictors of behaviour if habits are absent. This is the case in unknown situations or behaviours that are performed annually or biannually and less frequently. According to Dual Process Theory, numerous behaviours are guided by automatic, repeated and habitual processes by using mental shortcuts (Kahneman, 2003). Behavioural economics (a combination of the two disciplines psychology and economics) connotes that most of our everyday choices are far from being rational in the sense of rational choice theory. Humans have bounded rationality, are subject to behavioural biases, make decisions based on cognitive heuristics, and rarely make deliberate choices (Strack and Deutsch, 2004). Pertinent literature reveals time inconsistency, framing, and reference dependence to answer why people do not make rational choices (Abrahamse and Steg, 2009; Jackson, 2005; Martiskainen, 2007; Wilson and Dowlatabadi, 2007). People cope with cognitive biases and experience conflicts between their long-term and short-term preferences and they make choices in settings characterised by information overload (Sousa Lourenço et al., 2016).

To fully understand decision-making and why certain energy behaviours are performed, the Dual Process approach can help to understand this venture. It states that our brain works in two different ways: the first is called the automatic system (System 1) and the second one is called the reflective system (System 2) (Evans and Stanovich, 2013; Stanovich and West, 2000; Strack and Deutsch, 2004). These systems refer to different processes and ways of handling information and acting (Thaler and Sunstein, 2009). System 1 is our intuition and decisions are made fast, automatic, emotional and subconsciously, with view demands on our cognitive capacity. System 1 guides a large part of our daily behaviours (e.g. brushing teeth). The cognitive operations involved by system 1 can be (but not always) led by different cognitive biases that may cause sub-optimal decisions. System 2 requires more mental effort, is slower and deliberate.

Regarding the TPB, we can conclude that intentions often represent individual's reflections of their own behaviours based on System 2 (Hagger, 2016). Actual behaviour is mostly the result of known situations (routines and habits) using heuristics and cognitive shortcuts produced by

System 1 (Kahneman 2003). In the overall cases, research addressing altering pro-environmental behaviour did not acknowledge that most of these behaviours are less conscious but habitual. The TPB undermines the role of habits and does not give it a relevant role. Pierce et al. (2010, p. 1990) state that most "*daily interactions with energy consuming devices or systems can be characterised as unconscious or habitual rather than the result of rational decision-making*". Van den Broek et al. (2019) found that habits and perceived behavioural control significantly predict energy saving behaviours in the dwelling, while intentions have not been found significant. The authors explain that contextual factors are of utmost importance and unlike TPB assumptions, energy behaviours are typically not intentional but strongly driven by habits (Maréchal, 2010; Semenza et al., 2008).

TPB targets changing behaviour through altering System 2 and conceptualises individual decisions as driven by cognitive processes. However, one limitation of the TPB is that it neglects to account for every-day System 1 behaviours. Combining the environmental psychological literature to explain heating-related behaviours, it needs to be emphasised that often an activation of System 1 occurs because decisions are affected by "self-control problems, unrealistic optimism, and limited attention" (Sunstein, 2014). In such cases, habits approach helps to shed light to explain self-restricting energy behaviour. Changing behaviours through System 2 is more complicated as it requires analytical and reflective reasoning on why to change behaviour. That is why the TPB and the other popular theoretical frameworks, such as the norm-activation model, can only to a limited degree explain behaviour change deducting it from attitudes, PBC, social norms or intentions (Schwartz, 1977). Changing behaviour by targeting non-conscious processes is proposed to be more effective than engaging conscious deliberative processes, as Hollands et al. (2016) illustrated for health-related behaviour. For instance, the decision to retrofit would constitute an activation of System 2. This is because rational thinking, effortful deliberation and decision making is required to calculate required costs of the retrofit, taking a loan from the bank, deciding on various renovation depths (Taranu and Verbeeck, 2018). It is a System 2 behaviour because difficult technical information needs to be read, understood, considered and weighted according to its pro's and con's. Therefore, a vast majority of empirical studies found homeownership, higher income families and younger age of home/ apartment owners as the core independent variables of 'technological choice' to retrofit (Banfi et al., 2008; Bartiaux et al., 2006; Nair et al., 2010; Trotta, 2018).[32]

3.2 Habits and its Disruption

Theories of behavioural change are commonly distinguished from theories of behaviour (Karatasou et al., 2014). The former analyses how to change behaviour over time, the latter seeks to identify predictors that influence that behaviour. While the previous chapter explored interpersonal psychological predictors that affect behaviour, this chapter concentrates on change theory, specifically on habits and automatic repeated behaviours. Drawing on the definition of habits from health-related research, Gardner describes habits as "a process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations" (Gardner, 2015, p. 277). This definition highlights the importance of contextual cues that trigger behaviour. Habits are formed in stable environments and are repeated over time (Lally et al., 2011). Verplanken and Wood (2006) emphasised that repetition is vital in habit formation, but **automaticity** complemented with encountering context cues characterises habits. Wood and Neal defined habits as (Wood and Neal, 2009, p. 580):

> *"A type of automaticity characterised by a rigid contextual cuing of behaviour that does not depend on people's goals and intentions. Habits develop as people respond repeatedly in a stable context and thereby form direct associations in memory between that response and cues in the performance context."*

Both definitions indicate that habits underlie less cognitive effort and thought than non-habitual behaviours, as they require less mental motivation or attention. Moreover, habits differ from intentions. To sum up, the major three pillars of habits are (Kurz et al., 2015):

1. repetition,
2. automaticity, and
3. context stability (environmental cues).

The latent construct of habits is usually operationalized using markers like "doing something in *everyday life* without thinking about it", "*frequency* of past behaviour", "unconscious *repetition* of behaviours", "doing something *automatic* because it is learned that way", "*being used* to behave in a certain way".

32 This thesis does not analyse the predictors that lead to the decision to retrofit because households living in social housings in Vienna did not make an active decision in the meaning of activation of System 2. Neither were they required to make a large down payment/ investment for the retrofit.

To sum up, when learned sequences of actions are repeatedly performed and become automatic without conscious consideration of their pros and cons, they transform into habits (Verplanken and Aarts, 1999). Habits are developed and performed to achieve a certain goal or a desired outcome (Mazar and Wood, 2018). Over time and with an increase in frequency, habits may shift from being goal-directed to context dependent behaviours, which increases the risk of choosing a suboptimal alternative if the conditions change. Habits are executed in stable contexts and triggered by *external* (environmental, physical, social, symbolic) or *internal* (psychological, mood) stimuli (Hollands et al., 2015; Verplanken and Orbell, 2003). Certain home-related energy behaviours become habitual because of their repeated execution in a consistent environment. Van den Broek et al. (2019) found that habitual and situational processes are the strongest predictors of energy conservation compared to intentions. Barr et al. (2005, p. 1426) provided some examples of habitual non-conscious energy behaviours:

> *"thermostat setting, closing off of unused rooms, altering room use, window closure when heating is on, using a clothes line rather than a tumble drier, not filling the kettle full before boiling, putting a full load of washing on rather than a half load".*

Although habits are beneficial to individuals, they constitute a major barrier to change behaviour because first old habits and routines need to be broken before new ones can be established (Stern 2000). Huebner et al. (2013) concluded in their study that established habits are the biggest obstacle to changing behaviour. The authors suggest that changing the physical environment, such as installing a new heating system control, can be more effective in disrupting habits than changing goal intentions. Research from health and transportation studies has also shown that destabilising people's environments can help to break habits (Darnton et al., 2011).

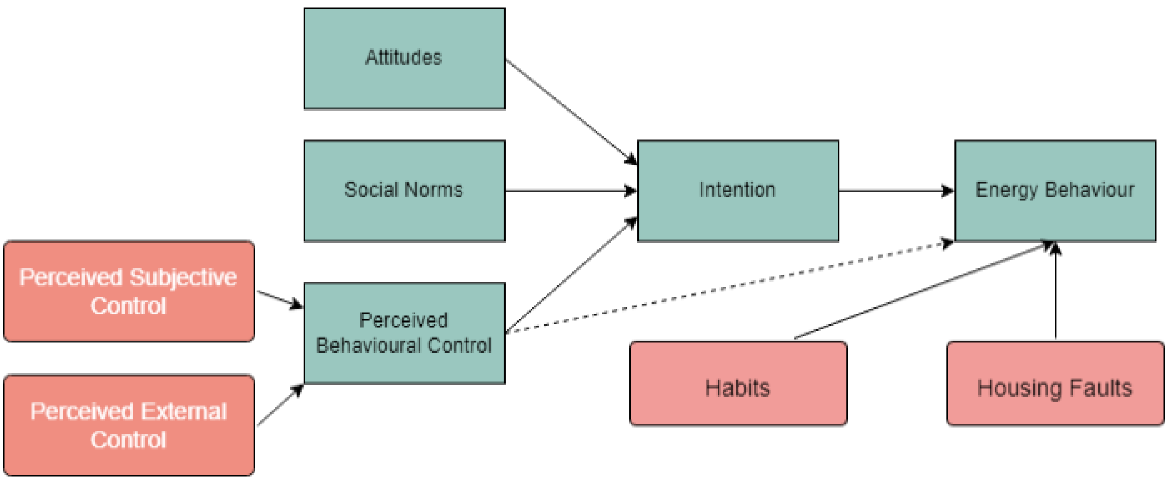

Figure 11 Conceptual Framework of Energy Behaviour for the Retrofitted Sample (Source: Own Visualization).

For a "successful" behavioural change, the context has to be disrupted, altered or changed so the habitual behaviour is questioned, interrupted or hindered.

The challenge to change behaviour lies within the circumstance to create an environmental context that makes the automatic execution of the habit impossible or unattractive to motivate an individual to make a deliberate choice so that System 2 is activated. If the context (and habitual behaviour is unlikely to be executed) is disrupted, and more conscious reasoning is activated, it may act as a trigger for new behaviours to occur. In such situations, the TPB provides sufficient explanatory power to explain behaviours (Ouellette and Wood, 1998b; Wood et al., 2005). Triandis (1980; 1977) found that when a new behaviour is executed, it is fully under control of behavioural intentions. After repetition of the behaviour, the explanatory power of intentions drops and habits become more influential in explaining behaviour.

This integrative literature review has provided the necessary knowledge to apply an extended version of the TPB in the empirical part of this thesis. Therefore, an integrated model is proposed by considering the constructs of the TPB and the concept of habits by exploring the relationships between both sets of variables for the context of not retrofitted social housings in Vienna (see Figure 11). Following the line of argumentation of the chapter, the subsequent hypotheses for the structural equation models among the latent variables are stated as follows (see Table 3):

Research Hypotheses for the Not Retrofitted Sample	
H_1	Positive attitudes towards the efficient energy use have a positive effect on intentions to save energy.
H_2	Social norms have a positive effect on energy saving intentions.
H_3	Internal PBC have a positive effect on the intentions to save energy.
H_4	External PBC contribute positively to the intention to save energy.
H_5	External PBC have a positive effect on energy restriction behaviour.
H_6	Habits have a direct positive effect on energy restriction behaviour, which are stronger than intentions.
H_7	Housing faults has a positive direct effect on energy restriction behaviour.

Table 3 Proposed Hypotheses for the Not Retrofitted Sample.

3.3 Windows of Opportunities in Destabilised Environments

According to Verplanken and Wood (2006, p. 96) behavioural changes are more likely to occur when

> *"changes in context render people with strong habits to new information. Specifically, environmental changes that disrupt habits also challenge habitual mind-sets and thus increase openness to new information and experiences. [..] These environmental changes impair the automatic cuing of well-practices responses, they enable performance of new actions."*

There is empirical evidence that behaviours can successfully be altered through energy efficiency interventions as they also change environmental contexts (Albarracín et al., 2005). The transformations in the surrounding environment (dwelling or building) can trigger at least three major behavioural outcomes. The new environment can

i. either initiate higher energy consumption,
ii. it can constitute an opportunity to increase the likelihood to reduce energy consumption as household conciousness grows, or
iii. have no effect on household behaviour (Azevedo, 2014; Daniel Khazzoom, 1980; Greening et al., 2000; Šćepanović et al., 2017; Seebauer, 2018; Suffolk and Poortinga, 2016; van den Bergh, 2011).

There is a dilemma in relation to retrofitting buildings, which is known as the *rebound effect*. A rebound effect is defined as the gap between the theoretically estimated energy savings from an energy efficiency improvement and the actual lower energy savings (Mashhadi Rajabi, 2022). Research findings indicate that low-income households more often experience a rebound compared to high-income households (Aydin et al., 2017; Guertin et al., 2003; Haas and Biermayr, 2000; Madlener and Hauertmann, 2011; Nadel, 2016; Nesbakken, 2001). In Austria, Seebauer (2018) showed that behavioural changes occur after a retrofit and households 'take back' the energy they have been restricting *ex-ante* a retrofit.

Galvin and Sunikka-Blank (2016) introduced the "prebound" effect to describe self-restricting behaviours before a retrofit and lower than expected energy savings after a retrofit. This is explained by miscalculations of the potential energy saved, which stem from *ex-ante* overestimation of the energy consumption in old energy-inefficient buildings that is driven by the prevalence of self-restricting behaviours prior to a retrofit in predominantly low-income households (Gram-Hanssen 2014). After long periods of skimping down on energy, deprived households might take their warmth back after a retrofit. This outcome occurs because the energy bills decrease, and warmer temperatures can be realised (Deurinck et al., 2012; Stafford et al., 2011).[33] Modelling results lead to an overestimation of the expected carbon and energy saving of a retrofit because these energy self-restricting behaviours are not included in the *ex-ante* calculations compared to its rated energy performance (Teli et al., 2016).

Research on rebound effects, however, has so far mostly overlooked psychological explanations (Santarius, 2015). Peters and Dütschke (2016) applied the TPB constructs in focus groups on behavioural changes after efficiency improvements. Their results indicated mixed behavioural change outcomes: some participants reported no behavioural changes, some others reported direct rebound effects, while others still stated they had decreased usage and achieved energy savings. The authors concluded that energy efficient technology adoptions may trigger changes in behaviours (transport and lightning behaviour) via psychological factors. For heating behaviour, however, results indicated more stable unchanging behaviours.

To summarise, "rebound effects" have been studied from various theoretical perspectives, such as macroeconomics, psychology, sociology, and several meta-analyses revealed direct rebound effects ranging between 10 - 30% (Freire-González, 2017; Santarius et al., 2016; Santarius and Soland, 2018; Sorrell et al., 2009). However, studies also indicated inconclusive results (Andersen et al., 2019; Aydin et al., 2017; Guerra-Santin et al., 2017; Madlener and Hauertmann, 2011; van den Brom et al., 2019b). In line with the study context of the thesis, the "prebound effect" helps to reveal self-restricting energy behaviours as it addresses potentially larger rebound effects for energy poor households compared to the general population (Teli et al., 2016). Rebound behaviours of social housing residents will be explained using key constructs of the TPB in the empirical part of the thesis. Next to energy efficiency measures and retrofitting activities, it is argued that sensitive life events, such as, a job change, moving

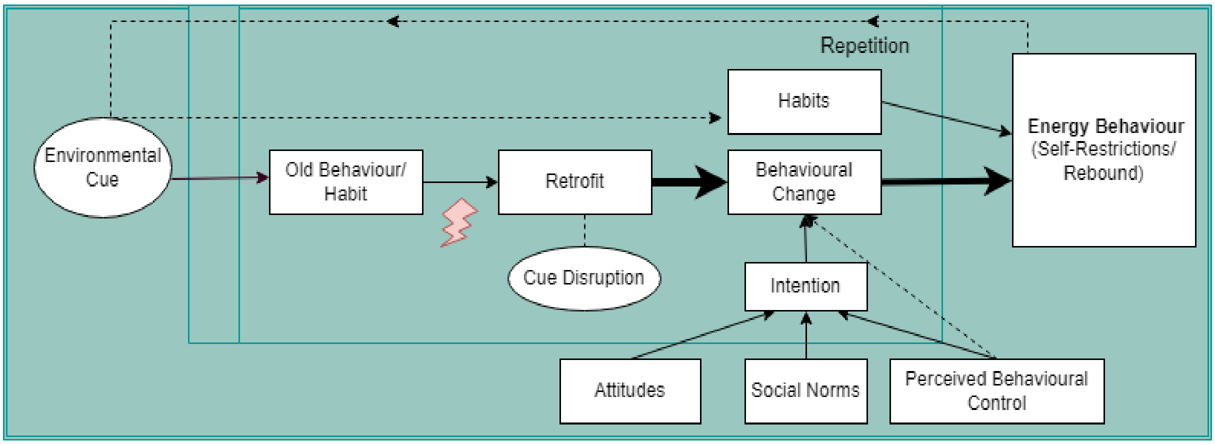

Figure 12 Theoretical Framework Highlighting Behavioural Change Due to a Retrofit (Source: Own Visualization).

33 It should be highlighted that low-income households that profit from a retrofit and "taking back" comfort (rebound-effect) should not be seen critically as their general well-being increases due to the improvement of the buildings.

to a new home, starting a family, retirement, serious illness, and more recently the COVID-19 pandemic constitute 'windows of opportunities' to change behaviour (Di Renzo et al., 2020; Schäfer et al., 2012; Smeaton et al., 2017). Old habits are not executed because they are no longer useful or feasible because environmental cues have changed. Life events often require a reorientation and offer the opportunity to establish new behaviours. Figure 12 visualises the theoretical underpinning of a cue disruption (e.g. retrofit). As a result, old cues that lead to the execution of a habit (triggered) are altered, so the habit is no longer useful or feasible (e.g. it is unnecessary to heat as often as before the retrofit). In such situations, typically more deliberate processes in the sense of TPB are activated (Verplanken, 2018).

From the energy poverty perspective, e.g., energy price shocks, COVID-19 pandemic, the war in Ukraine, or hydrocele or boiler breakdowns constitute 'windows of opportunities'. While scholarly work on habits and interventions is more extensive in health studies (dietary and physical activity habits), it can be fruitfully extended to social science and, specifically, inform and improve further research in energy poverty. The habit disruption approach has been validated empirically in the following - predominantly transportation-related - studies:

Wood et al. (2005) highlighted how a change of location supports decisions to be more in line with intentions than with habits. The authors studied students who recently moved and analysed their habits in TV watching and newspaper reading: new behaviours are more likely to be performed if the new environment differs from the old one. Furthermore, they found that old habits are more likely to be maintained if the new environment was similar to the old one.

Fujii and Gärling (2003) reveal in a study that students who graduated were more likely to change their travel mode choice. Furthermore, Fujii et al. (2001) demonstrated that during an 8-day freeway closure, drivers continued to use public transportation more frequently one year after the closure than those drivers who did not change to public transport during the closure. Fujii and Kitamura (2003) and Thøgersen (2009) identified that temporary price promotions, such as the provision of free bus travel for a specific time period, can even bring out a modal shift.

Studies demonstrated that significant life events, such as moving or starting a new job, can disrupt transportation habits and lead to changes in mode choice. The impact of habits on behavior decreases when context changes, resulting in an increase in public transportation use. This has been supported by various studies, including the provision of free public transportation tickets and schedules after a residential move (Bamberg, 2006; Klöckner, 2004; Ralph and

Brown, 2019; Thøgersen, 2012; Van der Waerden et al., 2003). Studies demonstrated that life events such as pregnancy or parenthood offer window opportunities for sustainable consumption changes. Young, highly educated parents tend to adopt healthier habits (Schäfer et al., 2012). Their argument is that during life course events, people are more receptive to information to behave differently (Burningham and Venn, 2020). Food consumption changes with events such as serious illness, retirement, and food scandals (Brunner et al. (2006)). A randomised experiment supported the habit discontinuity hypothesis, indicating that behavioral change is most effective within 3 months of a context change with intervention (Verplanken and Roy, 2016). Maréchal (2010) studied the effect of energy subsidies offered by the Brussels Region on energy-related behaviors. He found that people who recently moved house in the previous 3 years were more receptive to energy subsidies compared to current residents. This was attributed to a perturbation of the context and related habits, which increased receptivity to subsidies.

Studies that dealt with habit discontinuity exploited predominantly car use habits, life events, or moving to a new house. However, there have been few quantitative analyses aimed at analysing household self-restricting energy behaviours without and with a retrofit. Here, the evidence from the academic literature is thin, but suggests that life events constitute a disruption of habits. Whether a retrofit can be considered a disruptive event in the sense of habitual change, however, remains an open question. It is hypothesised that a retrofit may be disruptive as it can lead to increased rent for lower-income households, causing them to become more cost-conscious and alter their energy use to avoid economic distress. Therfore, the following research hypotheses are proposed (see Table 4):

Research Hypotheses for the Retrofitted Sample	
H_8	Positive attitudes towards the efficient energy use have a positive effect on intentions to save energy.
H_9	Social norms have a positive effect on energy saving intentions.
H_{10}	Internal PBC has a positive effect on the intentions to save energy.
H_{11}	Intentions to save energy have a positive effect on energy restriction behaviour.
H_{12}	Intentions to save energy have a negative effect on rebound behaviour.

Table 4 Proposed Hypotheses for the Retrofitted Sample.

To summarise, retrofits may present opportunities to change energy consumption behaviours. It is possible that the increased energy efficiency resulting from the retrofit may lead to a rebound effect, in which households increase their energy use they have been skimping on due to the lower cost of energy services. The retrofit may also lead to increased energy saving behaviors, as suggested by the habit discontinuity hypothesis. The objective of this research is to understand the factors that influence these different outcomes and to investigate the psychological factors at play in retrofitted and not-retrofitted social housing, as this area of research has yet to be examined. Both assumptions will be tested in the empirical part of the thesis. This chapter has built the bridge between hidden energy poverty and psychological constructs to understand self-restricting energy behaviours. Further key determinants need to be addressed to answer the question of what factors increase the risk of self-restricting energy behaviours and being hidden energy poor.

3.4 Physical Building Characteristics as Determinants of Self-Restricting Energy Behavior

Occupants actively play a role in shaping the amount of energy consumption that is being used in dwellings. Hansen et al. (2018) proposed the argument that the building design influences heating behaviours: the frequency of adjusting thermostats to regulate heating, the frequency of window opening, the amount of clothes that the respondents wore during winter and the perceived temperature level was regressed on the *material* (e.g. energy efficiency, technical installations and building layout) and *social* (e.g. socio-demographic and socio-economic characteristics) context. They found that material arrangements have an impact on heat-related habits and on the temperature level.

Mainstream energy modelling paradigms that utilise technical or econometric approaches (often steering from engineering studies) frequently miss out to take occupant-dwelling behaviours into account (Calì et al., 2016; Fabi et al., 2013; Johnson et al., 2014; Schakib-Ekbatan et al., 2015). They either classify residential building blocks as a 'system' or they estimate energy consumption of end-uses on descriptions of a representative sample of buildings[34] while neglecting socio-technical and/ or behavioural aspects. Occupants are included in the building simulation tools as static entities (Hoes et al., 2009). In a review, Gauthier et al. (2016, p. 29) concluded that

> *"[t]here is a strong focus on building performance and thermal characteristics but very little on user behaviour and its large but mostly under-researched role in energy consumption. Most of the research is focused on modelling techniques, algorithms and*

34 Such typical representative buildings are single-and double-family houses, small and medium-sized multi-family houses, and larger multi-family houses.

data mining but not on analysing patterns inferred from a representative sample of real homes".

Over the last 15 years, energy use and demand models faced the pressing problem that estimations revealed performance gaps: it is a mismatch between *expected* (often simulated) and *actual* energy consumption that has been even up to 300% difference (Al-Mumin et al., 2003; Delzendeh et al., 2017; Gaetani et al., 2016; Martinaitis et al., 2015; Menezes et al., 2012, 2012; van den Brom et al., 2018; Wilde, 2014). The lack of explanations of occupants' private-sphere behaviours are identified as one of the major causes of the energy performance gap. This insight has led to an expansion of interdisciplinary work of social-scientific energy research (Al-Mumin et al., 2003; Cayla et al., 2010; Gaetani et al., 2016; Jia et al., 2017; Pombo et al., 2016; Schmidt and Weigt, 2015; Wei et al., 2014; Yan et al., 2015; Yohanis et al., 2008). Despite the increasing use of energy modelling studies, many of these studies do not incorporate behavioural explanations or a clear theoretical framework informed by social sciences. Hence, an extensive amount of studies in this research area lack behavioural realism, which limits their explanatory power as they cannot explain why occupants differ in their energy habits and behaviours.

While social energy science research has traditionally emphasized individual-level factors like attitudes and beliefs to explain energy behavior, recent studies suggest that physical building characteristics and structural aspects also play a significant role. As a result, researchers are increasingly incorporating these physical factors into their investigations to better understand the complex interplay between individual and structural factors that shape energy behavior (Guerra Santin, 2010; Hong et al., 2016; Jia et al., 2017; Sovacool et al., 2015; Sovacool, 2014; Stazi et al., 2017; Stephenson, 2018; Stephenson et al., 2015).

To avoid these presented limitations, the TPB framework and the habits discontinuity approach cannot be used as a standalone theoretical framework to explain household self-restricting energy behaviours, as housing characteristics also determine vulnerability to be energy poor. The guiding question of this paragraph therefore is: *what are the main housing related factors that increase the likelihood of skimping down on energy and being vulnerable to (hidden) energy poverty?*

Research results indicated that renters are more prone to energy poverty compared to owner-occupied houses (Bollino and Botti, 2017; Burlinson et al., 2018; Leicester and Stoye, 2017; Paloma Taltavull de La Paz et al., 2019; Seebauer et al., 2019). Housing tenure influences how much control a household has over keeping their home adequately warm and their energy supply by selecting a heating system and being able to manage energy consumption (Boardman, 2013; Healy, 2003a; Healy and Clinch, 2002; Hills, 2012b). While owners have more choice options to decide autonomously, for instance, to change the heating system or installing solar panels on their rooftops, tenants are more limited in their choices due to their low negotiation power to leverage such energy system changes.

Huebner et al. (2015) revealed that building characteristics account for 39% of the variability of energy consumption, socio-demographics 24%, heating behaviour 14%, and attitudes and other behaviour account for only 5%. Their full model explained 44% of the overall variance. Also, Guerra Santin et al. (2009) found that building characteristics explain 42% of the variation in energy use for heating and only 4.2% of variation explained by household characteristics. Sonderegger (1978) was the first to analyse the extent to which occupants are responsible for the large variance in the performance gap. He finds similar results where the physical characteristics of the dwelling explained 54% of the variation in energy use, 15% by the change of household occupants, 17% by lifestyle, and 13% by household-related quality differences. In the same line, Brounen et al. (2012) demonstrated that residential heating consumption is mainly influenced by the characteristics of the building, such as its *construction year*. Van den Brom et al. (2019a) calculated the energy-performance gap between actual and theoretical energy consumption and found that 50% of explained differences in heating consumption can be explained by characteristics of the building and approximately 50% of explained variance can be attributed to occupant's behaviour.

In various studies, *floor area* was one of the strongest predictors of expenses and consumption as an increase in size is accompanied by a higher demand for space heating (and cooling). While, Bedir et al. (2013), Tso and Yau (2007), and Vine (1986) found no significant floor area effect, various other authors revealed that size of the dwelling has a positive (increasing) effect on energy consumption (Baker and Rylatt, 2008; Bartusch et al., 2012; Brounen et al., 2013; Gram-Hanssen et al., 2004; Guerra Santin et al., 2009; Kavousian et al., 2013; Wyatt, 2013; Yohanis et al., 2008). Studies revealed that *each extra room in the dwelling* (Bedir et al., 2013; Leahy and Lyons, 2010), as well as *number of heated or cooled rooms* (Guerra Santin et al., 2009; Steemers and Yun, 2009; Yun and Steemers, 2011) increases heating consumption.[35]

35 This is also in line with Baker and Rylatt (2008), Bedir et al. (2013), Fuerst et al. (2020), Leahy and Lyons (2010), Liao and Chang (2002); Lindén et al. (2006); Brounen et al. (2012), Guerra Santin et al. (2009), Wyatt (2013), and Tiwari (2000) who found that, inter alia, number of rooms, main heating, and floor size are significant and positive predictors of energy consumption.

Another predictor that increases energy consumption is the *time occupants spend at home* (Barthelmes et al., 2018; Campbell, 1993; Guerra Santin et al., 2009; Roberts, 2008a; Schuler et al., 2000). It is assumed that *housing faults* lead to higher prevalence of energy saving behaviours. Boomsma et al. (2019) found for social housing residents that condensation, damp and mould were associated with more frequent heating related energy saving behaviours. The authors included constructs of the TPB, dwelling characteristics and socio-demographics (age, gender) and found only modest to low total explained variance of the models (energy saving 13% and heating-related energy saving behaviour 5%). However, the reason for the low explained variance they explained stems from the fact that habits have not been considered in the models.

The *age* of the building has also a significant influence on energy costs (Hills, 2012b). The EU's housing stock is relatively old, with over 40% built before 1960, which has typically higher energy demand and higher energy expenditure (Artola et al., 2016). Older properties compared to modern dwelling are likely to have an inefficient thermal quality. There is ambiguity of the effect of *dwelling age* on energy consumption: a significant positive effect of dwelling age is found in Bartusch et al. (2012), Wyatt (2013) Brounen et al. (2012), Leahy and Lyons (2010), and Genjo et al. (2005), while several research studies found no effect of construction year of the building (Kavousian et al., 2013; Tso, 2003; Tso and Yau, 2007; Vine, 1987; Wyatt, 2013). *Comfort temperature* is a significant predictor of energy use: people who prefer warmer temperatures at home have more likely higher energy consumption and lower self-restricting energy behaviours (Bedir et al., 2013).

While sufficient studies find building characteristics explaining a large proportion of variance of heating/ energy consumption, various studies found, on the contrary, that behavioural factors and the occupants role are more important than dwelling characteristics (Fuerst et al., 2020; Gram-Hanssen, 2011; Steemers and Yun, 2009). Studies imply that these determinants explain about 30% of the variance in overall heating consumption (Chen et al., 2013; Langevin et al., 2013; Mansouri et al., 1996; Steemers and Yun, 2009; van Raaij and Verhallen, 1983). Although there is ambiguity whether building or behavioural aspects play a more meaningful role in explaining the amount of variance. Overall, these studies are hardly comparable as they refer to

- different sample sizes, different houses (e.g. social, rented, owned, detached) and geographies;
- different modelling techniques;

- different independent and dependent variables;
- different orders when predictors are regressed (if building characteristics are introduced in the models first, they have more explained variance, for instance, and conversely);
- different objectives, theories that the researcher set for the term occupant behaviour.

To conclude, to date, a few empirical studies have attempted to explain the relationship between dwelling characteristics and self-restricting energy behaviours. Belaid and Garcia (2016) were the first who applied micro-data to investigate the impact of household characteristics, climate, physical and energy performance characteristics on domestic energy-saving behaviour. These presented major factors are included in the analysis of this thesis to explain the higher risk of being (hidden) energy poor in social housings in Vienna using energy self-restrictions.

3.5 Determinants of Self-Restricting Energy Behavior: Socio-Demographic and -Economic Characteristics

Next to psychological and building related predictors, socio-demographic and -economic factors influence self-restriction behaviours. Such predictors are household characteristics, like gender, employment status, household size, income and education (Nair et al., 2010; Poortinga et al., 2003; Rehdanz, 2007; Shi et al., 2017; Trotta, 2018). Various studies assert that socio-demographic factors may have a significant impact on energy behaviour (Belessiotis and Mathioulakis, 2002; Stazi et al., 2017; Vilches et al., 2017). However, available research concerning the effect of socio-demographic and -economic determinants has returned contradictory results. There are intersecting axes between the socio-demographics that enhance the likelihood of energy self-restricting behaviours. The guiding question of this paragraph is: *what are the main socio-economic and socio-demographic factors related to household self-restriction behaviour?*

Energy consumption and energy self-restrictions have a gender dimension (Clancy and Roehr, 2003; Djoudi et al., 2016; Sunikka-Blank, 2020). Many energy self-restricting behaviours are *gendered* as women and men behave differently because of differing energy needs and societal power relations (Kaijser and Kronsell, 2014). However, the intersections between gender and self-restriction behaviour are yet poorly understood and analysed in Austria, as well as in energy poverty debates (Feenstra and Clancy, 2020; Sánchez-Guevara Sánchez et al., 2020). A pitfall in current analysis and literature is the lack of awareness and disaggregated data on gender and energy poverty, as emphasized by Clancy et al. (2017). This is not only the case in research but also in political debates on energy poverty in the EU: the gender dimension did not expand and is not yet fully recognised, as it is underrepresented in support programs or subsidies.

Research on gender dimensions and climate change has emerged over the past 10 years and brought to light that climate change increases gender inequalities by putting on average more burdens on women because of changing environments and livelihoods (Cohen, 2017; MacGregor, 2017, 2010). Although the relationship between energy and gender has traditionally been understudied in energy studies (Ryan, 2014), academics and practitioners are becoming more aware, because of the work of feminists and women-focused scholars that also highlight intersectional social categories. More recently, Matzinger and Berger (2021) emphasised the under-researched link between gender and energy poverty, in which they call for a gender-sensitive analysis of energy poverty. However, when there is no sex-disaggregated data, there is also a lack of awareness. If there is a lack of visibility of gender and energy poverty, it is not present in policy discourse: no data - no visibility; no visibility – no interest; no interest – no action; no action – no accountability (European Parliament, 2017, p. 8). Clancy et al. (2017, p. 7) identified three gender gaps that are drivers, or outcomes of energy poverty:

- **Economic**: women are more likely than men to be energy poor because of their lower average income. More women compared to men who live alone at a pensionable age in the EU. There are also more single-parent families where women are the head of the family. Over the life course women have higher exposure to income poverty.
- **Biological/ physiological**: women are more sensitive to ambient temperature than men. Age is an important factor to deal with too cold or too warm temperatures as children and older people are more vulnerable.
- **Socio-cultural**: women’s energy needs and consumption patterns differ from men due to employment and marital status (Shrestha et al., 2021). Research from Germany demonstrated that elderly women use less energy than younger women, making them more vulnerable to older, inefficient homes. Preisendorfer (1999) referred to a cohort effect of older women and the socialisation processes, as they grew up in times of austerity, whereas younger women are more familiarised with greater uptake of technologies and use new devices more often.[36] Climate policies and environmental studies addressing “greening the household” and energy consumption behaviour unavoidably touches upon intersectional gender topics. *But, why does*

36 Internal temperatures in UK houses increased from 13.8 °C in 1970 to 18.2 °C in 2000, while the average number of electric appliances increased from 17 to 47 over the same period of time (Martiskainen, 2007).

it matter to analyse energy poverty from an intersectional lens and what implications does the gender focus have on energy self-restriction behaviour and hidden energy poverty?

- Women's incomes are on average lower compared to men (in Austria and OECD) as women do a disproportionate higher share of household work (22 hours women compared to 9 hours men in Austria per week) and are more often in part-time jobs (Jourová, 2019; Sunikka-Blank, 2020).[37] As household work is unpaid, this leads to women's disproportionate lower levels of economic wealth and lower hours in labour force (OECD, 2020; Schneebaum et al., 2018). Overall, these circumstances reduce women's relative affordability of energy services compared to men. Women with lower incomes typically consume less energy than those with higher level (Clancy and Roehr, 2003). Single-headed women, compared to men, own less technical appliances (Räty and Carlsson-Kanyama, 2010).
- Pension entitlements of women are lower compared to men leading female pensioners to be in a higher energy vulnerability risk group. Austria and Germany have the highest gender pension gaps in the OECD and are on the upper edge of the gender wage gap in the EU (Lis and Bonthuis, 2020; O'neill et al., 2006). Relating thereto, elderly (low-income) women more often use less energy, try to self-restrict on energy and change energy patterns compared to younger women (Clancy et al., 2017).[38] According to Elnakat and Gomez (2015) research results, more women compared to men who live in older, less efficient homes built before the 1970ies.
- Women spend more time at home than men, especially if they have children, which corresponds to higher energy demand and consumption (Brounen et al., 2012; Fell and Chiu, 2014).
- Women typically require more energy as they are responsible for more energy related domestic work (Carlsson-Kanyama and Lindén, 2007).
- In case of a separation or divorce, in which kids are involved, single-parent households in the EU have a higher risk of energy poverty. These households are less likely to heat their homes to an adequate level (Eurostat, 2019c). In Austria, 8% of single-parent households are in energy poverty compared to 2.4% of all households (Sunikka-Blank, 2020).

37 COVID-19 crisis impacts and increases gender inequalities: „*COVID-19 will amplify women's unpaid work burdens. For example, the widespread closure of schools and childcare facilities will not only increase the amount of time that parents must spend on childcare and child supervision, but also force many to supervise or lead home schooling. Much of this additional burden is likely to fall on women. Similarly, any increases in time spend in the home due to confinement are likely to lead to increased routine housework, including cooking and cleaning. Fulfilling these demands will be difficult for many parents, especially for those that are required to continue working*" (OECD, 2020).

38 Socialisation and cohort effects are often discussed as reasons for these empirical results (Bardazzi and Pazienza, 2020).

- Studies suggested that women have higher levels of environmental concern about energy use, hold more pro-environmentally friendly attitudes and intentions than man and consume less energy in households (if single women households are compared to men) (Dzialo, 2017; Räty and Carlsson-Kanyama, 2010; Zelezny et al., 2000). Women are found to be more inclined to save energy and undertaking self-restricting behaviours (Carlsson-Kanyama and Lindén, 2007; Niamir et al., 2020). Hansen et al. (2018) results demonstrated that women wear more clothes during winter, regardless of the energy efficiency of their houses. Further research results suggested that due to gendered division of domestic labour, women are more responsible and dedicate more time to reproductive behaviours of housework and care-work, while men are more responsible for non-routine home maintenance (Lee and Waite, 2005; Sayer, 2010; Tjørring, 2016).
- Empirical results revealed that women prefer warmer ambient room temperatures, feel often uncomfortably cold (Carlsson-Kanyama and Lindén, 2007; Day and Hitchings, 2009; Karjalainen, 2007; Petrova et al., 2013; Sardianou, 2007; Schellen et al., 2012). A French study found intersecting vulnerabilities of being cold at home, women-headed households and retirement. These results point to different energy needs and preferred indoor temperatures between men and women.

To conclude, signified by previous research, women more often lower their energy consumption and might fall out of typically employed energy poverty indicators that primarily focus on high-energy expenses (based on household income). From a policy perspective, women have a higher risk of being overlooked by current policy designs.

Household size and composition have been investigated extensively and results indicate that household size is positively related to the level of energy use as energy demand increases with household size e.g. washing, cooking (Brandon and Lewis, 1999; Druckman and Jackson, 2008; Gatersleben et al., 2002; Genjo et al., 2005; Huebner et al., 2015; Kavousian et al., 2013; Poortinga et al., 2004; Yohanis et al., 2008). Fuerst et al. (2020), on the contrary, find contrary results: single family households consume more gas for space heating, especially older (over 60 years) single-person households. Hence, their results suggested that the larger the household, the lower is their heating consumption. For self-restriction behaviour, research indicated that larger households are more likely demonstrate energy restraining behaviours (Mills and Schleich, 2010; O'Doherty et al., 2008; Poortinga et al., 2004).

Mixed results are reported for *children* in the household. Some research results point to positive associations between the presence of children and increasing energy demand, use and expenses accompanied by low energy-saving behaviours in daily lives (Aydin et al., 2004; Bartusch et al., 2012; Brounen et al., 2012; Craemer et al., 2012; Dupont, 2004; McLoughlin et al., 2012). This is typically explained by higher demand for warm internal temperatures (van Raaij and Verhallen, 1983; Weihl and Gladhart, 1990; Xu et al., 2009). These research results have been challenged as several authors reported a negative relationship between the presence of children, heating expenses and energy self-restriction behaviour (Bartiaux and Gram-Hanssen, 2005; Gram-Hanssen et al., 2004; McMakin et al., 2002; Mills and Schleich, 2012; Rehdanz, 2007).

Household income is a major determinant for the *use* and *expenses* of heating: data from several studies suggested that energy use increases with higher income.[39] Vringer (2005) demonstrated that a 1% increase of households income corresponds with a 0.63% increase in energy use. Bedir et al. (2013), however, found no positive association between income and energy use. The explanation relates to the circumstance that high-income households have more means to buy energy-efficient appliances and spend less time at home (often in employment) and have, therefore, lower heating and electricity expenses. Nevertheless, the majority of studies predominantly indicated that occupants who belong to the medium and high-income groups save less energy or execute fewer curtailment behaviours (Abrahamse and Steg, 2009; Barr et al., 2005; Day and Hitchings, 2009; O'Doherty et al., 2008; Sardianou, 2008).

Literature on the factors that relate to energy self-restrictions of *low-income households* is limited and inconclusive: studies results showed that people with higher income are *more* (Testa et al., 2016), *less* (Martinsson et al., 2011; Trotta, 2018) or *equally* (Whitmarsh and O'Neill, 2010) likely to cut down energy consumption, compared to lower income households. Poortinga et al. (2003) reported that low-income households were less willing to carry out energy-saving measures. Hansen (2016) examined household and building data in Denmark on socio-cultural differences and showed that households heat consumption levels vary by income: his main results indicated a positive income effect but he also found that higher income occupants live in larger buildings that require less energy. Trotta (2018) confirmed that low-income households more often live in dwellings with housing faults and spent proportionately more of their incomes on energy. Umit et al. (2019) results implicated that high income

39 Scholars like Abrahamse and Steg (2009); Brandon and Lewis (1999); Druckman and Jackson (2008); Estiri (2014); Gatersleben et al. (2002); Genjo et al. (2005); Guerra Santin et al. (2009); Hansen (2016); Poortinga et al. (2004); Sanquist et al. (2012); Yohanis et al. (2008) have extensively investigated this issue.

correlates negatively with the frequency of engaging in habitual energy curtailment. For example, low-income households with housing problems show larger rebound effects after energy efficiency retrofits, than higher income households in thermally better homes (Boardman, 2010; Galvin, 2020; Hong et al., 2006; Ürge-Vorsatz and Tirado Herrero, 2012). The temperature take-back effect indicates a high prevalence of unmet energy needs.

The effect of *education* is inconclusive: Poortinga et al. (2004) found a positive effect of education on energy self- restricting behaviour, whereas Karlin et al. (2014), Sardianou (2007), and Trotta (2018) did not found such a positive effect. Hansen's et al. (2018) study results revealed that dwellers with higher education are more likely to dress warmer in winter.

Age is commonly included in social energy research and reveals mixed results. The human body undergoes structural changes as it ages, altering how it adapts to various thermal environments. *Elderly* have higher energy expenses and use more energy because they leave the heating longer on as they are typically longer at home. They move less and require[40] warmer temperatures, because of health reasons (Day and Hitchings, 2009; Estiri, 2014; Guerra-Santin and Itard, 2010; Kelly et al., 2013; Oreszczyn et al., 2006; Wei et al., 2014). Fuerst et al. (2020) connotes that particularly single old aged households have the highest space heating energy consumption. They use approximately 30% more gas compared to other households. This is in line with Brounen et al. (2012) and Leahy and Lyons (2010) who found significant positive associations between old age and domestic energy consumption. Sardianou (2007) revealed that as the age of the occupants increases, the number of energy restricting behaviours decreases. Contrary, some research results indicated that older residents engage more in energy saving behaviours if controlled for income. They have typically more energy inefficient household appliances compared to younger households (Barr et al., 2005; Carlsson-Kanyama and Lindén, 2007; Jones and Lomas, 2016). Poortinga et al. (2003) found seniors less willing to apply energy-saving measures at home. Predominantly qualitative energy poverty studies indicated that low-income elders use energy self-restrictions to avoid high energy and heating costs, despite their higher energy needs (Anderson et al., 2012; Anderson et al., 2010a; Brunner et al., 2012; Chard and Walker, 2016; Wright, 2004).

There is little research linking specific energy self-restrictions to *severely sick* or households who are or taking care of an ill person. Großmann and Kahlheber (2018, p. 13) convincingly pointed to intersectional vulnerabilities and highlighted the circumstance that an illness "can be

40 The WHO (1987) acknowledges higher energy needs (minimum temperature of 20°C) of the elderly (over 65 years old).

both a trigger of energy poverty by causing increased energy needs and consumption and a consequence of energy deprivation". Also, due to causality issues, there is little research on that matter, but it is highlighted that long-term sick people are more likely to be living in energy poverty. The nature of the intersection between energy consumption and/ or self-restriction behaviour and illness/ caring duties requires an embedding in the energy poverty discourse and further investigation.

3.6 Conclusion

This chapter has explored energy poverty from a behavioral perspective, highlighting the need for research that delves into the relationship between energy behaviors and energy poverty as indicated by Streimikiene et al. (2020, p. 10):

> *"it is also necessary to stress that behavioral theory in this area has not focused on households that are in energy poverty but on more general issues of adoption of responsible or sustainable behaviors. Nevertheless, the findings from this broader literature on shaping sustainable behavior can be also applied to energy poor households. […] There are studies dealing with changing habits in the behavioral and psychological literature, however, with no focus on specific behavior of the energy poor consumer groups."*

By proposing an integrated theoretical framework that incorporates the Theory of Planned Behaviour (TPB) and the concept of habits from the Dual Process approach, this research contributes to understanding the connection between (hidden) energy poverty and pro-environmental behaviour. Furthermore, the inclusion of socio-demographics and building-related characteristics as explanatory factors for energy self-restriction behavior adds to the depth of the analysis. The literature shows that energy use in the private sphere is deemed to be doubly invisible and, therefore, hardly facilitates cognitive dissonance. It was argued that energy behaviours are hard to change, as they typically constitute long-lasting habits. Behaviours that address System 2 (reflective and deliberate) are suitable to be explained by the TPB, but if habits (System 1) are analysed, then the association between intentions and behaviour is rather weak and habitual behaviour is a better predictor of energy behaviour. This study offers a novel approach by combining the TPB with a focus on (hidden) energy poverty in both retrofitted and not-retrofitted buildings. A retrofit can present a "window of opportunity" for behaviour change as it disrupts habits because environmental cues no longer exist that trigger the habit. It can lead to either increased or decreased energy consumption. Chapter 12 uses structural equation modeling to further understand the relationships between factors affecting energy behavior.

4. Methodology

This chapter describes the methodological tools employed in this thesis to answer the research questions. The overriding aim of this study is to evaluate household energy poverty with primary survey data by improving identification of hidden energy poor. Therefore, this chapter serves the following purpose. It shall provide the understanding of the reasons how and why social housing residents in Vienna have been chosen as a particular case study. It describes how the quantitative research was designed, and how the data in social housings in Vienna was collected. A detailed presentation of methods, used statistical techniques of how the data was analysed and interpreted, is given.

This methods chapter is composed of four themed sub-chapters: the *first* sub-chapter explains the rationale behind the case selection of retrofitted and non retrofitted social housings in Vienna. The second chapter lays out the retrofitted and not retrofitted social housings sampling strategy. Sub-chapter *three* introduces the survey questionnaire, followed by relevant quantitative methods that are utilised in the thesis. Sub-chapter *four* concludes by outlining the anticipated ethical considerations in the study.

4.1 Social Housing in Vienna and the Selection Process

This section serves to introduce the rationale for selecting social housing residents in Vienna, Austria as a research setting. Social housing provides secure and affordable homes for households who have difficulties in affording market prices through subsidised and regulated (sub-market) rents. Because it represents approximately 12% of the overall European housing stock, adopting energy efficient retrofitting measures in social housing represents an important step in the goal of decarbonising the residential housing segment in Europe (Hafner et al., 2020). Within this context, Austria represents an important case since it accounts for approximately 23% of Europe's overall social housing stock (Whitehead and Scalon 2007). Much of Austria's social housing is concentrated in the capital of Vienna.

'Wiener Wohnen' is a city-owned housing association that provides approximately 220.000 homes to approximately 500.000 people with housing in Vienna (Wiener Wohnen, 2021). Almost one in every four inhabitants in Vienna lives in a social housing owned by the City of Vienna. It is the biggest publicly owned municipal housing association in Vienna. According to Hafner et al. (2020), social housing tenants are a societal group that is often overlooked in behavioural change research, although it is an interesting case study because more often low-income, low educated, unemployed, pensioners, and disabled individuals- groups of people that have higher likelihoods to be affected by energy poverty live in social housings (Caballero and Della Valle, 2021; Schaffrin and Reibling, 2015). Retrofitting this building segment has some advantages over other forms of accommodation:

- Increasing energy efficiency of social housing is a preventive long-term public policy measure to increase well-being and health (Charlier et al., 2019; Reeves et al., 2010).
- Social housing has a single owner and features energetic underperformance (Beagon et al., 2018). Social Housing Operators are well established institutionalised players that are specialised in housing management. As they manage a large housing stock over a very long period, there is a strong incentive for them to reduce future operational and maintenance costs (Milin and Bullier, 2011).
- Social Housing Operators have an explicit social/ public goal and are committed to the public good with a long-term view to guaranteeing affordable housing quality.
- Social Housing Operators have high decision-making capacity and the ability to reach a very large number of dwelling blocks (and non-detached housing).
- A well-maintained, energy efficient building stock lasts longer and is future-proofed against energy price increases (Crilly et al., 2012). Compared to the private sector, companies are commissioned and involved that have built up a high level of project management repertoire and expertise. Installation of new technologies most probably is carried out more effectively and successfully compared to privately owned or rented accommodation (Walker, 2008).

The decision to conduct a survey of social housing in Vienna was made based on rational and pragmatic reasons:

- Wiener Wohnen is the biggest housing provider in Vienna and it is characterised by a large spread throughout the entire city to counteract segregation.
- Open Data Austria provides a plethora of information on the substance of the dwellings for the selection of the social housing units (Open Data Österreich, 2021): year of construction of the building; beginning and end year of retrofit, retrofit measure; street name of the dwelling/block; number of apartments in a building.
- Housing problems are more often experienced in social housings compared to owner-occupied dwellings (Pevalin et al., 2008).
- Several interviewed experts stressed the importance of the social housing sector to be the most feasible option to retrofit on a wider scale and implement EU requirements.

- The European Renovation Wave advises MS to target and prioritize the social housing segment to implement energy efficiency measures and tackle energy poverty at the same time (European Commission, 2019i, p. 10).

4.2 Primary Data Collection and Sampling

The primary data analysis employed computer-assisted web interviewing (CAWI) and pen-and- paper personal interview (PAPI) questionnaire distributed to a random sample of 6,500 social housings residents in the city of Vienna. To ensure representativeness and adequate geographical coverage around the city, an equal number of houses was sampled from every district. In order to analyse how retrofitting affects different household behaviours, 2,750 questionnaires were sent to not-retrofitted housing and 3,750 were distributed among retrofitted dwellings. An over-sampling of the retrofitted dwellings was decided because it was anticipated that households from the not-retrofitted sample are more prone to answer the survey because they more often experience housing faults and see the survey as means to articulate and communicate wishes or annoyances. Data was collected between July and October 2019. Following the literature review and the expert interviews, a pre-selection was made for buildings constructed between 1945 and 1980 due to the energy inefficient building ratings in Austria (Lang, 2007; Umweltbundesamt, 2018).

Social Housing Dwellings in Vienna	**1,747 Buildings 218,950 Dwellings**	
Selection	**Retrofitted**	**Not-retrofitted**
Total	1,050 buildings 168,965 dwellings	696 buildings 49,985 dwellings
Between 1945-1980	607 buildings 109,392 dwellings	325 buildings 23,855 dwellings
Dwellings that underwent a retrofit in the past 5 years (2014 – 2018)	53 buildings 11,465 dwellings	-
Final selection	**26 buildings 3,500 dwellings**	**34 buildings 2,500 dwellings**

Table 5 Selection Procedure of the Social Housing Buildings for the Case Survey (Source: Open Data Österreich, 2021).

There are 1,747 buildings with 218,950 dwellings of social housing units managed by Wiener Wohnen. For the predefined selection criteria of buildings constructed between 1945 – 1980, the sampling frame[41] comprised 325 buildings with 23,855 not-retrofitted dwellings and 607 buildings with 109,392 retrofitted dwellings (see Table 5).[42] The final sample comprised 26 retrofitted buildings with 3,500 dwellings and 34 not-retrofitted buildings with 2,500 dwellings, with an equal geographical spread around Vienna (see Figure 13).

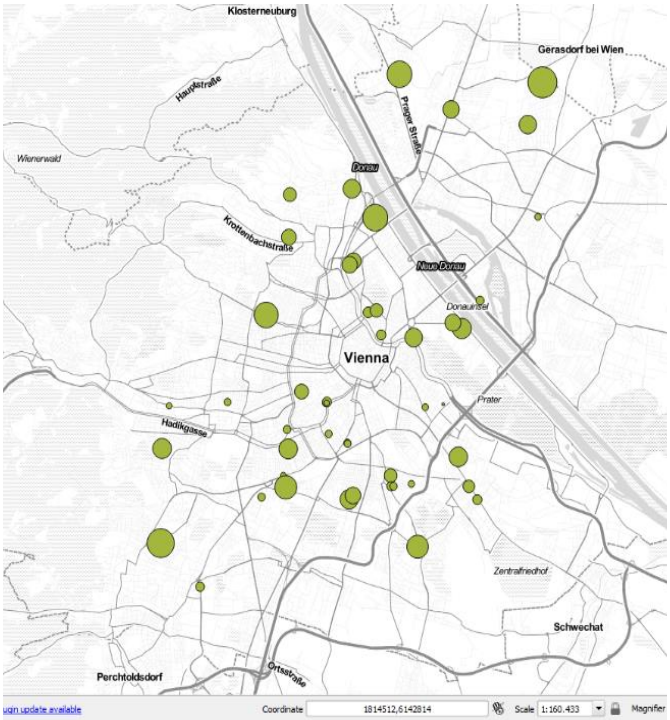

Figure 13 Selection of Social Housing Units in Vienna (Source: GIS, kindly provided by Michael Friesenecker).

4.2.1 Social Housing Survey in Vienna

Following guidelines suggested by Ajzen (2006) on TPB questionnaire construction, the instrument for this study was developed on review of relevant literature about energy poverty, energy behaviour and pro-environmental behaviour. Questionnaire development followed the basic rules of questionnaire design (Bradburn et al., 2004). The retrofitted and not-retrofitted questionnaires differed, as the former contained additional questions about the retrofit. The questionnaires contained several thematic sections:

1. The first section of the questionnaire focused on introductory questions concerned with the dwelling (square meters, moving in year; energy counselling).
2. The second part contained questions concerning heating, energy and rent costs, housing problems and questions on the heating systems (and retrofits).

41 Sampling frame is the "set of the target population members that has a chance of being selected into the survey sample" (Groves et al., 2009, p. 45).

42 An excel code was written to distinguish what kind of retrofitting improvement(s) each building underwent. The possible options were: façade renewal including a thermal insulation system, rooftop insulation; renewal of windows, doors and renewal of the heating system.

3. Item batteries make up the largest part of the questionnaire. Psychological constructs (e.g. attitudes, perceived behavioral control, social norms, behavioral intentions), behavioral change and heating habits constituted the core of the item batteries.
4. One open-ended question was included to give the residents room to express their views – whether critical or positive- about the current state/ condition of the building (see responses in the Appendix E).
5. The last part of the questionnaire contained personal households data, such as the street name[43], socio-demographic and socio-economic questions, the number of hours spend at home per day, sensitive data on important life events, and household's income.[44]
6. The end of the survey contained the data protection statement.

Content Validity of the Questionnaires

Content validity refers to the degree to which the test reflects all the dimensions of the concept in question.

- A *prima face* assessment of validity was made by seeking feedback from groups of experts that reviewed the pilot survey instrument. Once drafted, the questionnaire was discussed with the project partners, with students from the University of Vienna[45], and members of the Institute of Sociology, who provided refined feedback to the questions selected for the survey.

- Three pre-tests were conducted for the purpose to identify unforeseen problems with the survey and gain feedback from participants (first paper questionnaire and second the online questionnaire):

1. A web-based questionnaire pre-test with students was carried out.[46] A convenience sampling was utilised because of the easy accessibility (Yu & Cooper, 1983, p.37). In a first step, students in two empirical methods courses filled out the online pre-test of the questionnaire (~ 55 students). In a second step, students were instructed to let their friends and family take part in

43 In order to match open accessed data to compare when the retrofit took place, what measurements have been done, and when the building was constructed.

44 The survey participants were given the opportunity to opt into a lottery for a chance to win an incentive prize and/or to participate in a follow-up survey. Incentivation was offered in the form of gift vouchers (100 x prize of €25) redeemable at various shops and supermarkets (Sodexo) in Austria. If respondents expressed interest by answering "yes", they were required to provide their contact information.

45 The project was utilized as a case study in "Research Practice 1: Researching the interplay between environmental and social policies" (LV-Nr. 230033) during the summer term 2019, at the Department of Sociology of the University of Vienna, held by Y. Kazepov, K. Eisfeld and E. Mocca and Research Practice 2: Researching the interplay between environmental and social policies" (LV-Nr. 230033) during the winter term 2019/2020 held by K.Eisfeld and by E. Mocca. Moreover, the distribution of the online questionnaire of the project was used as a case study in "Empirical Social Research" (LV-NR. 230014) during the summer term 2019, at the Department of Sociology of the University of Vienna, held by the author.

46 The survey was administered through the Limesurvey online tool (https://www.limesurvey.org/).

the survey. Some spelling mistakes, filter setting problems, and data entry errors were improved and solved. The pre-test compromised 154 valid responses and students presented the first results in the seminar. After the pre-test, the questions were changed as required until the items were no longer vague or in need of clarification.[47]

2. A face-to-face pre-test with 20 social housing inhabitants (10 retrofitted and 10 not retrofitted) was carried out. With the input of the inhabitants, suggestions were included (questions were dropped, and some added).

3. The final questionnaire underwent an in-depth pretested again with 20 students from the research practice seminar to complete both questionnaires.

The distribution of the 6,000 printed questionnaires started on the 06.06.2019 and took place with the assistance of students from the research practice seminar from the University of Vienna.[48] In case some households provided access to their housings, possible biases (e.g. response biases) were critically discussed in the seminar beforehand. All data were treated confidentially and respondents' anonymity was preserved. To avoid disturbance when entering the buildings in groups of three, the students received badges with their names and logos of the University of Vienna. General keys (z- keys) to enter (most of the) social housings were given to the students to provide them with uncomplicated access to the post boxes.

During the summer, I distributed remaining questionnaires and conducted some further interviews. On average, respondents took between 10-15 minutes to complete the online survey. The results of the online survey were downloaded into an excel file, which constituted the master data file where the postal questionnaires were entered afterwards. Survey data was analysed with STATA 15.1.[49]

4.2.2 Variables Overview in the Social Housing Survey in Vienna

The items from the psychological instruments have all been self-constructed and inspired by predominantly qualitative energy poverty research literature and expert interviews. The central variables of the TPB and habits were assessed based on a 4-point Likert scale ranging from 1- "strongly agree" to 4- "strongly disagree". As the behavioural variables have categorical values, they have been re-categorised in most cases to binary variables, indicating the presence or

47 Factor analysis was performed and questions with low factor loading were excluded to limit the amount of survey items.

48 The students were trained by the researcher prior to data collection and a distribution plan was provided.

49 The questionnaires can befoundin the Appendix E.

absence to the statements. In order to avoid exhaustion of the respondents and reducing response style bias, a commonly used practice is “item reversal” (Weijters et al., 2013).[50] Response style bias is a thread to the validity of self-reported constructs. This was achieved by using an antonymic expression[51] in the item formulation (less use of negations such as “I do not consider myself as an environmentally friendly person), particularly in the behavioural items (Swain et al., 2008).

During data transformation, when necessary, behavioral and psychological item scales were semantically converted in order to keep a consistent response format. Agreement to the item then corresponds to a positive environmental dimension. However, inconsistencies during data analysis were encountered, which leads to the assumption that some semantically reversed items overburden the respondents. Items that measure the latent constructs of the TPB shall point to the area of interest and ask respondents about their actual behaviour. To avoid inconsistencies and misunderstandings during the formulation of the items, general queries, such as *broad* environmental attitudes, were avoided and detailed questions that pointed to concrete heating and self-restricting behaviours were formulated.

Biases and Influence of Social Desirability

Social desirability describes a person's tendency to not respond honestly to sensitive issues or questions, but in a way that puts them in a favourable light. Individuals thus provide responses to achieve a better social impression of themselves or to reduce cognitive dissonance (Kaiser et al., 2008; Seebauer et al., 2017). For instance, in self-reports, an individual could present him/herself as more environmentally friendly than he/she actually is. Heating behaviour responses might be especially vulnerable to social desirability bias as some behaviours potentially describe/ expose respondents as low-income households who avoid high utility costs. The problem of shame and self-stigmatisation has already been outlined in relation to energy poverty in previous studies (Grossmann and Trubina, 2021; Reid et al., 2015). Households might be reluctant to uncover these sensitive behaviours as they might feel ashamed or inferior when providing such information.

50 It is the tendency to agree to statements without paying enough attention to the content.

51 For example, for the item ”Before I turn on the heating, I put on a pullover“ agreement corresponds to a positive environmental behaviour. Conversely, agreement to the following item “I'm heating as much as it is comfortable without paying attention to the costs” indicates a negative environmental behaviour and was accordingly recoded so the direction of all items follow the same direction of content.

Research surrounding the extent of social desirability for environmental issues has produced mixed findings, but suggests the existence of a small social desirability correlation ranging from 0.06 to 0.11 (Vesely and Klöckner, 2020). Although it is common practice to use self-reported behaviour as a proxy measure for actual behaviour, result therefore might be biased (Chao and Lam, 2011; Kormos and Gifford, 2014; Seebauer et al., 2017; Vesely and Klöckner, 2020). Individuals might systematically exaggerate their behaviour or reversely downplay their actual behaviour to answer consistently or in a manner that conforms to what they believe to be culturally anticipated “normal behaviour”. It is, however, difficult to the eventual extent of social desirability bias or its effects on responses, since "true", unadulterated behaviour was not measured.

Forced Choice or Not?

Likert scales are one of the most used psychological scaling methods and research results have not agreed on the best (length of) rating scale. In this quantitative study, item batteries with the constructs of the TPB contained forced choices. Including or leaving out a middle/neutral point in Likert scales has a long, controversial history (Kreitchmann et al., 2019; Ray, 1990). During the pre-test with social housing residents, a 4-point Likert scale and 5-point Likert scale questionnaires were provided to the respondents. Encouraged by the pilot study, respondents clearly preferred four rather than five options to choose from. During the face-to–face interviews with the social housing residents, several respondents critically pointed out and asked about the meaning of the middle category. Although some researchers clearly state that it is unethical not to offer a middle option, it was deemed appropriate in this survey. Also keeping in mind, that when a middle option is offered to respondents, it is more often the option that is most selected (particularly if respondents are suffering with cognitive dissonance towards a topic) because of central tendency bias, what may occur in this case.

4.2.3 Demographic Profile of Respondents

In total, 412 valid cases were obtained for statistical analysis.[52] The response rate was 6.4%, with the amount of retrofitted (46.6%) and not-retrofitted (53.4%) questionnaires being almost equal and satisfactory. The low response rate possibly stems from the fact that the target group

52 The final dataset includes households that completed at least 80% of the online survey, while those with less than 80% of responses have been excluded.

was hard to reach ("hidden population") from the point of view of sampling (Atkinson and Flint, 2001). Respondents may also have forgotten the answer the survey or lacked incentives for completion. A further contributing factor in depressing the response rate may be linked to the fact that respondents had to return proactively the envelope back to the post offices.

Compared to the overall Viennese population, the sample includes a higher share of women (sample: 66.2%; Vienna: 51.2%), pensioners (sample: 48.6%; Vienna: 16,5%), and households disposing of only means-tested minimum income or unemployment benefit (sample: 18.7%; Vienna: 11.7%) (Stadt Wien, 2021a, 2021b). The sample is characterised by a large proportion of low-income households: the equivalised median household income in the study amounts to €1.133 per month, while in the Austrian population it was €2.213 per month in 2019 (Statistik Austria, 2021a). On average, households live in buildings constructed between 1951 and 1960 and -excluding kitchen and toilet - households have on average 2.6 rooms. On average, households pay 6.6€/m^2 rent. Appendix B (Table 42) contains a summary of respondents' demographic characteristics.

4.2.4 Data Revision and Data Cleaning

In order to track down incorrect information in the interview and errors in the data entry, the data was searched for inadmissible values, inconsistent case numbers, and illogical combinations of characteristics. Three duplicate responses have been identified and deleted. Consistency checks of approximately 10% of the paper questionnaires have been carried out randomly to check for keying errors during data entry. As some questions have not been answered and contain missings, figures and tables may not always sum up to 412 responses. Item non-responses are coded as missing and are not included in data analysis. All extreme cases for the cost variables (fuel, electricity, and rent costs) have been double checked with the paper questionnaires to ensure they were not incorrectly reported during data entry.[53] An initial descriptive analysis using scatterplots revealed outliers for the variable of heating costs.[54] The following plausible but not exhaustive reasons may account for these outlier values:

- households have extremely high heating costs,

53 One not-retrofitted household was identified as an extreme outlier that had abnormally high heating costs of €600 per month. For this case, the median heating costs of the not-retrofitted sample conditioned on the heating system was imputed.

54 In STATA, the syntax 'extremes var,iqr(1.5)' was utilized to detect the outliers.

- respondents did not read the instructions attentively and provided the yearly/ quarterly instead of monthly expenses for heating (as this is commonly provided billing procedure in Austria),
- households misinterpreted their heating expenses, or
- households did not take the survey seriously.

4.3 Quantitative Methods - Data Analysis Procedures

The thesis employs several quantitative methods to test hypotheses and uncover patterns in the survey data. An initial overview of the data is provided using descriptive measures, such as frequency tables, cross tabulations and summary statistics with means, standard deviations and correlations. Several statistical tests were also performed. The Shapiro–Wilk test was utilised to evaluate the degree of skew in the distributions of several variables. The Spearman correlation coefficient was calculated to evaluate the correlations between variables. This test is appropriate as it can be applied to non-parametric and ordinal data. It measures a linear dependence between two variables (x and y) and it ranges from -1 to 1. The closer r is to +1 or -1, the more closely the two variables are related, with values of 1 and -1 indicating a perfect association. If *r* is close to 0, it means there is no relationship between the variables. Correlation coefficients between 0.1 and 0.29 represent a small association, whereas values between 0.3 and 0.49 are considered moderate/ medium, and correlations greater than 0.5 are considered strong (Cohen et al., 2002; Cohen, 1988). To test hypotheses and corroborate the results from the descriptive statistics, inferential techniques are also utilised. An *a priori* significance level of $p < 0.05$ is used in this thesis to reject the null hypothesis.[55]

4.3.1 Optimal Sample Size?

Green (1991) suggested the following formula to calculate the minimum sample size for multiple regressions: $N \geq 50+8k$ where k is the number of predictors (if the researcher is only interested in the multiple R^2).[56] If beta weights are of interest, the recommended formula is $N \geq 104 + k$. Referring to the formula, the sample size has to contain at least 130 observations for 10 covariates (50+ 8(10) = 130) for the first formula, and 114 observations, respectively

55 For each of the presented results from the tests, the significance value is stated with in the presented tables, using the symbols ***, **, * which denote a significant difference at the 1% ($p < 0.01$), 5% ($p < 0.05$), and 10% ($p < 0.10$) level, respectively.

56 Formula is calculated for a medium effect (R2=.07; β=0.2).

(104+10). Other authors suggested having at least 5 observations per independent variable as a rule of thumb if the distribution is normal and 10 if it is not (Bentler and Chou, 1987; Ho, 2014). Schumacker and Lomax (2016) also recommended a sample size ranging from 10 to 20 observations per variable. Power analysis was used to determine an optimal sample size with a confidence ratio of 95% and a power of .80 for each of the independent predictor variables to reject the null hypothesis. The results indicate a target size of 193 households (two tails; correlation = .20; $\alpha = .05$; power $= .80$). Therefore, between 200 and 300 respondents are needed to have an optimal sample size for regression analysis. Taken together, 412 respondents are a sufficient number of cases to model multiple regressions and reaching statistical significance. However, if the analysis concerns only the retrofitted sample, sample size might not be sufficient and covariates need to be reduced to estimate stable results because sample size was 192 observations.

4.3.2 Latent Class Analysis

The aim of employing Latent Class Analysis in this study is to introduce a novel approach for identifying hidden energy-poor households in Austria by differentiating between distinct groups of households exhibiting self-restrictive behaviors. Latent class analysis ("LCA") is a parametric model-based clustering technique that classifies people to subgroups (latent classes). LCA allows to draw conclusions and to generalise to the population from which the sample is drawn (in this case, social housing residents in Vienna in not retrofitted dwellings). LCA is particularly useful in capturing complex constructs when multiple behaviours are measured. With this statistical technique, the assumption is tested whether there are groups in a population which we can distinguish from each other. It is commonly used in an explorative manner to identify unobserved heterogeneous subpopulations based on a set of observed survey items (Collins and Lanza, 2010). It allocates individuals into mutually exclusive and exhaustive subgroups, each comprising households similar to members of the same subgroup and dissimilar to households in other subgroups.

The LCA resembles to factor or cluster analysis, where observed/ manifest responses to items are used to extract latent classes, so that classes are built on identical preferences and similar response patterns within classes. Hence, each household probabilistically belongs to one class based on the highest likelihood. In contrast to variable-centered regression analysis, LCA is a person-centered technique that assumes the existence of distinct classes within the population and identifies common attributes shared by households within the same class, instead of focusing on associations between attributes. This is a clear advantage compared to regression analysis, which assumes a single homogeneous population (Sevenant and Antrop, 2010).

Given that energy poverty is not a uniform or homogeneous phenomenon, LCA is a valuable approach to differentiate between different groups or classes within the population. This is supported by the energy poverty literature, which emphasizes the diversity and complexity of energy poor households. LCA allows for the identification of distinct classes or groups of households with similar characteristics or behaviors, which can provide valuable insights into the heterogeneity of energy poverty and help tailor interventions and policies more effectively to address the specific needs of different groups. This method has been utilised in environmental, social science research on climate change opinions (Crawley et al., 2020), climate change scepticism (Sibley and Kurz, 2013) and environmental concern (Rhead et al., 2018), but, to the best of my knowledge, only twice in energy poverty research (Llorca et al., 2020; Robinson et al., 2018b).

LCA holds several methodological advantages over common cluster analysis: it is probability-based, which enables to allocate households to the cluster to which they most likely belong to, and it is not sample dependent, meaning that results can be replicated in other samples. Magidson and Vermut (Magidson and Vermunt, 2004) showed that LCA clustering outperforms the K-mean algorithm. Moreover, it allows for missing responses on items; it does not rely on scaling and measurement assumptions (e.g., linear relations, normal distribution, homogeneity) and flawed questionnaire items can be identified (high standard errors). Another advantage is that LCA is less subjective than cluster analysis as goodness-of-fit criteria allow comparing model solutions with different numbers of classes: the minimum Akaike Information Criterion (AIC), the minimum Bayesian Information Criterion (BIC) and the sample-size adjusted Bayesian Information Criterion (SSABIC). Smaller model fit values indicate a better model fit and model parsimony. However, the BIC is considered the most reliable for obtaining parsimonious models (Morgan, 2015; Nylund et al., 2007).

In the thesis, model estimation is terminated if, by increasing classes, models either turn under-identified or convergence issues arise. Model convergence issues are widely experienced in LCA caused either by poor starting values of parameters, mis-specified models or under-identification. Under-identification is avoided by using not less or equal but greater numbers of items than classes. With five binary items and two classes, there are seven degrees of freedom.

With only four parameters and three classes (d.f.: 7), the model is just identified (MacCutcheon, 1987).

LCA uses maximum likelihood (ML) to estimate the parameters and the expectation maximization (EM) algorithm finds the ML estimates.[57] It is a difficult computational task to maximise the likelihood through ML estimation because of the presence of multiple local maxima and the lack of concavity (Tekle et al., 2016). Hence, the model sometimes does not converge at a global maximum. It is important to estimate the models in LCA several times with different starting values of parameters to avoid local maxima. Furthermore, it is necessary to establish criteria for stopping the iterative estimation algorithm because otherwise the procedure could continue indefinitely. Two criteria are essential: the maximum number of iterations and the stopping rule to determine when the search for the maximum likelihood is stopped (Collins and Lanza, 2010).[58]

In practice, the decision on the optimal number of classes also considers theoretical meaning, model parsimony, conceptual interpretability, and classification diagnoses, such as class homogeneity and class separation (Matthies et al., 2006). High class homogeneity implies that for an item, households in the same class are likely to respond similarly to the item, indicated by item-response probabilities close to 0 or 1, but not middle response probabilities. Item probabilities >.70 (high endorsement probability) and <.30 (low endorsement probability) are set as benchmarks for a high class homogeneity (Masyn, 2013). The degree to which the classes are distinguishable from each other is called class separation. A low class separation is present if, for instance, two-class solution estimates for a specific item an item-probability of .90 in class one and an almost equal probability of .80 in class two. Although it indicated a high class homogeneity (>.70), the separation between the two classes was poor. Overall, researchers should also holistically consider how well each item contributes to class separation (Nylund-Gibson and Choi, 2018).

LCA assigns households to classes based on their observed response patterns. Using several items ensures that the latent construct is captured with sufficient depth. However, five coping

57 In the beginning, the EM algorithm randomly splits the cases into a defined number of classes assuming that we have the information about classes, then- based on improvement criterion known as the global maximum (ML) - it reclassifies until the best classification is found. This step consists of the maximization of log-likelihood function. This procedure can be repeated using different starting values.

58 In an ideal scenario, the estimation algorithm will converge on the global maximum solution -the parameter values associated with the single largest log likelihood. The existing LCA algorithm cannot distinguish between a global maximum and a local maximum of log likelihood. In order to avoid local maximum solution, it is advised to keep the number of latent classes as few as possible and to test multiple random start values. After some trials, if all runs converge to the same solution, we can accept it as the global maximum.

items with a four-step response scale each would amount to 4^5=1024 response patterns. Sample size is too small that each response pattern could be observed at least once in the data. Therefore, items are recoded to binary variables, bringing down the number of response patterns to max. 2^5=32. Recoding to binary variables also avoids potential difficulties in estimation, which are more likely to occur with a larger range of response categories (Collins and Lanza, 2010; Masyn, 2013).

In the best-fitting model, posterior class probabilities are calculated to indicate each household's probability of being in each of the latent classes based on the parameter estimates and the household's item responses. A further classification diagnostic is the household's average posterior class probability: it provides information about how well a model classifies households to their most likely class, in other words, its classification uncertainty. The minimum criterion for acceptable class membership classification is an average posterior probability of >.7 (Nagin, 2005). A probability close to 1.0 indicates a low likelihood of misclassification of a household. In the best-fitting model, posterior class probabilities are calculated to indicate each household's probability of being in each of the latent classes based on the parameter estimates and the household's item responses. A binary variable then indicates the class membership of each household to the respective class, where this household shows the highest class probability.

4.3.3 Structural Equation Modelling

In this study, the structural equation modeling (SEM) technique will be utilized to test the proposed integrated theoretical framework, which incorporates the Theory of Planned Behaviour (TPB) and the concept of habits from the Dual Process approach. This aims to contribute to the understanding of the connection between (hidden) energy poverty and pro-environmental behavior. SEM is a robust statistical technique that allows for the testing of complex relationships among multiple variables, making it suitable for examining the proposed integrated theoretical framework and testing hypotheses related to energy behavior in the context of (hidden) energy poverty and not retrofitted and retrofitted buildings.

SEM is a multivariate statistical method that describes relationships among multiple variable by combining factor and regression analysis. Unlike in linear or logistic regression, in SEM a construct can be a dependent and independent variable and observed or unobserved in one relationship (Schreiber et al., 2006). Also multiple dependent variables can be estimated simultaneously (Tabachnick and Fidell, 2019). SEM is utilised to confirm the theory presented in chapter 12. Hence, SEM is chosen because a priori theoretical knowledge and hypothesis existed. Relationships among *exogenous* (independent) and *endogenous* (dependent) variables were assessed (e.g. attitudes → intention). Factors that are influenced by other factors in the model are called endogenous factors (η). They are not influenced by other factors in the quantitative model. In the example, energy behaviour and intentions are endogenous factors. Factors that only have an influence on other factors, but are not themselves influenced, are exogenous factors (e.g. social norms).

SEM was conducted employing the two-step modelling approach (Anderson and Gerbing, 1988; Pentz and Chou, 1994). Path models contain a *structural model* (inner model) and a *measurement model*, which describes the relationship between the latent variables and their measures. In the first step, the *measurement model* specifies the relationships between the measured (observed) variables to their hypothesised latent constructs. This proceeding includes Confirmatory Factor Analysis, in which factor loadings, goodness-of-fit, validity and reliability are assessed. After the model fit of the measurement model is calculated, if needed modified and evaluated, hypothesised relationships among the latent factors are tested in the second – structural- step. If a SEM includes only the structural model, it is also called path model, and if only the measurement model is included, then it constitutes a Confirmatory Factor Analysis.[59]

Typically, SEM includes the following steps: model specification (hypotheses and model identification), data preparation, model estimation, evaluation, and model modification (Hoyle, 2015; Kline, 2005; Tabachnick and Fidell, 2019). A fundamental step in SEM is model identification, in which each parameter in a specified model must be identified and produce a set of parameter estimates (Kline, 2005). In order to determine whether the model is under-identified, just identified, or over-identified, the number of data point must be compared to the number of estimated parameters. The formula is $p(p+1)/2$, where p is the number of measured variables. If the number of data points equals the number of parameters to be estimated, then the model is "just identified" or "saturated". If there are fewer data points than parameters to be estimated, than the model is "under identified." Here, the parameters cannot be estimated, and the researcher needs to reduce the number of parameters to be estimated by deleting or fixing them. If the number of data points is greater than the number of parameters to be

59 A mathematical formulation is dispensed in this thesis. Please refer to the relevant literature for further information Aichholzer (2017); Arzheimer (2016); Backhaus et al. (2016); Jöreskog (1978); Kline (2005).

estimated, the model is “over identified”. If the model is over identified, it is possible to proceed with model analysis. To achieve identification, two solutions can be utilised: one of the indicators is fixed to one or the variance of the latent variable is set to 1 (the latent variable is viewed as standardised) (Arzheimer, 2016). The researcher has to make sure that in the measurement model a latent construct contains enough, usually at least two indicators (observed items) and those indicators errors are uncorrelated (Bollen, 1989; Kline, 2005).

In the structural model, estimated relationships among the latent variables are shown as path coefficients, which are the same as beta weights coefficients, like regression coefficients. Effect sizes of the direct and indirect path coefficients were examined. Also, standardised values of these path coefficients are included. They range between 0 and 1, whereby 1 indicates a perfect relationship, 0 implicates no relationship between these underlying latent factors. Standardised coefficients less than 0.10 were small, those larger than 0.30 were moderate, and coefficients larger than 0.50 were considered large (Kline, 2016).

SEM should not be used in an exploratory manner. Instead, after content-related considerations and previous studies, a model structure must be adopted a priori that applies to a data set and supported or refuted by it. Various fit indices indicate how well a model structure fits the data. The relationships between the variables in the structural model are assessed regarding the criteria of significance, direction of effect and strength of the effect and compared with the hypotheses. The critical values for fit indices were determined by convention.

4.3.4 Goodness-of-Fit indices

In a usual scenario, the effects of constructs cannot be measured directly, instead latent, and not directly observable factors are measured through several observable indicator variables, which reflect the latent factor. The measurement model in SEM defines the relations between these latent variables and its observed indicator variables (items).

One of the most critical stages is the validation of the overall model. The aim of the assessment is to see if the defined model proves an adequate fit to the data. The data should be rejected or modified. Several indices have been developed to evaluate the models (see Table 6). Critical values for the fit indices reported in this study are distinguished between absolute and incremental (relative) fit indices: absolute fit measures provide an indication of how well the proposed theory fits the data, while incremental fit indices compare a simpler (null) model to the hypothesised model.[60] The Chi-Square Test, Absolute Fit Index, The Root Mean Square Error of Approximation (RMSEA), The coefficient of determination, The p of Close Fit (PCLOSE), Standardised Root Mean Square Residuals (SRMR), Incremental Fit Index, Tucker Lewis Index, Comparative Fit Index (CFI), Comparative Fit Index (CFI) are indices that will be used in the thesis to evaluate the goodness-of-fit of the models.[61]

STATA has the option of calculating modification indices. This offers remedies for discrepancies in a proposed and estimated model. The model can be improved by adding new paths that are theoretically sound to increase its explanatory power. Modification indices specify how much the chi-square value of a model drops if the parameters were free instead of constrained. Usually, model fit can be improved substantially by allowing the error terms to be correlated.

Error terms were only considered eligible for co-variance if they were from the same latent factor and it is theoretically sound. To increase the model fit, in this thesis, items with low factor loadings (< 0.4/ 0.3) were deleted from the models.[62] Factor loadings are the weights and correlations between each variable and the latent factor. As attractive as it may seem to increase the fit of the data, during the modelling of the measurement and structural models, the intention was not to abuse the modification indexes (Schreiber et al., 2006). The key question to remember is whether they is a good theoretical reason to let errors correlate. This question guided the modification step. Table 6 summarises the applied goodness-of-fit indices in this thesis.

Goodness-of-Fit Indices	Criterion Guidelines
Chi-square probability level $\chi 2$	P >.05 (insignificant results)
Absolute Fit Measures	
Root mean square error approximation (RMSEA)	<.10 (<.08)
PCLOSE	Close to 1
Standardised Root Mean Square Residual (SRMR)	<.08
Incremental Fit Measures	
Comparative fit index (CFI)	>.90
Tucker Lewis Index (TLI)	>.90
Average Value Explained AVE (in Confirmatory Factor Analysis)	>.50

Table 6 Goodness-of-Fit Indices
Source: Byrne (2001) Hooper et al. (2008) Kline (2005) Tabachnick and Fidell (2019).

60 It should be noted that goodness-of-fit indices are useful to guide the research, but they should be evaluated regarding substantive theory.

61 Please see Table 48 for more details.

62 Setting the coefficients of paths to be equal or fixing the coefficients of paths to a certain value was waived.

Maximum likelihood was assessed as the estimation technique most suitable for this study as it can withstand violation of normality and it is recommended if the Likert scales are 4 or greater (Arzheimer, 2016; Jöreskog and Sörbom, 2001; Kline, 2005; Olsson et al., 2000). With not perfectly normally distributed or ordinal, but quasi-metric indicators, Finney and DiStefano (2006), Urban and Mayerl (2014), and Aichholzer (2017) recommend using robust estimator by Satorra Bentler, which is a form of the ML estimation that considers deviations of the variable distributions from a normal distribution.[63] Schermelleh-Engell et al. (2003) refer to simulation studies in which ML estimation with non-normal data leads to better parameter estimates than distribution free estimation methods (in STATA asymptotic distribution free). Although the multivariate normality requirement seldomly appears to be achieved with raw empirical data (Arzheimer, 2016; Gao et al., 2008), the ordinal four point Likert scale in this study must be addressed.

There are violations of normality as Likert scales ranged from 1 to 4. Therefore, all estimated SEM models were estimated using maximum likelihood with Satorra-Bentler adjustments. This correction method relaxes the assumption for multivariate normal data by creating robustness to non-normal distributions which provides better estimates to common fit indices (including correct heteroscedasticity, and adjusts standard errors). Overall fit was determined by the Satorra-Bentler adjusted chi-square statistic that tests for comparability between the proposed model and the model in which constructs are assumed to be unrelated (StataCorp, 2019).The comparative fit index (SB-CFI), Satorra-Bentler adjusted Tucker-Lewis Index (SB-TLI), standardised root-mean square residual (SRMR), and Satorra-Bentler adjusted root-mean-square error of approximation (SB-RMSEA) were examined to determine goodness- of-fit.[64]
Unfortunately, STATA does not provide the option to utilise Full-Information Maximum Likelihood (FIML) estimation to deal with missing data in congruence with the Satorra Bentler ML. That is why a trade-off on the sample size must be made, which in some models fell below <100. Although there is no consensus on minimum sample size in SEM application, it can also be performed on a small sample size. Nevertheless, sample size depends on the number of variables used in an analysis and if there are more parameters to be estimated, larger sample sizes are required. Due to these reasons, the result should be interpreted with caution. If the

63 Unfortunately, the robust SB estimation in STATA does not allow to use ML with missing values (Full-Information Maximum-Likelihood).
64 Due to the violation of the multivariate normality assumption, all model estimations have been performed with a.) the Satorra Bentler ML estimator, b.) the Maximum likelihood estimation with full-information and c.) the robust estimation of Wolfgang Langer after the Satorra Bentler ML estimator (Langer, 2019), and quasi-maximum likelihood (QML) estimation. Afterwards, all model estimations and fit indices have been compared. In the results section, only the Satorra Bentler ML estimation results are presented.

structural path model is not overly complex and simple, Iacobucci (2010) argues a sample size of 50 to 100 is sufficient. Alongside with the Satorra Bentler estimation method, quasi-maximum likelihood (QML) which also relaxes the normality assumption when estimating the standard errors has to be employed (STATA syntax: vce(robust)) as it can be used with Full-Information Maximum Likelihood and it does not require listwise deletion of missing data (Williams et al.).[65] However, also here a trade-off must be made as this method does not provide the necessary goodness-of-fit measures. During the analysis, both estimation results were compared to further validate the model. For the sake of simplicity, results of the Satorra Bentler estimation method are discussed in the results section of the thesis. As a rule of thumb, it is recommended to us a minimum of three items per latent construct (Taber, 2018). Identification reasons are a major concern if latent constructs contain less than three items. In this study, over three items per latent construct were not available for some latent constructs inter alia, due to low factor loadings, which resulted in item exclusion (Hair et al., 2014). This circumstance may produce unstable solutions and lead to convergence issues. Nevertheless, because over two latent factors are employed in the model estimations, identification issues were not encountered.

4.4 Anticipated Ethical Considerations in the Study

Following the view that "researchers have an ethical duty to protect the privacy and dignity of those lives we study to contribute to knowledge in our scholarly fields" (Josselson, 2007, p. 537), this thesis carefully considered and took steps to avoid any potential ethical issues surrounding data confidentiality, obtaining participants consent and the potential for causing embarrassment or harm to participants at any stage of the research process. To this end, the research was conducted in accordance with the ethical guidelines of the University of Vienna. At the beginning of each expert interview, a mutual agreement was signed between the interviewee and the researchers concerning the handling and privacy of data, general confidentiality, and the participants' consent to audio record the interview. All raised questions were answered, and a declaration was given to the participants stating that all collected data, including audio recordings and written notes, were only used for research purposes. Moreover, each participant was assured that their participation would be kept confidential and that any result or quote would only be reported in fully anonymised form. For the quantitative survey,

65 The Satorra-Bentler ML analysis used list-wise deletion and it is deemed acceptable as data are missing completely at random. Because of the presence of missing completely are random, all models were also estimated with the FIML option with quasi-maximum likelihood (QML) and showed similar results as presented here with robust Satorra Bentler maximum likelihood.

all results are reported anonymously and data protection was guaranteed. Regarding the participants' identification, home addresses and email addresses were only gathered as optional fields to take part in a post-hoc study and to receive the vouchers. The postal returned surveys are kept locked storage, and will be held in the Institute of Sociology (University of Vienna) for five years as standard practice. When the students were provided with the data, personal information was excluded to guarantee anonymity.

5. Instruments for Addressing Energy Poverty in a Multilevel Governance Framework

The transition towards decarbonization, as mandated by the EU decarbonization strategy, requires a profound societal, energy, and employment transformation. This necessitates joint efforts at multiple levels of governance to effectively address this challenge. According to Benz (2021, p. 6) multilevel governance is characterised

> *"as a network-like pattern of interaction among actors representing local, regional or national governments, the European Union or international organizations including private actors like firms, associations or NGOs."*

This pattern of governance is shaped by the reallocation of powers between territorial levels, leading to increased interdependence of governments (Benz, 2021). At the international level, the Paris Agreement, a legally binding agreement by national governments to reduce global greenhouse gas emissions, has a significant influence on EU and national climate policies (Panel on Climate Change and Conference of the Parties reports efforts). The analysis of policy efforts in this chapter begins at the the European Union ("EU") level, as the EU plays a crucial role in shaping national and subnational energy and climate policies. Subsequently, national level efforts are examined, followed by the Federal State level of Vienna.

This chapter aims to present a comprehensive overview of the different instruments available for addressing energy poverty, with a particular focus on the multilevel governance framework. It will argue that cross-sectoral cooperation between political administrations needs to be coordinated at various scales through multilevel governance to effectively combat energy poverty, providing a coherent framework for action. It will highlight that adequate responses to energy poverty and climate change should not be conceived in isolation but should involve a network of joint actions taken by governments, municipalities, non-profit organizations, private households, and companies at all levels of governance.

The chapter has two main areas of investigation: *first*, it examines climate and housing policies from a European multilevel governance perspective, assessing the policy instruments in place. Second, it critically examines the complex intersections and coordination efforts related to energy poverty across multiple levels of governance (Bache et al., 2016; Kazepov, 2018) Despite the shared focus of climate and social housing policies on the housing sector, there has been limited academic attention to how these policies may (re)produce or alleviate energy poverty. Coordinating efforts between climate and social housing policies may support initiatives against energy poverty, as their targets and instruments are likely to interact. Coordinating efforts between climate and social housing policies may support initiatives against energy poverty, as their targets and instruments are likely to interact. Energy efficiency targets, which are translated into building policies, are crucial for the just transition and represent a key area where social, housing, and climate policies intersect. The central argument of this chapter is that reducing greenhouse gas ("GHG") emissions and overcoming energy poverty can be accomplished through a combination of policy measures that span various policy areas and involve a variety of actors at both horizontal and vertical governance scales. The main questions addressed in this chapter are:

- What climate and energy targets exist, and how does Austria perform in terms of the level of achievement?
- What laws currently exist to tackle energy poverty and climate change in the EU?
- Do instruments focus on short-term symptoms or long-term solutions to tackle energy poverty?

The overall structure of this chapter takes the form of five sub-chapters. Sub-section *one* will examine the key EU climate policy framework, as well as current EU and Austrian targets and achievements in terms of the three fundamental areas: GHG emissions, renewable energy, and energy efficiency. Sub-chapter *two* will then analyse in-depth the Clean Energy for all Europeans package with its main Directives and Regulations and direct references will be made to energy poverty. The goal is to evaluate their prospective short- or long-term influence, as well as barriers and drawbacks connected to climate reduction targets or lowering energy poverty rates. The subsequent section *three* will illustrate how and why the 'Renovation Wave' constitutes a core instrument to decarbonise the EU housing stock. The *fourth* sub-chapter will provide a summary of an evaluation of EU efforts in social and housing policies. Last, sub-chapter *five* summarises the analysis of the EU climate policy framework.

5.1 Key Developments in EU's Climate Policies

In December 2019, the European Council approved climate neutrality by 2050 and, in December 2020, it agreed on an even more ambitious EU target: decreasing GHG emissions from 40% to at least 55% by 2030, compared to 1990 levels. The elected European Commission president Ursula van der Leyen announced that climate policies would be prioritised, and she proposed the Green Deal to make Europe the first carbon neutral continent by 2050 (COM(2019) 640 final). The major three proposals are (European Commission, 2020e):

1. European Climate Law to achieve climate neutrality until 2050.
2. European Climate Pact to facilitate the participation on the transformation of all Europeans.
3. 2030 Climate Target Plan to achieve a reduction of GHG emissions by at least 55% by 2030.

The European Commission ("EC") has proposed the first European Climate Law (in form of a regulation), which reached a provisional political agreement by the Council and the European Parliament before going through the formal steps of the adoption procedure (COM(2020) 80 final). It constitutes a legally binding obligation to achieve net zero GHG emissions for the EU by 2050 (European Commission, 2020h).[66] It sets a trajectory for the GHG emission reductions, issue recommendations, and takes corrective actions to Member States ("MS") in case of non-achievement. In line with procedural justice principles of the Aarhus convention, Article 8a of the European Climate Law foresees broad public participation, meaning that the policy will actively seek to establish an inclusive and accessible process at all vertical multilevel governance levels and include social partners, citizens and civil society (European Commission, 2020i).[67]

The 20 proposals for the European Green Deal range from drafting a Sustainable Europe Investment Plan to the extension of the EU emissions trading system. The Green Deal also foresees an extensive Renovation Wave (COM(2020)662), which is aimed at increasing energy efficiency and helping households to reduce their heating and electricity bills, since approximately 75% of the European building stock currently does not comply with energy efficiency requirements (Rousselot et al., 2020). The political pressure on the MS from the EU to increase the sped of action is high because the renovation rates across MS are very low (approximately 1% p.a.; Member States vary from 0.4-1.2%; European Commission, 2021a). One of the main pillars addresses energy poverty and provides individual recommendations to MS (European Commission, 2020d). Solidarity and just transition aspects are an integral part

66 Unlike social policy that has no substantial legally binding ground on the EU level, the EU sets frameworks and decides legislation in the field of environmental policies (addressing environmental protection of air quality, water, waste and biodiversity), including climate policies on the basis of qualified majority (called "ordinary legislative procedure") voting of MS with the European Parliament (Delbeke and Vis, 2016).

67 In October 2020, the European Commission (2020l) proposed an amendment of the Regulation (EC) No 1367/2006 to provide environmental NGO's more far reaching possibilities to challenge acts and omissions of the European institutions in accordance with the objectives of the Aarhus Convention.

of this “leaving no one behind” philosophy. The agenda includes an Investment Plan that provides small (e.g. individual household energy renovation) and large (e.g. modernising district heating services) projects support in the shape of financial means and funds (e.g. Just Transition Fund, InvestEU’s Just Transition Scheme, and public sector loans). For instance, the Just Transition Fund is located at the local level, in a similar way to the European Regional Development or the Social Cohesion Fund, and aims to help the most vulnerable people, households and certain employment sectors that are negatively affected by the energy transition. Direct financial support from the EU to tackle energy poverty includes, inter alia, the European Structural and Investment Funds, Horizon 2020 research programs (STEP and ASSIST projects), European Local Energy Assistance facility, Smart Finance for Smart Buildings initiative supported by the European Investment Bank, and a Recovery and Resilience Facility in form of grants (European Commission, 2020n; European Investment Bank, 2019; Magdalinski et al., 2021; Tankler, 2019).

5.1.1 Current Climate Policy Achievements in the EU

The EU has set forth a series of climate targets to be achieved by 2020 and 2030. Figure 14 illustrates the structure of the EU's climate and energy framework for these timeframes, along with Austria's primary targets under the Paris Agreement. The EU is well on track to meet its 2020 GHG emission targets; however, national situations vary significantly. Between 1990 and 2019, the EU decreased its overall GHG emissions by 24%, thus beating its target of a 20% reduction (European Commission, 2020g). This positive achievement provides greater hope that, if effective and legally binding climate policies are implemented, the EU can achieve even more ambitious emission targets by 2030. For renewable energy, the minimum target of receiving 20% from renewable sources was almost met in 2019 when it amounted to 19.4% (European Environment Agency, 2020a). However, a negative trend is evidenced regarding energy efficiency (decrease either in final energy consumption or primary energy consumption), where the EU has fallen short of its 20% reduction target. Primary energy consumption should amount up to a maximum of 1.236 Mtoe and final energy consumption 907 Mtoe in 2020. The latest Eurostat data indicated that primary energy consumption in the

EU was 5.8% below the 2020 energy target and final energy consumption was 5.4% below the 2020 energy target (European Commission, 2023a).[68]

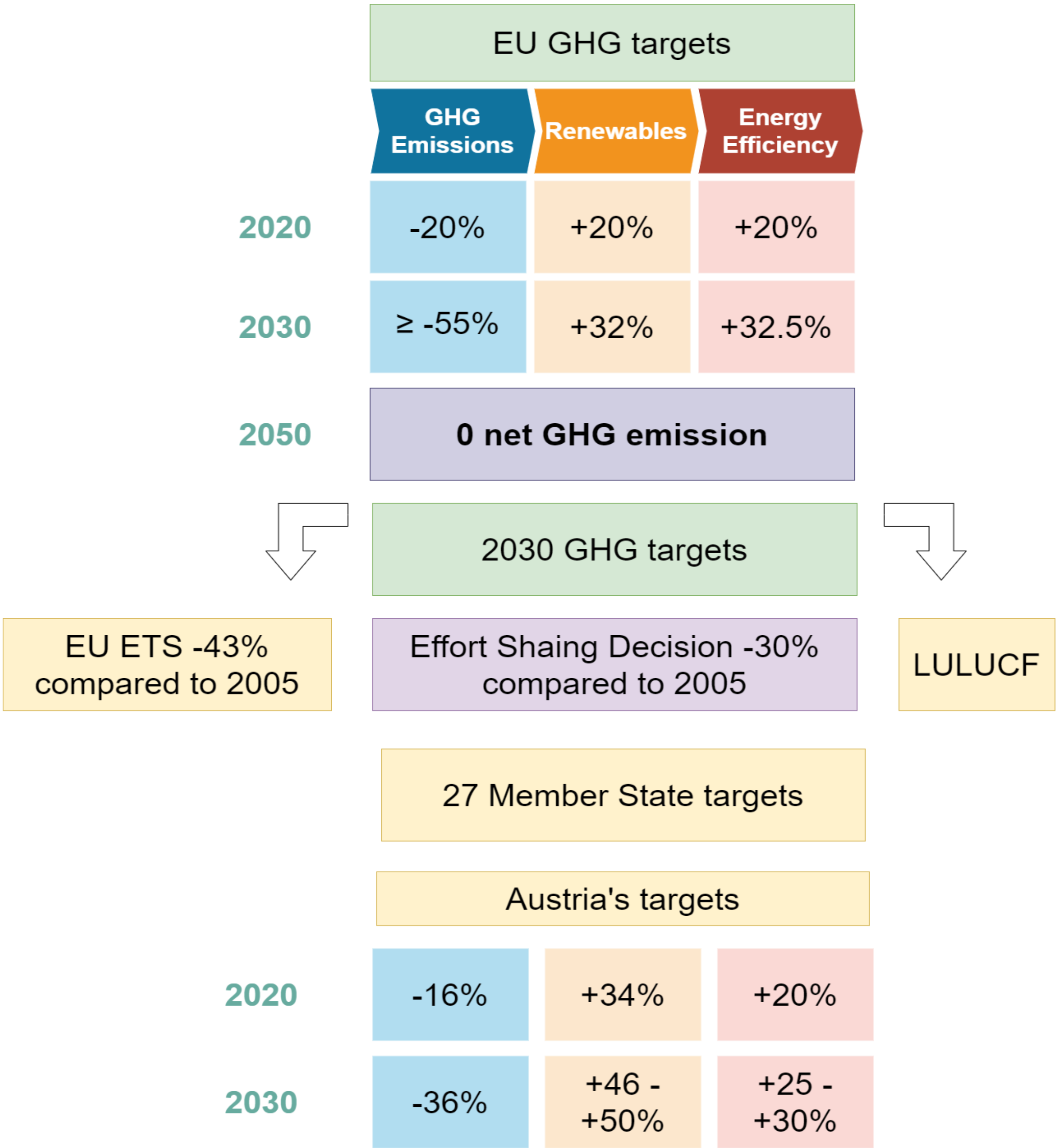

Figure 14 2020 & 2030 Climate and Energy Framework of the EU and Austrian Targets (Source: Own Visualization).

68 It's important to note that the 2020 values were greatly impacted by the COVID-19 pandemic and the nationwide lockdown measures, which caused a decrease in energy demand due to reduced overall activity.

The EU GHG emission targets are subsumed under the Climate Action Regulation ("CAR"), which is a follow-up of the Effort Sharing Decision that defined targets between 2013 and 2020. The CAR sets emission reduction targets for the next period (2021-2030) within the building, transport, agriculture and waste sectors that are not covered by the EU Emissions Trading System. The CAR, also called Effort Sharing Regulation (2018), is legally binding, contains a strong enforcement mechanism, and sets individual targets for EU countries depending on their wealth (GDP per capita) to ensure fairness. The rationale is that richer MS can take on more ambitious targets than lower income MS. The national targets range between 0% and 40% compared to 2005 GHG levels. From a legal point of view, the framework has changed from a Decision (2009) to a Regulation (2018).[69] In case a MS does not fulfil its emission reduction target, corrective measures apply, and the Commission initiates an infringement action (Peeters and Athanasiadou, 2020). While the CAR is an umbrella law that sets the general targets, it does however not prescribe how and with which measures MS should reach these targets.

5.1.2 Climate Targets and Achievements in Austria

Austria's 2030 GHG target, covered by the Effort Sharing Regulation, is -36% compared to the base year 2005 (specified in Annex I of the Effort Sharing Regulation). For renewable energy, Austria provided a range of 46% to 50% increase in renewable energy by 2030. For the sector of renewable electricity supply (national balance), it sets an even more ambitious goal than the EU: Austria aims to reach 100% renewable energy by 2030. Similarly, Austria also provides a target range for energy efficiency that is based on both best and worse-case forecasts, which aims to achieve an increase of 25% to 30% in energy efficiency by 2030 compared to 2015 levels (decreasing either final energy consumption or primary energy consumption) (European Commission, 2020c).

Despite its ambitious target, compared to other EU countries, Austria is one of the worst climate performers (alongside Malta, Germany, and Ireland). Despite predicting a 16% reduction in GHG emissions, Austria witnessed a rise of 1.8% compared to 1990, with the transportation sector being responsible for this increase (78.5 Mtoe in 1990 to 79.8 Mtoe in 2018; Environmental Ministry, 2021). Considering the sectors covered by the Climate Protection Act (non-emissions trading area), the 2019 emissions are 50.2 million tonnes of carbon dioxide

69 While EU Directives become national rules after being transposed into each country's legal frame (EU targets), EU Regulations become immediately applicable in each country, without any national transposition (European Union, 2020).

equivalent, which is around 1.9 million tonnes above the national target for 2019 (Umweltbundesamt, 2021). Austria has successfully achieved the renewable energy sources' target of 34%, with the renewable energy share reaching 36.5% in 2020 (Eurostat, 2022c). Progress in energy efficiency is expressed either through a decrease in primary energy consumption or final energy consumption compared with projected levels for 2020 in the EU'S 2005 baseline modelling scenario. Austria could not reach the target to decrease either its final energy consumption or the primary energy consumption (European Environment Agency, 2020b).

5.2 From the Third Energy Package to Clean Energy for All Europeans

Since the foundation of the European Coal and Steel Community in 1951, and the European Atomic Energy Community six years later, energy policy has been one cornerstone of European Integration. Subsequently, the Lisbon Treaty (2009) dedicated an entire chapter on the European Union's energy policy. While in the past, energy policies have been primarily a national level responsibility, the EU has gained more competences in this domain, and there is increasing public support for energy policy challenges to be handled at the EU level (European Commission, 2019f). The first endeavours to establish the EU's internal energy market were laid down in the First Energy Package (1996/1998) that aimed to remove obstacles and trade barriers, strengthen integration of the internal electricity and gas markets, and to stipulate competition in the interest of consumers (European Parliament, 2021). Energy poverty has not only been recognised recently in EU law and policy, but it was mentioned already in 2001 in an opinion document by the European Coal and Steel Community Consultative Committee and in 2002 in an European Commission Communication:

> *"In adopting appropriate measures to encourage improved energy efficiency by the domestic sector, the EU and its Member States should avoid any measures that risk exacerbating fuel poverty" (European Coal and Steel Community Consultative Committee, 2001).*[70]

In 2003, vulnerable customers were acknowledged in the revised Gas and Electricity Internal Market Directive. Finally, during the preparation stage of the 3rd Energy Package, energy poverty received legal recognition. The European Council Directive 2009/72/EC17 on the Internal Market in Electricity acknowledged the existence of energy poverty and pointed more

70 Energy poverty was primarily used by the European Commission in a 2002 Communication also concerning energy cooperation with developing countries outside of the EU and in connection to a lack of access to modern energy services, rather than highlighting energy affordability issues in developed European countries (European Commission, 2002).

than a decade ago to the fact that it is a growing problem in the EU that needs immediate action. However, coordinated EU policy packages or concrete quantitative targets addressing the issue are still absent and policy responses often referred to the principle of subsidiarity and national state responsibility (Art. 5/TEU). In invoking these principles, it is considered that national governments are in a better position to deal with energy poverty by establishing regional measures and policies.

In June 2008, members of the European Parliament adopted a text addressed to the European Commission "*to define the notion of energy poverty*" (European Parliament, 2008). Almost ten years later, several Members of the European Parliament echoed this request: "*we have to define once and for all, what energy poverty means across our Member States,*" said British centre-left MEP Theresa Griffin. Luxembourgish Member of the European Green Party Claude Turmes added, "*how can you solve a problem if you don't even agree on what is [sic] the problem?"* (Teffer, 2018). Over ten years later, considerable progress has been made: the 4th Energy Package, also known as the EU "Clean Energy for all Europeans" or "Winter Package" acknowledges and mentions energy poverty. Moreover, it does not subsume energy poverty as a question of consumer vulnerability[71], unlike the 3rd Energy Package. However, it still shuffled the responsibility onto MS to define the concept of energy poverty in their own way in order to adapt to local contexts.

Within the 3rd Energy Package, the Electricity and Gas Directives did not contain energy poverty concerns and only alluded to the issue.[72] Specifically, it understood the phenomenon as being connected to the risks associated with increasing energy prices and energy disconnections of their vulnerable consumers within the energy sector. This understanding of energy poverty, however, sheds light on only two aspects, neglecting the building-related situation. Moreover, this conceptualisation of energy poverty is limited to electricity and gas consumers, which are linked to energy utilities, regulators or Ombudsmen as key actors (Pye et al., 2015a). Therefore, the interventions will be more short-termed, resolving immediate access to energy or financial problems (e.g. debts) connected to energy services. Specific measures to protect vulnerable customer were not defined in these two Directives.

71 European Commission's (2016) definition of vulnerable consumes: "A consumer, who, as a result of socio-demographic characteristics, behavioural characteristics, personal situation, or market environment is at higher risk of experiencing negative outcomes in the market; has limited ability to maximise his/her well-being; has difficulty in obtaining or assimilating information; is less able to buy, choose or access suitable products; or is more susceptible to certain marketing practises".

72 "Member State should define a concept of vulnerable customers which may refer to energy poverty and, inter alia, to the prohibition of disconnection of such customers in critical times" (Article 3(7) of Directive 2009/72/EC).

MS must also define their own categories for who qualifies as a vulnerable customer. In Austria, the criteria are only specified for gas and electricity customers through the level of monthly income, and specifically, whether households have arrears on utility bills (I2). In other EU countries, vulnerable customers may include senior citizens, households with children with a defined low income level, disabled people, or customers from remote areas (Zametice et al., 2011). More problematic, these Directives do not apply to customers who use other energy sources, such as district heating. Despite these pitfalls, the 3rd Energy Packagehas strengthened consumer rights by enabling them to choose and change suppliers, receive information on energy consumption, and quickly resolve disputes without extra charges (European Commission, 2021l).

The EU Winter Package contains newly amended Regulations and Directives that include important aspects that streamlined the discussion on the alleviation of energy poor households. The policy priorities are articulated along five policy areas of the Energy Union: (i) energy security, solidarity and trust; (ii) internal energy market integration; (iii) energy efficiency; (iv) decarbonisation; (v) research, innovation, and competitiveness. The legal frameworks of point ii., iii., and iv. will be further elaborated in more detail in this sub-chapter by focusing on the interrelation of energy poverty. The legal basis of the "Clean Energy for All Package" is based on the Treaty on the Functioning of the European Union under Article 194(2) and it extended the Energy Union. It is a comprehensive set of laws that contributes to the EU's climate and energy policy until 2050. It comprises eight EU binding and non-binding laws: 1. renewable energy, 2. energy efficiency, 3. energy performance of buildings, 4. governance rules for the Energy Union, 5. electricity market design, 6. internal market for electricity, 7. common rules for the internal market for electricity, 8. risk-preparedness in the electricity sector, and non-legislative areas, namely the Eco-design working plan and the report on energy prices and costs were added. Figure 15 summarizes EU legislation on climate and energy policies to reduce GHG emissions and tackle energy poverty. It also shows the results of a document analysis using a deductive content approach for the categories "vulnerable groups", "energy poverty" "fuel poverty" "income poverty", to see if they are mentioned or targeted in the legal frameworks.[73]

73 Further instruments, including the LULUCF Regulation and the ETS Directive are not addressed and are beyond the scope of this chapter.

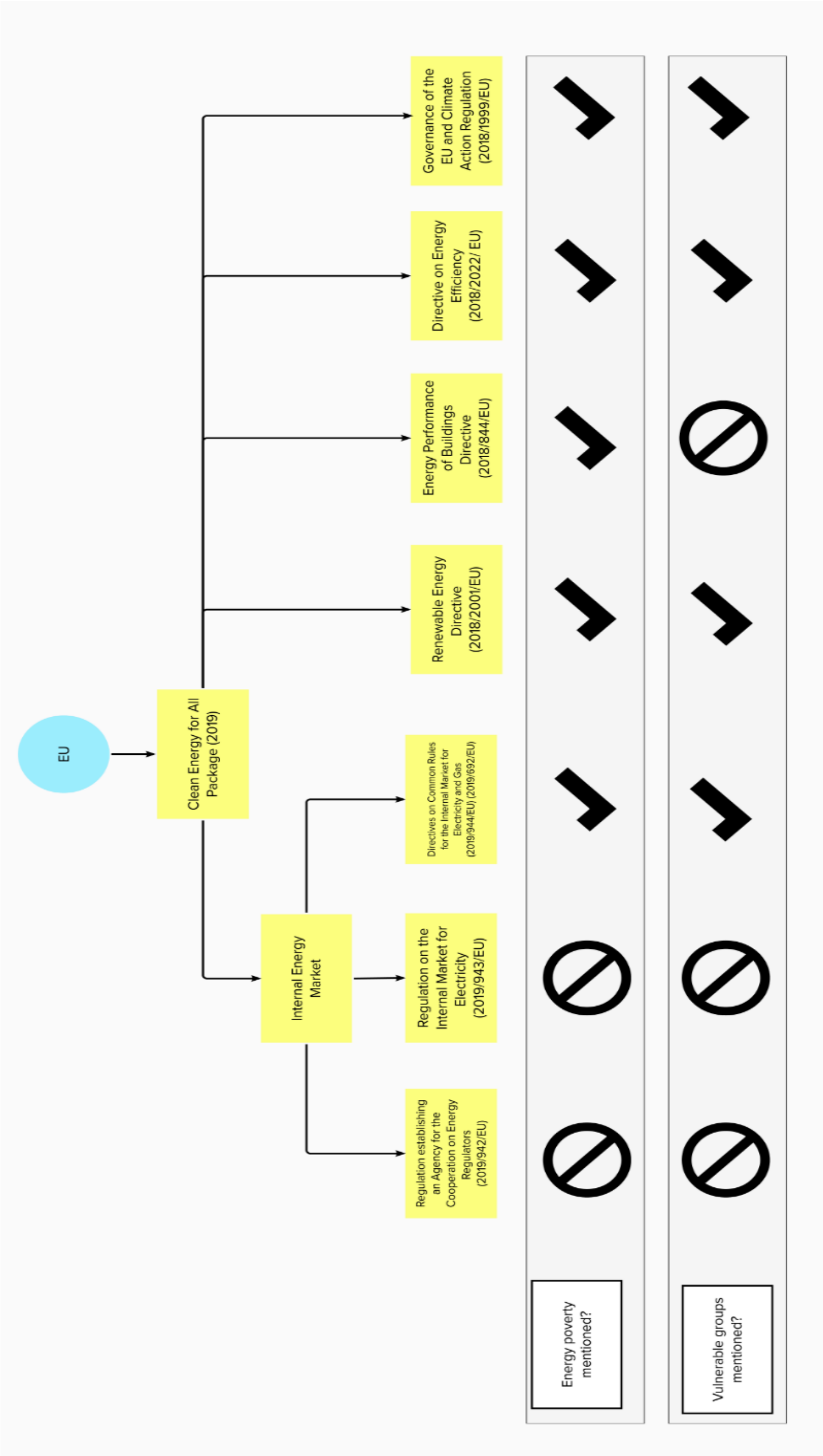

Figure 15 Core EU Legislative Instruments Connected to Energy Poverty (Source: Own Visualisation).

5.3 The Regulation on the Governance of the EU

One major establishment is the Regulation on the Governance in the legal structure of the 2030 Framework, as -for the first time- energy and climate policy planning and reporting are integrated into one Regulation. The Governance Regulation thus is a unifying framework that acts as an umbrella structure for several goals, such as the Paris Agreement, 2030 Climate and Energy Framework, and the Energy Union policy to streamline new obligations (Nouicer et al., 2020). It builds upon the legal structures implemented in EU's 2020 targets but introduces a single governance mechanism. These innovations represent a step-change compared to the 3rd Energy Package, which had created different reporting obligations of EU MS, leading to a lack of policy coherence and coordination, and ensuring that energy and climate issues were not aligned (Monti and Martinez Romera, 2020).

Similar to the structure of the 2020 framework that comprised -20% cuts in GHG emissions, +20% increase share of renewable energy, and +20 increase of energy efficiency, the 2030 **"**Clean Energy for All**"** contains the following overall EU goals: -55% GHG emission decrease, increase share of renewable energy by 32%, and 32.5% increase in energy efficiency (see Figure 14). Being a Regulation rather than a Directive, obligations are directly binding for MS. Whereas Article 191 and 192 of the TFEU provides the EU legal power to intervene into areas connected to climate change policies, it is limited to intervene in legal basis of MS energy policies and the national energy mix.[74] Overall, the Governance Regulation mandates the MS to (1) **plan**, (2) **report** and (3) **monitor** several key areas.

(1) It obliges MS to **plan** and submit two documents:

a. the long-term strategy ("LTS") covering a 30-year span.[75] The LTS covers GHG emission and adaptation policies, renewable energy, energy efficiency, and considerations of the finance of the energy transition.

b. the Integrated National Energy and Climate Plans ("NECP") on the overarching theme of "*energy efficiency first*"[76] to reduce final energy consumption of buildings starting from 2021 (and every ten years after), updated in five-year intervals (includes national renovation

74 Article 191 TFEU outlined the following objectives: preserving, protecting and improving the quality of the environment, protecting human health, prudent and rational utilisation of natural resources, promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change. As detailed in Article 194 TFEU(2), MS have own responsibility to decide on their national energy mix.

75 It includes the EU long-term strategy and national long-term strategies of EU MS (European Commission, 2020k).

76 According to the European Commission Recommendation (EU) 2019/786.

strategies). Major drawbacks of the Governance Regulation are its lack of long- and midterm emission reduction targets, long-term perspective, and the risk of creating lock-in effects (Duwe et al., 2017). The proposed European Climate Law might fill this gap in the future with its 2050 climate neutrality target (Kulovesi and Oberthür, 2020).

During the drafting phase of the national NECP "*Member States shall ensure that the public is given early and effective opportunities to participate in the preparation of the draft plans* [...]" (Governance Directive Chapter 2, Article 10 Public Consultation). The Governance Regulation included important milestones, such as mutual learning, stakeholder exchange, consultation with the public and multilevel dialogues that are proposed as instruments to innovate, create synergies for climate and energy policies (Bean et al., 2019). A downside of the proposed European Climate Law and the Governance Regulation is the reluctance to address all three procedural justice principles of the Aarhus Convention: while public consultation is included, the right to information and access to justice are not included.[77]

(2) In compliance with the **reporting** obligation, MS prepare annually GHG inventory reports and biennial progress reports in a two-year cycle (starting in 2023), which outline progression relative to the national plans. Thus, the EC assesses and monitors progress.

(3) The Governance Regulation **monitors** the implementation of the 2030 framework by assessing the ambition of MS in their draft NECPs and evaluating progress on the biennial progress reports by the MS (Articles 9 and 13, Chapter 5). In case of insufficient progress implementing NECP's, the Commission *may issue* recommendations if its aggregated assessment shows that the EU is at risk of not meeting the overall objectives of the Energy Union. However, the use of the conditional form "*may issue*" refers to Commissions discretion. Article 9.3 states that MS "shall take utmost account of the recommendation" (European Commission, 2020a; Kulovesi and Oberthür, 2020).

Issuing recommendations has not been a very effective EU instrument, similar to the European Semester Country Recommendations, which suffers from a low compliance rate. Formally, recommendations have weak legal effects due to their non-binding nature compared to, for instance, infringement proceedings.[78] These contain penalties and legal obligations to comply with the rulings by the EC Court of Justice (Kulovesi and Oberthür, 2020). In other words,

77 Aarhus Regulation includes public participation for plans and programmes but not for policies.

78 Although also infringement proceedings have shortcomings: if MS fail to meet a target, any infringement action against MS can only start after the deadline of the target has passed (Nouicer et al., 2020).

recommendations often present vague language and lack adequate sanctioning mechanisms, as they do not contain an implementation check nor do they state penalties if MS do not comply. To conclude, there are no negative consequences of non-compliance outlined.

Referring to energy poverty, the Governance Regulation (2018/1999) brought out a novelty and asks MS to

> *"assess the number of households in energy poverty taking into account the necessary domestic energy services needed to guarantee basic standards of living in the relevant national context, existing social policy and other relevant policies [...]" (Article 3). In the event that a Member State finds that it has a significant number of households in energy poverty as supported by its assessment based on verifiable data, it shall include in its plan a national indicative objective to reduce energy poverty. The Member States concerned shall outline in their integrated national energy and climate plans the policies and measures which address energy poverty, if any, including social policy measures and other relevant national programs."*

Within the Governance Regulation (2018/1999/EU), MS must define, monitor, report and propose measures for energy poverty. If there is a significant number of energy poor households, MS must regularly report on progress. However, until now, what constitutes a "significant number" remains unspecified, also because countries can decide on their own definition, and consequently the amount of affected households differs enormously between countries. The guidelines therefore give a concrete implementation mandate to combat energy poverty, but do not contain any explicit requirements for the MS. The EC will provide guidance on the definition of "significant number of households in energy poverty" in accordance with Article 14 of Regulation (EU) 2018/199 on the Governance of the Energy Union and Climate Action using indicators (Directive on the Common Rules for the Internal Market for Electricity) (Bouzarovski and Thomson, 2019). MS also need to report information on the outcome of energy efficiency and energy saving measures targeting vulnerable residents of social housing.

The reporting obligation facilitates transparency to track energy poverty indicators and contemporary developments on the national level. If, however, each EU MS proposes its own energy poverty definition, as it is currently the case, it is impossible to compare data across MS. The main EPOV indicators, however, provide some sort of guidance.

A substantive change was introduced in the Winter Package that differs strongly from the old 3rd Energy Package: national energy efficiency and renewable energy targets are not specified for each MS. In the scientific community, the Governance Regulation has therefore been named "harder soft governance" (Knodt et al., 2020; Oberthür, 2019; Schoenefeld and Jordan, 2020), as direct or indirect sanctions for non-compliance are left out (Knodt et al., 2020). This constitutes a substantial change compared to the previous 3rd Energy Package, which detailed national binding targets for GHG emissions ***and*** also a national renewable energy target. This lack of quantified criteria has been strongly criticised by scholars and several NGOs for not being progressive enough, as it represents a step backwards and a weaker policy choice compared to the Renewable Energy Directive I (Duwe et al., 2017; Monti and Martinez Romera, 2020).

5.3.1 The Renewable Energy Directive

The recast **Renewable Energy Directive (RED) II** (2018/2001/EU) offers an overall EU-wide target of ensuring that 32% of the EU's total gross consumption comes from renewable energy sources by 2030. It is a collective obligation, legally binding, and according to Article 42 of the Draft Articles on State Responsibility of the United Nations it is "owed to […] the international community as a whole" (International Law Commission and United Nations, 2001). National renewable energy targets in the RED I, including its interim targets, constituted an important strength of EU energy legislation.

The change from legally binding national target to national contributions has softened the renewable energy target, making it less ambitious, also because infringement proceedings were an instrument in the 2020 Framework if MS did not comply.[79] That is why, for the new period 2020-2030, Austria provided a range between 46- 50% instead of a fixed percentage, which ensures leeway to determine its own contribution to the target and it is, at the same time, not legally binding. For buildings, the EC sets the goal to reduce the energy consumed in buildings by at least 49% by 2030 through direct renewable heat, district heating and cooling, and renewable electricity (European Commission, 2021i).

On the EU level, there are no legal consequences arising from the non-achievement of this target (Monti and Martinez Romera, 2020).[80] In 2023, the EC may revise the renewable target upwards in case of significant cost reductions resulting from technological development or a significant decrease in energy consumption (RED Article 3.1). If the EC detects gaps in progress, MS will be asked to contribute financially to the financing platform. Furthermore, if

79 A case study by Bürgin (2015) found that Energy Commissioner Günther Oettinger, including a small fraction of other commissioners, favoured the less ambitious target of 35% for renewables. He was also opposed to make the renewables target legally binding for the MS. Former Commission President Barroso compromised by maintaining -40% GHG reduction target and abandoning the national binding character for MS.

80 Failure to comply and gap-filling mechanism: MS adjust share of renewable sources in specific sectors or MS make financial contributions to EU-level renewable energy sources financing platform or through other measures. Unfortunately, there was little clarity on its functioning.

in 2023 the EC finds that collective EU renewables target will probably not be met, MS shall ensure that they cover the gaps through additional measures (financial contribution to a financing platform or adjusting the share of renewables in the sectors transport or/and heating and cooling) (Vandendriessche et al., 2017).

The Energy Union places questions of democracy and the empowerment of its citizens (development of "prosumers who interact with the energy market") at the centre of the energy systems by supporting citizen to take ownership in the energy transition.[81] Thereby, the RED II incorporates recognition justice into the EU law (Milčiuvienė et al., 2019). So-called "prosumers" can search for an affordable energy tariff but also produce, store, consume and sell renewable energy independently.[82] What remains to be evaluated is how vulnerable households, energy poor or disadvantaged communities participate or how they can be empowered to take part in these endeavours (Hanke and Lowitzsch, 2020).

When planning new construction or retrofitting buildings, MS must introduce necessary measures in their building regulations and codes to increase the share of renewable energy in the building sector (RED Article 15.4). Furthermore, MS should increase their share of renewable energy in heating and cooling by 1.3% annually between 2020 and 2030 (RED II Article 23).

5.3.2 The Electricity and Gas Directive

A major novelty brings the amended **Internal Market in Electricity Directive** (2019/944/EU) that requires MS to publish a set of criteria to assess the number of customers in energy poverty. While the previous Electricity Directive (2009/72/EC) only stated high energy prices and/or low income, this amended Directive incorporates inefficient buildings and concrete vulnerability aspects:

> *"The concept […] may include income levels, the share of energy expenditure of disposable income, the energy efficiency of homes, critical dependence on electrical*

81 "The legislation frames energy communities as co-operatives that aim solely to promote social and solidarity-based economy and innovation in the energy sector, address energy poverty and promote energy sustainability, generation, storage, self-consumption, distribution and supply of energy as well as improve end-use energy efficiency at local and regional level" (Roberts, 2019, p. 20).

82 The RED II introduced novel concepts to enhance consumer empowerment, provide citizens and communities support by removing administrative barriers to increase renewable energy, community participation in the energy market, and ensure fair and equal treatment:

- Renewable self-consumers are encouraged to generate renewable energy for their own consumption, to store it, to share it, or to sell it.
- According to Article 22 to promote and facilitate renewable energy communities: participation should be open to all customers, provide tools to facilitate access to finance and information.
- Reformulated sustainability and GHG emission saving criteria for biofuels, bio liquids, and biomass fuels.

equipment for health reasons, age or other criteria" (Directive 2019/944 on common rules for the Internal Market for Electricity).

This directive covers important factors that influence vulnerability and worse energy poverty. These outlined aspects are in line with the prominent causes of energy poverty that are frequently reported in the scientific literature. Although the Electricity Directive obligates MS to

> *"take the necessary measures to protect vulnerable and energy poor customers in the context of the internal market in electricity" (European Commission, 2019d),*

however, once again, the use of the conditional "may" implies a suggestion (not compulsory) to the MS without providing clearly specified benchmarks or relevant guidelines that are necessary for a comprehensive energy poverty analysis. Subsequently, MS hold ample scope to decide on their national energy poverty measures.

In terms of horizontal and vertical multilevel policy coordination, the Electricity Directive (2019/944/EU) and the 2030 climate target plan (COM562) explicitly encourage climate policy integration as a means for an inclusive transition:

> *"In doing so, an integrated approach, such as in the framework of energy and social policy, could be used and measures could include social policies or energy efficiency improvements for housing."*
>
> *"Mainstreaming of climate policy objectives into other EU policies is a key enabler and will allow for an inclusive transformation based on a just transition."*

In this context, reference is made to the possibility of an overall concept that could comprise energy, climate and social policy measures, as well as measures to improve energy efficiency, overcoming the limited focus to provide aid for vulnerable consumers to pay their energy bills but rather to bundle various schemes.

All things considered, energy poverty has become more prominent in the EU Directives and Regulations. Introducing the interconnectedness of energy poverty to energy efficiency improvements is a major advantage and constitutes an important stepping stone for further energy poverty mitigation, which was missing in the 3rd Energy Package. However, market regulation and regulated prices have been called off as they limit the development of effective competition between the energy providers, discouraging investments and new market players (Recital 22 and Article 5 of Market Design Directive, EU 2019/944). A notably positive aspect is the strengthening of electricity and gas consumer contractual rights to exclude vulnerable customers from the energy supply and avoid energy disconnections (Directive for the Internal Market for Electricity 2019/944 Article 28). For instance, the European Commission named elderly and disabled people with low incomes as examples of customers in need of protection. The **Electricity and Gas Directive** (Annex I) (Article 10 on Basic Contractual Rights)

> *"[r]equires that customers in arrears with their energy suppliers are given adequate information on alternatives to disconnection sufficiently in advance before the disconnection. These alternatives may refer to sources of [financial] support, alternative payment plans, debt management advice or disconnection moratorium and should not constitute an extra cost to customers."*

5.3.3 The Revised Energy Performance of Buildings Directive

Major EU legislation, reforms and packages have been passed in the last decade to boost retrofitting (deep renovations) activities and increase energy efficiency of buildings by setting minimum energy performance requirements. However, taking stock of these efforts has yielded sobering results, and continuing cause for concern, as households (building sector) have not reduced its energy consumption between 1990 and 2020, neither overall in the EU nor in Austria (Eurostat, 2023a). The **revised Energy Performance of Buildings Directive** ("EPBD"') (2018/844/EU), ratified in 2018, aims to address this challenge. The revised Directive serves to provide guidelines for building construction and retrofitting and it aims to help citizens to consume less energy, save money and live in healthier buildings. It outlines a set of measures, such as the energy performance of buildings, providing energy performance certificates if buildings are for sale or rent (larger public buildings must display energy certificates) indicating the energy rating of buildings, and ensure that nearly zero energy building ("nZEBs") are constructed by the end of 2030.

Minimum energy performance requirements are set for new buildings, buildings that undergo major retrofitting and for the replacement of building elements (heating and cooling systems, roof, walls, etc.). While the 2010 EPBD proposed to mitigate energy poverty through improvements in the buildings energy efficiency, the revised Directive contains stricter guidelines to address energy poverty and obliges MS to provide a **long-term building renovation strategy** ("LTRS")(Article 2a of the EPBD). In 2020, EU countries provided LTRS with the following core components:

- an overview of the national building stock, based on statistical sampling and expected share of renovated buildings in 2020;

- an identification of cost-effective approaches to renovations relevant to the building type and climatic zone;

- an overview of policies and actions to target the ***worst-performing segments*** of the national building stock, split incentive dilemma and market failures, and an outline of relevant national actions that ***contribute to the alleviation of energy poverty*** (EPBD Article 2a.1.d).

Notably, all national performance indicators on energy poverty measures ought to be integrated in the national energy and climate progress reports. Although the LTRS requires MS to introduce relevant national actions, indicative milestones and progress indicators that contribute to achieve a highly energy efficient building stock by 2050 and the alleviation of energy poverty, individual MS have the responsibility of drafting what they consider being relevant actions (Recital 11 EPBD). A clear limitation is that it is a non-binding obligation to implement the measures listed in the LTRS.

In December 2021, the EC published a full recast of the EPBD (proposal). Key element is the newly introduced Minimum Energy Performance Standards (MEPS) to increase the renovation rate of the 15% worst-performing buildings at the latest by the end of 2027 (EPBD Article 9). Residential buildings have to be upgraded to at least an Energy Performance Certificate's Grade F by 2030, and to Grade E by 2033. Building renovation passports[83] are introduced in Article 10 EPBD. MS must introduce them by end of 2024. Furthermore, as of 2027, the directive forbids MS to provide financial incentive for the installation of fossil fuel boilers. Currently (March 2023), the final text of the directive is negotiated in the trilogue. A final version of the EPBD amendment will probably be available in autumn 2023.

5.3.4 The Revised Energy Efficiency Directive

The revised **Energy Efficiency Directive** ("EED") (2018/2002/EU) contains an annual energy savings obligation (Articles 7, 7a, 7b) of 0.8% (final energy consumption) starting in 2021 until 2030. The overall target sets out to achieve an increase of at least 32.5% in energy efficiency in the EU by 2030 (Article 1). This target translates into 1.273 Mtoe of primary energy consumption and/or 965 Mtoe of final energy consumption. MS only have to provide indicative national contributions (European Parliament and the Council, 2018). In 2023, the EC can revise this target upwards. Initially, the EED addressed GHG emission reduction policies, but the measures gradually included energy poverty reduction instruments.

83 A "document that provides a tailored roadmap for the renovation of a specific building in several steps that will significantly improve its energy performance" (European Commission, 2021h).

The alleviation of energy poverty was prominently placed at the beginning of the EED, where it is stated that improved energy efficiency also prevents and decreases energy poverty. The Directive introduced energy efficiency obligation schemes ("EEOS"), in which large energy companies (>50 employees) are required to achieve yearly energy savings of 1.5% of annual sales to final consumers. This may include improving the heating system in consumers' homes, installing double-glazed windows, or better insulating roofs to reduce energy consumption. MS also have the option to introduce alternative policy measures (e.g. CO_2 taxes, training and education, including energy advisory programs), on condition that they deliver equivalent energy savings. A combination of both measures is also allowed.

The directive outlines that MS must provide information on the outcome of energy efficiency and energy-saving measures for either energy poor households or households living in social housing. The EED is an important legislative act as it changed its conditions for large energy providers from being a *can*-condition to a *should*-condition (Austrian Court of Auditors, 2019, p. 24): EE measures and investments **should** explicitly "*benefit vulnerable households, including those affected by energy poverty, and, where appropriate, those living in social housing*" (23). Article 7 is the most important component of the EED as it has been expected to deliver more than half of the reduction targets. However, energy efficiency policies did not deliver the expected outcomes just yet. The energy saving and expectations until 2020 stayed well below the initial notifications, particularly in Austria, Sweden and the UK (Rosenow, 2019). Because of its loopholes, the EED set only 0.7% of average energy savings per year compared to the original target of 1.5% annual energy savings for the period 2014-2020 (Rosenow et al., 2016). MS also need to summarise their national building stock and an estimation of the EEOS. The EEOS require MS to renovate 3% the total floor area of buildings owned and occupied by central government to act as a front-runner. To reduce import dependency and facilitate energy security, which is one of the core five pillars of the Winter Package, fossil fuel imports should be reduced by 12% from non EU-countries (Ferreira, 2020).

5.4 The European Union's Renovation Wave

Under the umbrella of the European Green Deal, a wide ranging Renovation Wave (COM(2020)662) is proposed. It constitutes an important milestone to trigger MS to step up their actions and increase the efficiency of the building stock. In more detail, the Renovation Wave specified three pillars (European Commission 2020):

1. decarbonisation of heating and cooling;
2. tackling energy poverty and worst-performing buildings;
3. renovation of public buildings such as schools, hospitals and administrative buildings.

The EU Renovation Wave discerns to double renovation rates in the next ten years to lower energy consumption and energy bills. One of the Renovation Wave's major goals is to decrease energy poverty, and it is a clear declaration intended to facilitate policy action. However, a novel report by the Unify project explains that

> *"the overall level of ambition proposed by the Commission is still not enough to be in line with the Paris Agreement nor to tackle energy poverty sufficiently" (LIFE Unify, 2020, p. 8).*

Considering the fact that an EU report (European Commission, 2019c) yielded the result that renovation rates amounted for less than 1% in the EU (between 2012-2016), the renovation strategy lacks ambition and does not go far enough to address energy poverty, also because an unified definition is missing. The EU report concluded that renovation rates need to at least triple to achieve a decarbonisation of the EU building stock by 2050 (BPIE, 2020b; LIFE Unify, 2020). Policy action includes 28 regulatory and non-regulatory measures. Energy poverty subsumes one non-regulatory measure by launching the Affordable Housing Initiative, piloting 100 renovation districts (European Commission, 2020n). Hence, when it comes to addressing energy poverty directly, the EU Renovation Wave objectives are not sufficiently far-reaching.

In October 2020, European Commission launched energy poverty recommendations, which were published jointly with the Renovation Wave initiative. Nevertheless, concrete quantitative targets (emission saved, decreased energy poverty rates) are absent and the recommended measures do not contain legislative backing, yet.[84] This stems from the circumstance that recommendations only suggest lines of actions that are not binding and do not have any legal consequences. To conclude, the Renovation Wave falls short on speed and accuracy as Martha Myers (Friends of the Earth Europe) evaluates:

> *"ring-fenced funding, guidelines and quality standards for low-income households are short on the ground in this [Renovation Wave] strategy" (Myers, 2020).*[85]

84 Currently in EU triloge (April 2023), the Commission will most likely introduce legally binding minimum energy performance standards for existing European buildings within the Energy Performance of Buildings Directive (EURACTIV, 2023).

85 For the sake of completeness, Bouzarovski et al. (2021) highlights three legal documents in the EU arena that pushed energy poverty on the forefront: (1) the "Energy Poverty Handbook", by Green European Parliament Member Tamás (Meszerics, 2016); (2) the European Parliament resolution "on delivering a new deal for energy consumers" European Parliament (2016); and (3) the European Parliament's Socialist and Democrats' group manifesto on the subject Group of the Progressive Alliance of Socialists and Democrats in the European Parliament (2016). European Economic and Social Committee, and the Committee of the Regions—provided extensive support for broader energy poverty policies European Committee of the Regions (2016); European Economic and Social Committee (2016).

5.5 EU Efforts in Social and Housing Policies

Housing policies are often called a “wobbly pillar of the welfare state”, as housing is a basic human need, but at the same time, it is subject to the market forces (Torgersen, 1987). In international discourses, different views exist weather housing policies can be subsumed under the umbrella policy field of social policy. In most EU Member States (“MS”) homelessness, social housing and housing allowances are selected areas that are listed as concrete social policy fields (Matznetter, 2002). Housing policy, however, is a vague term in terms of content, distribution of tasks and competences between various governmental levels, and constitutes a policy area that cuts across several domains, such as social, economic, environment, and community planning. Housing policies are also a key pillar of overall efforts to combat poverty, exclusion and energy poverty.

The EU has only limited legally binding competences in the realm of social and housing policies, as it is subject to the subsidiarity principle. Economic integration and energy questions were the initial rationale detailed in the founding treaties of the European Coal and Steel Community. According to Falkner (2016) social policy and issues of welfare would improve alongside the development of a common market. Hence the EU gained limited competences in the sphere of social policies.[86]

A core part of the EU’s approach to anti-poverty measures lies in adopting the Open Method of Coordination governance structure, which relies on annual national action plans and country-specific recommendations by the European Commission to individual MS. Every year, MS receive housing policy related country-specific recommendations of the European Semester in order to achieve EU 2020 goals. The country reports entail a detailed analysis of the housing market. These recommendations have become increasingly sophisticated over the last decade as they discuss a variety of topics, such as the social consequences of inadequate housing policies or housing exclusion and homelessness. It is a “soft policy tool” that defines common goals, objectives, and benchmarks. One of the overall objectives laid out in the Europe 2020 strategy was to bring at least 20 million people out of poverty and social exclusion by 2020, compared to 2008 (120 million people in the EU)(European Commission and Eurostat, 2021). Unfortunately, this EU goal has not been achieved by over 8 million Europeans that are affected

86 However, Article 9 & 151 of the Treaty on the Functioning of the European Union, and Article 3 & 6 of the Treaty on European Union set social policy objectives, whereby the fight against social exclusion and adequate social protection according to needs are detailed.

by poverty. Sanctions for non-compliance are not foreseen in the European Semester (Eurostat, 2021d).

The European Commission sets common indicators to assess national and EU progress towards these anti-poverty goals and aims to trigger reforms at the national level. It has a limited substantial impact because of its non-legislative power, although institutional pressures through other governance means are in place (e.g. European Semester, Six-Pack, Euro-Pact, Two Pact). Because poverty reduction and housing policy are subject to the subsidiarity principle, it is therefore national welfare state matter (Kazepov, 2008). Hence, national governments, regions, and municipalities decide on many public policies that also target energy poor households.

There is no official or legal definition of affordable[87] housing in the EU, but the housing cost overburden rate[88] is commonly used as a benchmark for comparisons (Caturianas, 2020). Other key housing indicators that are more difficult to track quantitatively are tenure security, substandard housing, and spatial segregation. Although the EU has no *direct* competence in the housing policy field, *indirectly* it influences housing conditions of MS through state aid law, fiscal law, and competition law. Regarding energy poverty, *Interreg Europe* supports local and regional governments through, for instance, a Social Green Project or *Affordable Housing Initiative* (EU Renovation Wave) will provide technical support for social housing projects (European Commission, 2020n; Interreg Europe, 2021). More substantially, the EU interferes through the establishment of minimum thermal standards and energy certificates within the "Clean Energy for All Package".

To sum up, the EU has indirect competence in housing policies and overall limited leverage, as f.i. country-specific recommendations are legally non- binding and lack legal consequences for non-compliance. Hence, from a pragmatic point of view, energy poverty policies are better dealt in the area where the EU has more leverage power, such as climate and energy policies (Directorate- General Energy).

87 The concept of affordable housing dates back to the Anglo-Saxon area and is a relative term as it incorporates a specific market segment with prices or rents under a threshold of defined market level depending on a certain income level.

88 Defined as the proportion of the population spending more than 40% of their disposable income on housing.

5.6 Conclusion

In its long-term strategy, the European Commission ("EC") aims to be climate-neutral until 2050. The interim 2030 emissions reduction targets of net 55% compared to 1990 levels are outlined in the "Fit for 55 Package" under the European Green Deal (European Commission, 2019i). Overall, the EU was on good track to meet its 2020 climate goal: 20% reduction of greenhouse gases, a 20% share of renewable energy sources in gross final energy consumption, and a 20% energy efficiency target.

All things considered, on the EU level, energy poverty has gradually emerged as a key policy issue after a long history of neglect and inadequate understanding. Energy poverty is now recognized as an important issue within European energy and climate policy, and new legislative requirements under the "Clean Energy for All Package" have reflected its importance. This includes a working definition of energy poverty that focuses on economic and structural factors (e.g. tenancy or the inefficiency of the dwelling), as well as new Directives and Regulations that require Member States to monitor, report trends, and provide national objectives in their NECPs. Successively, the amendments, new Directives and Regulations increased the salience of energy poverty, and the Clean Energy Package introduced key innovative elements, including strong obligatory action wording (e.g. "shall" instead of "may"). The Governance Regulation foresees specific reporting of energy poverty rates and facilitates transparency and the two newly amended Energy Efficiency and the Energy Performance of Buildings Directives focus on the need to retrofit the European building stock in conjunction with lowering energy poverty rates. Addressing issues surrounding vulnerable groups and social housings is specifically mentioned as a key target. Policy and inter-sectorial coordination between all vertical levels and between social, energy and climate policies are outlined to safeguard that "nobody is left behind". The EPOV (meanwhile EPAH) was launched in 2018 and is entrusted to track and make energy poverty related data on the European level transparent.

The change from the Effort Sharing Decision to the Effort Sharing Regulation for the 2021-2030 period sets legally binding GHG reduction targets individually to each MS and an Union-wide target of -55% by 2030 (Peeters and Athanasiadou, 2020). This constituted a major legal shift, as Effort Sharing covers 60% of the EU-28's total domestic emissions (Roumet, 2017). Next to the GHG reduction targets, a clear limitation is the legal character of the RED II and EED. As Monti and Martinez Romera (2020, p. 231) conclude:

> *“[t]he adoption of the 2030 Framework has marked the formal shift to non-binding renewable energy targets at the Member State level.”*

As national energy efficiency and renewable energy binding targets are absent, the Clean Energy for All Package lacks incentives for MS to make ambitious pledges and be compliant. The collective obligation approach has also weakened the overall EU targets. Nevertheless, the However, the Governance Regulation has introduced procedural obligations at the Member State level to counterbalance the non-binding aspect of the Renewable Energy Directive II (RED II). EU leadership brought major policy improvements to tackle both energy poverty and decrease GHG emissions. Further agenda setting is needed to “*solidify legislation and catalyse action*” (Dobbins et al., 2019). Besides various soft tools, recommendations and existing policies, Magdalinski et al. (2021, p. 21) comes to the sobering insight that “*current European provisions to fight energy poverty lack coercive force*”.

Given that energy poverty is context-specific and requires local expertise to adjust measures to local peculiarities, including those related to worst-performing buildings, more coherent measures at the EU level are needed to address the mixed record of action uptake across Member States. Therefore, it is crucial to prioritize the implementation of stronger policies to tackle energy poverty and its negative impacts on vulnerable groups and society as a whole.

6. Energy and Climate Policies and the Interrelation with Energy Poverty in Austria

Following the multilevel governance perspective, this chapter moves one level down to the national level and analyses the Austrian policy context by shedding light on current strategies and measures that are connected to decreasing greenhouse gas ("GHG"') emissions, and remedy energy poverty. National case studies offer unique and valuable insights as they illustrate the socio-economic and spatial characteristics of vulnerable groups and investigate the context-dependent processes that lead to energy poverty (Bouzarovski and Tirado Herrero, 2017; Simcock et al., 2018). Climate policy integration is outlined as a core Austrian challenge, an important determinant in energy poverty alleviation, and climate change mitigation.

This chapter analyses key climate policies to a.) evaluate its efficiency and effectiveness referring to energy poverty, b.) how tasks and responsibilities of climate policies are distributed between different levels of governance, and c.) the institutional arrangements for incorporating adaptation into sectorial (building) policies. This chapter presents the results of the document analysis of Austrian policy documents. Relevant expert interviews quotes will provide additional information to validate the document analysis results. The following questions will be answered in this chapter:

- What laws currently exist to tackle energy poverty in Austria and do they promote just outcomes?
- Are inequalities or misrecognition in the Austrian policy framework regarding energy poverty present? More precisely, from an intersectional perspective, are some households left behind, overburdened or neglected in the concurrent policy frameworks?
- Are there misalignments or barriers between social/ housing and climate policies in Austria?
- Do the policy schemes reach energy poor households?

Sub-chapter *one* begins by setting the scene for the analysis of Austria's targets and instruments by outlining major federal programmes and strategies. Key actors, federal programmes and federal acts will be presented. Sub-chapter *two* introduces the climate policy integration approach and links it to energy poverty. The specific focus of this sub-chapter also lies in assessing housing and climate policy integration to identify coherence problems between policies and different governance levels. Sub-chapter *three* evaluates retrofitting endeavors in Austria. Sub-chapter *four* unfolds how energy poverty is conceptualised and how energy poverty is addressed in Austria. Therefore, this sub-chapter deals with critical challenges related to the current Austrian energy poverty definition(s). Sub-chapter *five* moves on to assess the current federal instruments that have a direct impact on the Austrian energy poverty situation. The “Verbundstromhilfefonds”, which is a dedicated social project aimed at energy poor households organised by the social NGO Caritas will be outlined in sub-chapter *six*. The chapter concludes by summarising the federal energy poverty measures.

6.1 Setting the Scene: Austria’s Targets and Instruments

The Austrian Constitution of 1920, the “Bundes-Verfassungsgesetz”115 (B-VG), divides the spheres of competences between the Austrian Federal Government (“Bund”) and the nine federal states (in German: “Länder”). The Austrian Federal Government holds the highest share of legislative and executive power. Austria has a federal political system that devolves considerable legislative power in selected policy areas to sub-national authorities, despite their primary function being administrative and executive. In Austria the federal and the federal states (Länder) governments are involved in joint-decision making in many policies without the participation of local governments. The federal states have a key responsibility to implement policies, such as building policies. These are implemented through the department and/or magistrate for housing research, housing subsidy, environmental protection and spatial development.[89] Housing and building policies are an important policy area that is inherently linked to energy poverty, since they apply minimum thermal energy standards and implement housing subsidies (“right to decide and right to act” Steurer et al., 2020, p. 3). Lastly, at the local/regional level, there are 2,098 municipal administrations, which are self-governing administrative bodies without legislative power.

Within Austria’s multilevel governance system, not only horizontal policy integration (between the various ministries) but also vertical (e.g. building policies) integration across levels of government (federal, provincial, and local), or diagonally across sectors and levels (Steurer and Clar, 2015) plays a crucial role in integrating energy poverty instruments. An overview of the analysed Austrian policy setting is visualised in Figure 16, in which we can distinguish between a.) actors, b.) Austrian federal programmes and strategies, c.) major federal acts, d.) subsidies, funds, and social projects.

89 Interventions from the Federal level on the Federal States governments are usually pursued, and coordinated through Article 15a B-VG.

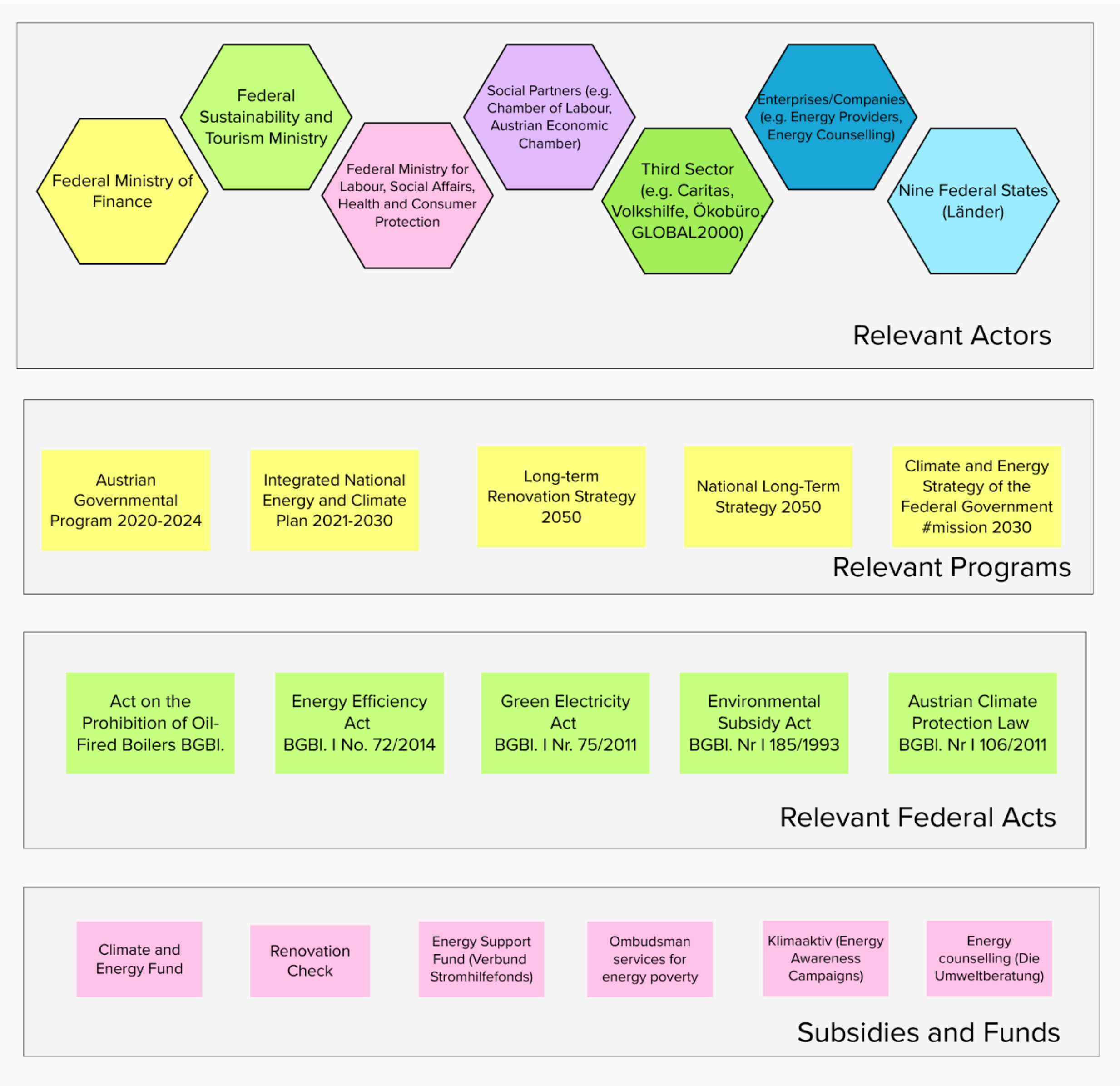

Figure 16 Austrian Governance System Connected to Energy Poverty (Source: Own Visualization).

Figure 16 illustrates the main *relevant actors* that form the network that is involved in alleviating energy poverty on the federal level. Matters concerning energy poverty, climate and social policies belong to the portfolio of the Austrian federal level are the Austrian Federal Ministry for Sustainability and Tourism (core advocate for climate and energy policies)[90] and the Federal Ministry for Labour, Social Affairs, Health and Consumer Protection (core advocate for poverty and social exclusion policies and basic welfare support). Each federal state can use its own legislative power to issue dedicated programs (e.g. heating allowances) to support energy poor households.

90 In 2018, the energy sector was transferred from the Economic Ministry to the Environmental Ministry.

Characteristic of Austria's welfare system is the powerful role of social partners (e.g. Chamber of Labor, Austrian Economic Chamber, Chamber of Agriculture, and Austrian Trade Union Federation) and a strong consensus-oriented democracy.[91] Social partners (e.g. Chamber of Labor) and the third sector are central institutions that have substantive power to influence policy agenda and to combat energy poverty.[92] NGOs play a crucial role in implementing measures and instruments in Austria. The Caritas emerged as a key NGO, which performs care and support tasks to ease energy poverty. Private (e.g. Environmental Counselling [in German: Die Umweltberatung]) or state owned-companies are embedded in the broad network to lift households out of energy poverty, too. Energy providers are embedded in this network and contribute to lower energy poverty rates through fulfilling EU obligations (e.g. energy saving certificates or energy supplier obligation schemes) that are transposed upon them. The following major federal programmes and strategies are found as key documents in the existing Austrian decarbonisation policy framework that support also energy poor:

- the climate and energy strategy of the Austrian Federal Government #mission2030;
- the integrated National Energy and Climate Plan (NECP) of Austria 2021-2030;
- the long-term renovation strategy 2050;
- the national long-term strategy 2050;
- the Austrian Governmental Program 2020-2024.

They have been analysed from a climate policy integration and multilevel governance lens to understand the Austrian political context by centring on goals and measures connected to energy poverty, climate, and housing policies. By applying this analytical lens, it is possible to understand general policy directions and whether governments stimulate adaptation across various levels and stakeholders, or constrain policy progress by building barriers (e.g. conflicting timescales, fragmentation, motives and willingness to act and resources).

Key federal acts are identified and evaluated as they contain concrete action plans and measures that can have a favourable or adverse effects on energy poor households. The focus of the analysis centres around policy coherence and coordination. Especially, the Austrian Climate Law, Act on the Prohibition of oil-fired boilers, Energy Efficiency Act, Green Electricity Act, Environmental Subsidy Act, Natural Gas Act and Electricity Act are analysed.

91 In the comparative welfare state literature, Austria is classified as a conservative, familialistic, corporatist, and continental welfare state, with a high degree of political cooperation among various interest groups (Esping-Andersen, 1990; Österle and Heitzmann, 2020).

92 As an example, one expert from the Chamber of Labour drafted amendments for the limited profit housing law on the passing on the renovation costs over a longer period of time (WGG) (I9).

6.2 Climate Policy Integration

EU strategies clearly advocate to no longer conceive policy fields as isolated silos, but call for a high level of policy coordination between horizontal and vertical levels. This also applies to energy poverty alleviation, as policy efforts are interwoven in climate, housing and energy policies. The success of these policies depends on cooperation and coordination between various governmental levels. One analytical approach to this coordination challenge is titled *climate policy integration* (Mickwitz et al., 2009). It describes the integration of environmental objectives into various stages of policy-making in other (environmental and non-environmental) policy fields (horizontal climate policy integration) and/or across different levels of government (vertical climate policy integration)(Adelle and Russel, 2013; Lafferty and Hovden, 2003). It is accompanied by the support of co-benefits and the minimisation of contradictions and trade-offs between climate and other policy objectives (Corfee-Morlot et al., 2009; Mickwitz, 2009). Vertical coordination refers to coordination efforts between different levels of government, and horizontal coordination and responsibilities mean the interactions with key actors and stakeholders within the same level (Dobravec et al., 2021). The third sector and other government actors, such as the civil society, interest groups, are included in this multilevel framework concept in Austria.[93]

6.3 Policy Coherence and Coordination Issues in Austria

Austria's integrated **National Energy and Climate Plan** (NECP) contains a list of measures with which the respective national climate and energy targets for 2030 can be achieved. The non-trade share is divided among the MS according to the "effort sharing" principle. Because Austria is evaluated by the EC as a high income country, the calculated 2030 GHG emission reduction target is -36%, compared to 2005. Austria's NECP contains the main five dimensions of the Energy Union: security of energy supply, the internal energy market, energy efficiency, decarbonisation, and research, innovation and competitiveness. The first NECP draft was submitted at the end of 2018. In June 2019, the EC declared it to be inadequate, especially regarding the description, extent and evaluation of the planned measures.

93 The European Committee of the Regions has substantial importance in implementing EU legislation at the local and regional level and it adopted the Charta for Multilevel Governance in Europe that helps public authorities to promote multilevel governance in their policy efforts (Committee of the Regions, 2009).

The Austrian NECP faced the following critiques in relation to energy poverty: lack of concrete quantitative energy poverty targets, lack of clear measures and instruments to decrease energy poverty, as well as staged plans on how to implement relevant instruments. It also failed to link energy efficiency in energy poverty mitigation policies. Moreover, the Austrian NECP did not outline or mention the inclusion of vulnerable households (Hanke and Lowitzsch, 2020). Austrian key organisations and NGO's, such as, WWF, GLOBAL 2000, VCÖ, Austrian Court of Auditors, and Greenpeace criticised the Austrian Federal Government for failing to consult the public during the drafting phase of the NECP, although such a step was explicitly envisaged in the Governance Regulation (Article 10).[94] The Austrian Court of Auditors highlighted that the provided measures are vague and goals are rudimentary. More concretely, income-poor or energy poor households cannot fully participate in the transformation as envisaged by energy communities (Renewable Energy Directive) because they lack adequate devices or financial means. In the assessment of the Austrian NECP, the Commission recommended

> *"to better exploit the potential of the multilevel climate and energy dialogues to actively engage with regional and local authorities, social partners, civil society organizations, business community, investors and other relevant stakeholders and to discuss with them the different scenarios envisaged for its energy and climate policies" (European Commission, 2019b, p. 4).*

One expert of the climate coordination of the City of Vienna evaluated this recommendation and underlined:

> *"regarding the interlinking of energy/climate protection and social matter: there is room for improvement. However, I feel that responsibilities for that topic get more attention" (I3).*

Federal countries, such as Austria, face potential challenges in the following areas:

- they need additional coordination efforts and, if not provided, that may lead to incoherent or fragmentary policy (Galarraga et al., 2011);
- they have a larger amount of decision-makers who might block, postpone or hinder compromises (Tsebelis, 1995);
- they are facing difficulties to negotiate international agreements as the relevant competencies lie in the hands of federal states or sub-national levels of governments (Hudson, 2012);
- economic rivalry between two or more provincial levels can lead to a "race to the bottom" and levelling down environmental standards;
- unclear division of competences may prevent a successful implementation of climate policies.

94 It follows Aarhus procedural justice principles (Austrian Court of Auditors, 2019).

The other side of the coin is that federal systems have also advantages: mutual learning and positive competition can lead to a "race to the top" between the levels of governments. The subsidiarity principle can enhance regional autonomy and flexibility, leading to better (tailored) adaptation for local/ regional peculiarities; an the ability to be a progressive climate frontrunner (Benz et al. 2015; Kammerzell 2019) that closes the gap between fragmentary national climate policy. One expert referred, for instance, to Vienna's coordination effort to bring various policy groups together to create opportunities to act on climate change mitigation and adaptation:

> *"And the climate protection program has always made sure that something is done with all business groups and that there is an exchange and cooperation. Because the organisation of the magistrate is like a silo, but precisely the strategies such as Smart City or climate protection program and the new climate change adaptation strategy that is currently drafted - so I notice that more and more business groups are being thought of and worked here jointly" (I3).*

Experts also referred to the complex Austrian multilevel structure as a potential source of coordination problems. An expert exemplified the following process to overcome these coordination problems with the federal ministries whilst drafting the NECP:

> *"strategically, before going into negotiations with the ministries and the Austrian Federal Government, federal states together set one coherent agenda (I3)"*

in order to enter negotiations more unified to reach goals. This subsequent interview segment illustrates that Austria constitutes a specific case in terms of horizontal and vertical climate policy integration because it is characterised by a high level of federalism and corporatism that needs additional political coordination at the horizontal and the vertical level.[95] Moreover, the following quote illuminates very well how climate proposals "flow" within the multilevel governance structure between the various levels:

> *"Topics go top-down and bottom-up. Some topics are politically desired and these are then passed on to the magistrates and directorates via the city councils. Or, when it comes to strategies etc., for example, it comes from the magistrate and you listen to experts. This is how we do it, for example, with adaptation and with the climate protection program. Here, experts present proposals and drafts, and these are communicated upwards to the top level. The governmental program comes from above and there were clear announcements that the magistrate then had to implement it. (I3)"*

An example of absent *horizontal* policy coordination between the ministries was exemplified during the drafting phase of the new Energy Efficiency Act, in which the Austrian Federal Ministry of Environmental had a designated coordinating role. Different stakeholders were actively approached during the policy drafting process (e.g. legal assessment, drafting the climate strategy, and Federal Renovation Checks), and mostly the Chamber of Labour and the

95 Please see Brand and Pawloff (2014) for an in-depth analysis.

federal states. However, the absence of the Austrian Social Federal Ministry was criticised as their motivation to participate was low (I11). At the ministerial level, underlying challenges and segregation tendencies are also outlined by the expert from the Austrian Federal Social Ministry who explained that

> *"[y]ou have to acknowledge that these are two inherently unpopular political issues [climate and social policies]. And when you link them, it doesn't necessarily get easier. But the two should be more closely linked, although I know that the consumer department of the Austrian Ministry of Social Affairs was involved in developing the climate strategy. But our department was not involved and our perspective is missing (I7).*

The lack of coordination between ministries underscores the urgent need for policy integration and coherence, as demonstrated by the quote. The importance of policy coordination is not limited to the intersection of social and climate policy, but also extends to other actors such as the Austrian Federal Ministry of Finance, which could wield significant power in blocking climate policies as a veto player:

> *"In my opinion, silo-like thinking and working exist even more at the federal level. Just one example: during the negotiations on the national energy and climate plan, it was the first time that representatives from the Austrian Ministry of Finance were present. Until then that was not the case. Before that, all the ministries worked out their own proposals and only then, the Austrian Finance Ministry viewed the proposal and said it is impossible to fulfil. And, now they do it in advance. They say it's 'not possible' but at least they are there and help. (I3)"*

From a *vertical* climate policy integration perspective, Austrian housing policies are crucial policy areas in terms of the embeddedness in a multilevel governance setting. The federal level (Bund) is responsible to achieve the international set GHG emission targets, and goals agreed in the Paris Agreement (United Nations, 2015), but the important competencies for regulating the housing sector (and therefore the underlying energy efficiency and housing specific sector goals) lie in the hands of the nine Austrian provinces. Therefore, the federal ministries have no substantial competencies in the relevant sector of housing policies compared to the federal states. Fragmented horizontal responsibilities for housing policies on the federal states level obscure a closer integration. One expert from the Federal Austrian Social Ministry explained pessimistically:

> *"the inter-linkages with climate policies are non-existent. The climate strategy is being discussed, […], but it cannot dock with social policy, because of a missing formal contact person coordinating (social) housing at the federal level.[…] Climate policy is located at the federal state level, but housing is a competence of the provinces. There I see a problem with climate policy […]. Therefore, climate policy in housing misses its federal counterpart. These levels will never - only if consciously interlinked - meet" (I7).*

In their analysis of Austrian expert interviews (federal and federal states level), Steuer and Clar found that the federal states felt excluded in the sectorial target negotiations that took place between international and national levels. Especially, when it came down to building targets, they felt that the housing sector (energy efficiency) received too ambitious (13.5% between 2013 and 2020) and the transportation sector too low sectorial level targets from the Austrian Environmental Ministry (Steurer et al., 2020). Hence, they criticised that the Environmental Ministry put insufficient efforts in other sectors to cut GHG emissions. As a reaction, the Environmental Ministry abandoned all discussions during the negotiations with the provinces and decided the sectorial targets independently without including the federal states, who are ultimately responsible for achieving them (Streurer and Clar 2015).

To sum up, the analysis indicates that climate policy integration is aggravated during negotiations and policy framing between federal ministries but also top-down vertically between the federal states and the federal level. The Federal Environmental and Social Ministry seems to have difficulties to build synergies and find a base to approach the complex intersection of climate and social policy, *inter alia*, to ease energy poor households. One expert highlighted the urgent need for a

> *"formalised structure of cross-sectorial policy work. This is important to enable networking and to avoid getting stuck on the conversation level" (I3).*

One expert comes to a scathing judgement:

> *"So (exhales loudly) ... At the federal level, I think the scope for action is more limited than it might seem. At least that's my impression" (I2).*

6.4 Increasing Retrofitting Rates

As part of the Energy Performance of Buildings Directive (2018/844/EU), Member States had to provide **long-term renovation strategies** ("LTRS") including mandatory elements, such as a roadmap with measures and measurable progress indicators. The LTRS must encompass several indicative milestones, with the main goal of reducing GHG emissions by 80% in the building sector by 2050. A further aim concerns expected savings in energy consumption compared to 2015 levels, which are respectively 31% by 2030, 52% by 2040, and 68% by 2050 (BPIE, 2020a). The Buildings Performance Institute Europe (2020a, p. 15) assessment concluded that Austria's LTRS is lacking of a "*comprehensive national strategy with a clear long-term goal*". The most evident shortcomings concern cost-effectiveness and the absence of a coherent plan across Austria's multilevel governance structure. Coordination and the division of responsibilities between different governmental structures are particularly in need of revision. Moreover, no clear objective is mentioned (Castellazzi et al., 2019). Because of Austria's complex multilevel structure, objectives, measures and policies are distributed in an uncoordinated way. The consequence of this complex and unclear approach is the concealment of insufficient retrofitting measures that also affect the area of energy or income poor households. Numerous experts affirmed that the objective to retrofit 2% (new target 3%) of the buildings has been established at least 20 years ago, but improvements are still missing (I2). Steuer et al. concluded in their analysis that

> *"sub-national building policymakers [...] did not transpose EU rules directly but waited until they were pressured to do so by "federal intermediaries", not because of lack of expertise and/or funds, but simply because most of them were not interested in environmental issues" (Steurer et al., 2020, p. 10).*

Specifically, the LTRS lack coherence and contain mismatches with other Austrian programmes:

- While the LTRS contain the aim to reduce 80% of GHG emissions in the building sector by 2050[96], the NECP (2019) specifies the aim to be climate neutral by 2050 (net- zero emissions). The newest Governmental Program, however, contains the goal to be climate neutral until 2040.
- The NECP (2019) contains the goal to increase the retrofitting rate from 1% to 2% in the period 2020-2030. The current Governmental Program (2020-2024), foresees a more ambitious goal to increase the retrofitting rate up to 3% p.a. in a socially compatible manner (Federal Chancellery, 2020, p. 108). The LTRS , on the other side, does not state a concrete goal but outlines associated costs.
- The LTRS foresees a continuation of the renovation activities but is not ambitious and does not to state an increased renovation rate. In addition, the theoretically estimated Green Gas share has been miscalculated and leads to incorrect assumptions on the path to climate neutrality. If the "Green Gas" mistake would be corrected, Austria could only reduce its GHG emissions by 77% and not by 80-95% as foreseen. This target lies under the set minimum and would constitute an EU violation.

The LTRS could have been an important program in furthering the decarbonisation agenda, however, it lacks forward-looking innovative measures and strategies that are concerned, for instance, with the tenant landlord dilemma.[97]

96 It is not legally binding.

97 Also, the Buildings Performance Institute Europe (2020a) assessed Austrian policies to target the worst performing segments, split-incentives, market failures and alleviation of energy poverty as incomplete.

To summarise, the LTRS does not contain concrete actions, renovation concepts and plans, measures to ease energy poverty, it presumably violates EU law (Energy Performance of Buildings Directive), and it presents inconsistent or contradictory provisions. The Austrian LTRS “fails to meet the minimum requirement of the EU-building directive”. As a result, GLOBAL 2000 and ÖKOBÜRO[98] filed an EU-complaint against the Austrian Federal Government for the unambitious LTRS (Friends of the Earth Europe, 2020). Legally, the EU-complaint constitutes a first step towards an EU infringement procedure.[99]

6.5 Assessing the Success: Addressing Energy Poverty in Austria

Only some European governments consider energy poverty as a social and climate problem in its own right. An important question is therefore, h*ow does the current Austrian government address energy poverty?*

The **Austrian Governmental Programme** (2020 - 2024) constitutes an outline of agreed upon action by the parties in the governing coalition. The Austrian Governmental Programme (2020 - 2024) constitutes an outline of agreed-upon action by the parties in the governing coalition. A major emphasis of this program is on climate protection, aiming to achieve climate neutrality by 2040, which is a decade ahead of the EU's climate-neutrality target. Only Sweden and Finland have set more ambitious goals than the EU, which puts Austria in a prime position relative to the ambitions of its overall climate policies.[100] Compared to the previous government, which made cuts of €300 million in the policy areas of climate and energy, the current coalition has frequently pledged increased funding to climate initiatives. This strong emphasis on climate issues stems primarily from participation of the Green party in the governing coalition, alongside the conservative ÖVP (Austrian People's Party). The Governmental Program acknowledges justice principles and the potential climate-related costs for households:

> *“We consider climate protection measures as a significant opportunity for justice [..]. The climate-friendly conversion of all sectors, in particular the energy system and the*

98 Ökobüro - Alliance of the Environment Movement is an umbrella association of Austrian environmental protection organizations. As an alliance, Ökobüro includes 16 different environmental, nature and animal protection organizations including GLOBAL 2000 (Ökobüro, 2021). GLOBAL 2000 is a member of Friends of the Earth, which is the largest international network of environmental organizations (GLOBAL 2000, 2021).

99 An infringement procedure constitutes legal action against an EU country that failed to implement EU law. Possible consequences are financial penalties (European Commission, 2021e).

100 The primary issues to be handled in the governmental period are intergenerational conflict and the present generation's obligation to leave a healthy environment.

infrastructure, is taking into account the cost to households and businesses. Cases of social hardship are avoided in any case [...] (Federal Chancellery, 2020, p. 102).”

While climate protection was given a prime position in the Governmental Programme, energy poverty is not mentioned and dedicated instruments for energy poor households are not adequately addressed.[101] Critical intersections between socially acceptable climate and housing policies are not detailed. The neglect of energy poverty in the government’s program can also be attributed to the fact that it is not an established topic thus not deemed to be policy priority.[102]

The insufficient implementation is partly due to the Austrian government not acknowledging energy poverty as a separate issue, but rather as a part of general poverty. Expert interviewees who represented the Austrian Federal Social Ministry confirmed this framing. They defined it as one component of income poverty and did not acknowledge the issue as a stand-alone problem**:** *“I think income is a good indicator to work with”(I7)*. Bouzarovski et al. (2021) convincingly argued that in Germany, Sweden and Denmark, energy poverty is treated as part of general income poverty domain and advocated in favour of addressing it via social policy. This may also apply to Austria. Depending on the chosen definition and salience of energy poverty in a country, there is a tendency for welfare states to subsume it under the umbrella of social policy rather than as an intersectoral policy issue to be handled across various ministries. However, because energy poverty is a cross-cutting intersectoral issue, it requires a strong collaboration between welfare offices and ministries from at least four departments, which are located along different levels of governance (climate, housing, social and energy). If only focusing on one policy area, the expert describes:

“Social policy measures are oriented towards income. But, you have to be honest here, it doesn't always lead to the best political solutions. Also due to the lack of data” (I7).

The quote signals two important pitfalls:

1.) If energy poverty is acknowledged primarily as a social policy problem focussing on low income and high energy prices, this can lead to an identification problem because energy inefficiency of the housing is not fully acknowledged. Social policy instruments are typically aimed at guaranteeing a particular level of income or provide heating allowances to utility bills; Solely income-centred energy poverty instruments typically focus on short-termed palliative remedies to alleviate households quickly of their impaired situation (e.g. arrears on utility bills).

101 Also, the previous Governmental Program (2017-2022) did not outline the issue of energy poverty or devise dedicated instruments to combat it.

102 The Governmental Program referred to the Energy Efficiency Act and measures for retrofits and the exchange of devices in the dedicated poverty measures chapter (Federal Chancellery, 2020).

These instruments neglect the cause of the problem (e.g. structural housings problems), which would require more substantial financial support, housing/climate reforms, and/or subsidies. Furthermore, the measures do not provide any incentives for efficiency improvements.

2.) Lack of coherent and harmonised statistical EU data is a major hindrance to measure the multidimensional problem of energy poverty.

A narrow conceptualisation/ understanding of energy poverty can be attributed also to a lack of inter-sectorial coordination and brief exchange at the federal level. This becomes apparent when experts pointed out that when the Austrian Federal Social Ministry commissioned a study on energy poverty, members of the Austrian Federal Environmental Ministry were not asked to join the advisory board (BMASK 2018b). When, however, asked about junctions with climate policies, the key expert from the Federal Austrian Social Ministry acknowledges the intersections between climate and social policy:

> *"Climate policy is also social policy. They are definitely interdependent. Currently, climate policy can target the lower social strata the most, for instance, through subsidies or energy prices. Simultaneously, it would require redistribution" (I7).*

Likewise, during the drafting of the #mission 2030[103], which constituted Austrian's roadmap to meet the EU 2030 targets and the full withdrawal from fossil energy, the Austrian Federal Environmental Ministry was not included in the program's development and budget calculations (Fellner et al., 2018; Laufer, 2018). The projects focusing on climate policy did not outline roadmaps, time frames, concrete instruments and -most importantly for the energy poverty domain- responsibilities between the ministries and various horizontal and vertical governmental levels (Fellner et al., 2018; Laufer, 2018). From the expert's point of view, #mission 2030 was developed without

> *"including the relevant department dealing with general social policy, only the department for consumer protection was included" (I7).*

MS had to define energy poverty under the EU Governance Regulation in their National Energy and Climate Plan. However, there is substantial divergence between the EU, MS (conditioned on energy poverty being formally defined at all), and scientifically debated energy poverty definitions. As EU MS define vulnerable consumers by referring to energy poverty based on various criteria (which leads to an array of population groups that are at risk), there are large

103 Meanwhile, the #mission2030 is out-dated whilst the dissertation is submitted. The Governmental Program and the long-term strategy are the current strategies in Austria.

differences between the definitions and consequent operationalization's of energy poverty in the MS (Kyprianou et al., 2019).[104]

Within the NECP, Austria utilises an *informal* definition that has been suggested in a study by the Vienna University of Economics and Business on behalf of the Austrian Federal Ministry of Labour, Social Affairs, Health and Consumer Protection, which was influenced by the energy poverty definition of the energy regulator E-Control (Federal Ministry for Sustainability and Tourism, 2019, p. 97):

> *"A household is considered energy poor if its income is below the at-risk-of-poverty threshold and, at the same time, it has to cover above-average energy costs."*

Within the NECP, it is acknowledged that this definition is only a suggestion and one of many energy poverty definitions.[105] This indicates the possibility to overcome the weakness of this conceptualisation and to include a more suitable definition that is more context-dependent or can address structural factors.

One implication of this definition is that energy poor are also necessarily income poor. However, as explained in chapter 2.4, energy poverty is not to be equated with income poverty: people who live in income poverty are not automatically energy poor and energy poverty does not necessarily go hand in hand with low income (Heindl et al., 2017). Kyprianou et al. (2019, p. 47) highlighted that, due to this pitfall, vulnerable consumers "may not be a true representation of the energy poor population." Several other issues arise when using this definition to operationalize energy poverty. For instance, the concept of 'above-average energy costs' in the outlined definition are set at a 140% threshold level of energy costs. However, the chosen threshold can be contested, as it may be considered both arbitrary and normative as outlined in chapter 2.1 (E-Control, 2013; Federal Social Ministry and WU Wien, 2018). Arguably the main shortcoming of the proposed working definition is that it cannot account for inefficient dwellings. However, just a view lines later, the NECP refers to the empirical results of the Austrian Federal Environment Agency (2019, p. 98), in which it is stressed that

> *"the main reason for the high energy costs incurred by energy-poor households is the poor thermal quality of the building envelope and the use of an expensive energy source for heating."*

It is difficult to understand, if inefficient buildings are recognised as a core driver of energy poverty, why this aspect is neglected in the official definition, with the focus solely placed on

104 Energy poverty is based on the definition of vulnerable consumers.

105 Proposal to use multiple indicators: household income, housing expenses, energy costs; information about past due bills, disconnections, installations of pre-paid meters.

thresholds for average energy consumption. The reasons are speculative, but it is possible to suggest that, because the inefficiency of the buildings is measured through "subjective/consensual" (self-reported) indicator, experts or policy makers may consider such an indicator to be 'less reliable'. Other plausible reasons concern the unavailability of building-related comparable data for Austria. Or it may reflect convention, since one of the first institutions to address energy poverty (E-Control, which is an energy regulator) excluded this subjective energy poverty indicator. Boardman's (2013, p. 21) critique, however, aptly illustrates that "*who is fuel poor depends on the definition; but the definition depends on who you want to focus on and this involves political judgment*".

Because of this neglected aspect, according to this definition, the estimated number of energy poor households amount to 3.2% of all Austrian housing in 2016 (Federal Ministry for Sustainability and Tourism, 2019, p. 97). The expert from the social NGO Caritas emphasised that high energy bills usually not only originate from an above average energy consumption, instead, they are caused by structural conditions that are outside of the household's control (I6). If energy inefficiency is included in the analysis, the amount of energy poor households is significantly higher in Austria and amounts to approximately to 7-12% (see previous chapter or Seebauer et al., 2019).

The energy regulator E-Control was one of the first institutions that provided an energy poverty definition for Austria in 2013. According to E-Control

> "*households that have an income below the risk-of-poverty threshold and at the same time have above-average energy costs should be classified as energy-poor*" (E-Control, 2013, p. 4).

Similar to the Austrian official benchmark indicator, their definition did not include housing faults or energy inefficiency, which results in a particular housing and socioeconomic segment that the experts described during the interview:

> *"big old housings, were a social component becomes evident, primarily in the countryside. If it comes down to our definition, it's the single widowers who live in family farm houses and who live alone and inhabit large living space and have high absolute costs."*

Considering a further approach to energy poverty based on people who approach social assistance counselling centres and report energy related issues, they are referred to the social NGO Caritas. Caritas does not provide a concrete energy poverty definition but their working definition includes financial burdens of paying for energy, as well as, self-restrictions on heating.[106] The Caritas is an NGO that offers energy support through the project "*Verbund Stromhilfefond*" for energy poor households. The expert relies on internal statistical data of their clients and summarises the typical energy poor profiles in such ways:

> *"a large proportion is privately rented, and it increased since 2016. […] Homeowners are a small amount […] The overall share in the energy poverty group is about 7% […]. It is [energy poverty] not only a city problem. The problems are just different"* (I6).

Diverging definitions of energy poverty lead to contradictory results, targeting mechanisms and foci (as shown in EU-SILC results chapter 9). This difference between the two Austrian key institutions dealing with energy poverty is remarkable because the energy poor segments differ substantially depending on the applied definition. The current Austrian expenditure-based focus leads to a blindspot as many energy-poor households can be found not only in the highest but also in the lowest energy spending categories, which would point to involuntary energy self-restrictions.

To conclude, there are no special measures outlined to tackle energy poverty in Austrias Governmental Program, and even the relevant chapter "introduction of a socially acceptable retrofitting order" did not address this issue. Consequently, if goals or objectives are left unaddressed, a clear opportunity for improvement is missed: if problems are not specified, their need for action is also non-existent. This problem can be traced to Austria's current energy poverty definition that does not include building characteristics and housing faults in the analysis. Therefore, one result of this analysis is that energy poverty in the Austrian governmental policy context is insufficiently addressed.

6.6 Federal Instruments Dedicated to Energy Poverty Alleviation

This sub-chapter focuses on federal instruments in Austria that aim to address the issue of energy poverty among households. It examines major laws and acts, such as the Climate Protection Law which sets the overall climate targets in Austria, the Energy Efficiency Act, Green Electricity Act, Environmental Subsidy Act, as well as federal funding for building retrofitting, which are all identified as effective instruments to alleviate energy poverty. The article evaluates the impact of these instruments on energy poor households and assesses who benefits from the measures. It aims to determine the efficiency and effectiveness of the

106 Please see the detailed description of the project's own definition of energy poverty (Christanell et al., 2014, p. 161).

instruments in reaching energy poor households, while also considering whether the measures are designed to provide short or long-term solutions to tackle energy poverty.

The structure follows this line of analysis: for every instrument or law, *first*, a short general introduction is given. *Second*, if the instrument contains major targets or objectives, then current Austrian national achievements are presented. *Third*, if necessary to understand the Austrian policy context, general criticism is given to frame the embeddedness of the policy instrument. *Fourth*, efficacy, synergies, barriers, pitfalls or misalignments connected to energy poverty are evaluated. As the Green Electricity Act and the Energy Efficiency Act are outlined in the Austrian NECP as particular legal instruments tackling energy poverty, they will be given a more room for an in-depth analysis. The social project "Verbund Stromhilfehonds" by the Caritas will be presented in this sub-chapter and assessed, as it constitutes a federal level instrument for energy poor households.

6.7 Climate Protection Law

The Climate Protection Law ("CPL"; *Klimaschutzgesetz* BGBl. I Nr. 106/2011) lays down GHG emission thresholds for sectors such as transport, buildings, agriculture, non-ETS industry and waste that are not covered under the EU Emissions Trading System (reduction of GHG emission (non-ETS) by -36% compared to 2005). It should enable the coordinated development and implementation of effective climate protection measures. It, thus, mainly applies purely procedural regulations for climate protection planning outside the ETS sector. That is why it is also referred to as the "contract or negotiation law" (Ennöckl et al., 2019, p. 787).

The CPL established a National Climate Protection Committee (Article 4) to counsel on fundamental climate-related questions and to develop long-term scenarios, climate protection strategies, and instruments. It should advise on fundamental issues relating to Austrian climate policy, and the committee meets at least once a year.[107] This committee comprises representatives from the ministries, nine federal states, NGOs, research (1 person), social partners, interest groups and energy providers (36 individuals).

Although the CPL was the product of over three years of negotiations between the Austrian Federal Government and the federal states, the law was criticised for presenting several shortcomings. For instance, it did not state ambitious emission targets for sectors beyond what

107 Resolutions must be passed with a majority of three quarters, with at least half of the representatives present.

had already been formulated by the EC. Furthermore, clear horizontal and vertical responsibilities between the various levels of government are missing, as well as sanctioning mechanisms (for the federal states) for eventually missed targets. If Austria exceeds EU proposed emission ceilings, additional measures should be introduced and carried out or current measures should be strengthened (§ 3 CPL). The law also does not have legal mechanisms for an *ex-ante* evaluation of sectorial measures. In the similar vein, an expert interviewee from the climate coordination authorities in Vienna deemed the CPL as not ambitious and far-reaching:

> *"The Federal Climate Law, yes there are no measures and the Climate Protection Law only says what I find ridiculous, it only says that the federal and state level have to develop measures together in order to achieve these [climate] targets. It only takes those EU obligatory goals […] and the Climate Protection Law does nothing else than copying the table" (I3).*

The Austrian Federal Environment Ministry could not find consensus on how to share costs for emission certificates if the sectorial targets are not met. As the result, if federal states do not comply with, there are no established sanctioning mechanisms outlined (Steurer et al., 2020). Also, the National Climate Protection Committee was criticised because it was not equipped with substantive decision power (I3):[108]

> *"It is branded as a talking-shop by the public. Partly, it is an information exchange, but what one would assume that far-fetching discussions and substantive decisions take place... that is not the case […]. Because of its composition, it is evidently that there will never be agreement. All parties are included, and of course some say A and others say B. Then we have the Chamber of Commerce and the Chamber of Labour. Also, they have different interests. And, all the affected ministries including the Austrian Federal Chancellery. They all have different approaches. In most of the cases, something is presented and the Austrian Federal Ministry of Finance says "we don't have the money"[…]. I have never seen a sustainable resolution in there."*

As a result of the amendment of the CPL in 2017, the division of emission ceilings into sectors is based on proposals of the Federal Austrian Ministry of Climate Action; the National Climate Protection Committee is not involved and the possibility to propose or design measures and consultation was severely limited. The primary objective of the law, to enable the coordinated implementation of effective climate protection instruments was not achieved, and EU GHG emission targets exceeded the EU binding levels. To achieve climate neutrality, as envisaged by the Austrian 2040 target, or in the EU until 2050, respectively, the climate neutrality objective must be explicitly anchored in the CPL to ensure its legal effectiveness.

108 At first, the primary responsibility of the National Climate Protection Committee was to provide guidance and create climate protection strategies that would serve as the groundwork for establishing emission limits for various sectors.

6.7.1 Energy Efficiency Act

The Energy Efficiency Act [*Energieeffizienzgesetz* BGBl. I No 72/2014] is a law that sets the target to improve primary energy intensity by 25-30% compared to 2015, and to expand the use of renewable energy as a proportion of gross overall consumption to 46-50% by 2030. According to the Energy Efficiency Directive (2012/27/EU), Austria's final energy consumption should not exceed 1,050 Petajoules (PJ) in 2020. In 2019, however, 1,139 (PJ) were consumed, meaning that the target will likely be missed (BMK, 2020). MS are obliged to achieve a cumulative end-use energy saving of at least 0.8% of final energy consumption annually (2021-2030). Thus, MS can choose to develop Energy Efficiency Obligation schemes or/and using alternative policy instruments. Austria implemented a combination of both (Rosenow et al., 2015). Energy providers have core responsibilities to achieve greater energy efficiency if they set at least 25 Gigawatt hours (GWh) of energy to end consumers (transposed from Art. 7 EED 2018/2002/EU). Energy providers are obliged to implement efficiency measures for themselves, their end customers, other end energy consumers or to make a corresponding compensation payment of 0.6% of their prior energy sales volume (Austrian Energy Agency, 2021b). In more detail, the law stipulates that energy providers must dedicate 40% (corresponds to 2.1 PJ) of their energy efficiency measures in private households towards decreasing energy consumption (measures for heating, air conditioning, cooking, or lightning). In 2019, 430 Austrian energy companies were obliged to do so (BMK, 2020).[109]

Measures for low-income households receive an additional factor of 1.5 (Austrian Court of Auditors, 2019). These include energy counselling or a substitution of appliances.[110] Experts and NGO's (e.g. GLOBAL 2000) criticised the low weighting factor of 1.5 for low-income households and called for an increase to 5% to reward action for vulnerable households.[111] However, increasing the weighting factor alone is of little effect if not combined with a specific mechanism to target energy poor households. One of the interviewed experts emphasized that the annual energy savings obligations were very easy to fulfil so that energy suppliers did not even need to target energy poor households as they typically overachieve the annual targets anyways (BMK, 2020; I2).

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109 The majority of the cumulative energy savings comes from energy taxes and by heating systems (exchange) and hot water (BMK, 2020).

110 Low-income households are people with primary residence in Austria and who receive the green electricity fee relieve (§ 5 (1) Z 14 EEffG).

111 Energy suppliers with more than 49 employees and a turnover of more than 10 million euros or a balance sheet total of more than 10 million euros must set up an energy efficiency advice centre for their customers.

In addition, according to Article 27 (4) Z4 EEffG allows energy suppliers to transfer savings to the following years (maximum 4 years). As energy suppliers are not required to conduct social projects *per se* (including energy poor measures), the weighting factor only constitutes a soft incentive to lower end-use energy savings. This issue stems from the fact that the Energy Efficiency Directive does not require energy suppliers to devise specific measures for income or energy poor households. Instead, it requires adopting generic measures for private households. Typical instruments include the distribution of Light-Emitting-Diode bulbs, water reducing filters, or "goody bags" (Austrian Energy Agency, 2021d; I2). Overall, measures targeting income poor households accounted for 0.66 PJ in Austria (between 2014-2018). Relative to the total annual savings (83.94 PJ), the overall share coming from low-income households is 0.79%, which can be considered negligible (BMK, 2020). Referring to measures targeting energy poverty, one expert alluded to compliance issues with the Energy Efficiency Act:

> *„So measures on the federal level, quite frankly, there are relatively few. So what exists is the Green Electricity Act.[…] And maybe we have the Energy Efficiency Act on the federal level. But it does not define a support object; it is not specified that you have to do something"(I2).*

From another point of view, the expert from the Caritas commented that large energy providers have a general social responsibility to their clients and offer several remedies for energy poor households (I6). For instance, during the energy counselling, they recommend to choose big energy providers, even if smaller ones may offer cheaper energy tariffs. The reason for this is that small energy providers are more likely to be reluctant to support and offer solutions to energy poor households who cannot pay their bills on time:

> *"It is a risk to change to a cheap energy provider, because companies like Wien Energie, they have so many clients. If households have issues,… it sounds a little evil, but they don't care. In the sense, they have buffers to cushion. Then they say, "yes, we can make an instalment or we go together to a debt counselling. We can solve the issue together". Cheap energy providers will cut-off your electricity, because they do not care. Either you pay or you are out. For clients with uncertainties, this is not something advisable. […] Big companies have a social responsibility in their neck" (I6).*

However, several interviews with experts from the Austrian energy regulator revealed that the energy poverty reduction schemes conceived by large providers to fulfill their obligations under the Energy Efficiency Act are seldom high-investment projects, such as the exchange of windows or boiler exchange (I2). The unanswered question, therefore, is to what extent small-scale measures (e.g. LED bulbs) are effective in tackling high energy costs or housing renovations (e.g. leaking windows). Corporate Social Responsibility, "green washing" and a certain “*social impetus*“ are mentioned as reasons why energy providers “at least take some money in their hands” to help energy poor households (I2).

A new Energy Efficiency Act is currently being drafted in Austria. According to the Governmental Programme, it will include a provision for the energy providers’ savings obligations to be "supplemented by the possibility of a replacement payment in a fund" (Federal Chancellery, 2020, p. 235). These funds are then to be used to finance energy efficiency measures in households "with special consideration of cases of social hardship" (Federal Chancellery, 2020, p. 102). Reflecting the increasing salience of energy poverty in the national agenda, the Austrian National Council has allocated €50 million to measures against energy poverty for 2021 and 2022 (Pucher, 2020).

6.7.2 Green Electricity Act

The **Green Electricity Act** [*Ökostromgesetz* BGBl. I Nr. 75/2011] has been in place since 2002 and will remain until the Renewable Energy Expansion Act[112] [Erneuerbaren-Ausbau-Gesetz - EAG] is ratified. With this law, Austria has a system for financing green electricity that considers various regenerative energy technologies and promotes the expansion of renewable energies. It specifies targets for transitioning to renewable energy sources (biogas, wind power, small hydropower, and photovoltaic systems).[113] Individual federal states targets, however, are not defined in this law. Regarding energy security, Austria aims to reach 100% renewable electricity by 2030 to eliminate reliance on imported fossil fuels. In 2019, the share was 73% (Austrian Energy Agency, 2021c). In absolute terms, as well as proportionally, Vienna generates the smallest amount of renewable electricity compared to the other federal states (Austrian Energy Agency, 2021c). Financing green electricity is ensured through a pay-as-you-go system via end consumers[114]. The expert from the Austrian Energy Regulator explains it will

112 The Renewable Energy Expansion Act contains an increase of 27 TWH renewable electricity generation. In more detail, it entails the energy target for increasing 11 TWh for photovoltaic (create a ‘100 000 rooftops solar panel and small-scale storage programme’), 10 TWh for wind power, 5 TWH for hydropower, and 1 TWh for biomass.

113 Based on the Renewable Energy Expansion Act, 27 Terawatt-hour (TWh) of electricity should be generated with renewable energies by 2030.

114 The Green Electricity Subsidy consist of the Green Electricity Subsidy and the green electricity lump sum: the green electricity rate was last set in the Green Electricity Act in 2021 for the years 2021 to 2023 and is an annual fixed amount of €35.97 excluding sales tax for household customers. The Green Electricity Subsidy is redefined annually by the Green Electricity Subsidy Regulation. It is a uniform percentage surcharge on the network usage fee and the network loss fee. This means that this contribution is consumption-based and that you also pay a higher green electricity subsidy if you use more electricity. The Green Electricity Subsidy is charged in cents per kWh. In 2021 amounts to around €56 per year for an average household with an annual consumption of 3,500 kWh (E-Control, 2021). In 2022, the fee was not collected due to high energy prices.

> *“not lead to a prevention of social exclusion, as electricity prices will certainly increase. It will be the question how it is going to be redistributed” (I2).*

The promotion of renewable energies through the Green Electricity Act has raised several discussions surrounding costs. For instance, the expansion of green electricity has led to a fall in the price of the electricity exchange, from which large wholesale businesses benefit; while the low wholesale electricity price is only partially or not at all received by private households.

Low-income households are relieved of additional costs for green electricity production by the so-called Green Electricity Relief. The relief is conditioned on several criteria, but most importantly on households who have - ORF-GIS[115] exemptions (telephone, broadcasting or TV charges). To receive the relief, households need to apply to the ORF-GIS authority. The reason why the responsibility of distributing the Green Electricity Relief is given to the ORF-GIS is because it aims to support households below a certain income level and ensure that energy providers do not need to examine whether a given household satisfies the eligibility criteria. To avoid this bureaucratic step, the responsibility of handling the Green Electricity Relief was docked onto the ORF-GIS institution.

The Austrian Court of Auditors (2019) evaluated the effectiveness and accuracy of this mechanism and concluded that support for energy poor households is not ensured. The reason lies in the fact that households who do not receive ORF-GIS relief are not eligible for the Green Electricity Relief. Furthermore, not all households who might submit an application actually apply or even make use of the ORF-GIS exemption. An official evaluation of the relief is outstanding. However, it is safe to claim that a large proportion of energy poor households do not benefit from the relief, such as:

a.) half of households who are eligible t do not make use of it, although there is a low rejection rate (Veigl-Guthann, 2021);

b.) energy poor are not directly addressed because the two eligibility criteria are 1.) a low-income threshold (one person household €1.120,54 in 2021) and 2.) being eligible for the ORF-GIS exemption.

The reasons for half of eligible households not receiving relief are unclear but could be due to the complicated application process, lack of knowledge about the relief, or needing more information than what is required for the ORF-GIS application. Moreover, educational campaigns are lacking, since -for instance- many are unaware of the additional requirement to

115 ORF is an Austrian Broadcasting Corporation and GIS (in German: Gebühren-Info-Service) is the so-called GIS Fee Info Service GmbH (GIS) has been in charge of collecting and billing the broadcasting fee in Austria. It thus implements the Broadcasting Fee Act and is subject to the instructions of the Federal Minister of Finance in this regard.

fill out a registration form. A further complication lies in the fact that, to be eligible for the ORF-GIS exemption, an individual must have the contract with the electricity company in their name (grid usage contract). Let us consider, for example, two people living in the same household. One person has the contract with the energy provider and the other is eligible for relief from ORF-GIS. In such a situation, the household would be automatically excluded from the Green Electricity Relief. Our key expert was sceptical about the renewables contribution of the Green Electricity Act and pointed to loopholes:

> *"In the case of green electricity, I pay depending on my consumption. In detail, it means if I am "unlucky" and have a big family, low income, and an old wretched house, I pay over unduly more for the climate target. […] There is the possibility to be relieved from the green electricity fee, but I mean it is in this system: there is a loophole and there is a loophole, too. […] Why does my network operator [ORF-GIS: broadcasting service] need to know that financially I am currently bad off? This is a joke; we need an own institution which regulates this.[…] That means the system causes additional costs; costs that the people have to carry" (I2).*

Although the instrument was aimed at energy poor households, as outlined in the Austrian NECP (Federal Ministry for Sustainability and Tourism, 2019, p. 51), it contains an identification problem; it is also short-termed and neglects the importance of the inefficient building stock. From a more general point of view, according to the Chamber of Labour, private households who use a quarter of all Austrian electricity approximately pay half of the extraction costs, which makes the amount of the green electricity contribution questionable (Chamber of Labour, 2020b). Industry is most responsible for energy consumption but does not pay as much as private households proportionally to its consumption. The Chamber of Labour evaluated the renewable Energy Expansion Act and recommended a cost ceiling for private households (approx. €100 p.a.) and a simplification to claim the exemption from the Green Electricity fee for income poor households. The Court of Auditors recommended the Federal Ministry for Climate Action to evaluate the measures to fight energy poverty regarding their accuracy, appropriateness and effectiveness. The public authority does not consider the concept to be suitable to target effectively low-income households (Austrian Court of Auditors, 2019). To conclude, the social compatibility of the system of the Green Electricity Relief is insufficient and is challenged to identify energy poor households.

6.7.3 Environmental Subsidy Act

The Environmental Subsidy Act (*Umweltförderungsgesetz* BGBl. Nr. 185/1993/ BGBl. I Nr. 114/2020) is an incentivising law that regulates the support of schemes to protect the environment for several sectors. For the new period, over 764 million euros in the environmental budget are dedicated (Wien Energie, 2023):

- Switch to climate-friendly heating (district heating, biomass, heat pump) and thermal building renovation 2023-2026: €480 million/a
- Expansion of local and district heating and decarbonization 2023–2026: €93 million /a
- Low-income households (SFH, MFH) 2023 – 2026 €142 million/a
- Energy efficiency measures: additional 2022 - 2030 €190 million/year
- Company and communal climate protection projects: 2023 million € 2024 – 2026 150 million €/a.

Since 2020, in newly constructed buildings, the installation of oil-fired boilers has been prohibited (Ölkesseleinbauverbotsgesetz BGBl. I Nr. 6/2020). From 2021, oil-fired boilers are also forbidden in case of retrofitting activities and renewable energy sources need to be used when replacing existing oil-fired heating systems. In 2025, all old heating boilers older than 25 years lose their operating permit and should be exchanged for renewable heating systems in a "socially compatible manner" to cushion social hardship (BMNT and BMVIT, 2018). By 2035, all oil-fired heating systems should be exchanged in Austria.[116] The proposed time horizon, however, remains too long (year 2025) and it is unclear both what a "socially compatible manner" means and what actions are taken to mitigate the risks posed to energy poor households. It is only detailed that "all measures are long term, are based on a tapering scale and socially staggered tariffs and subsidies" (Federal Chancellery, 2020). This explanation features uncertainties and questions about financing the transformation, particularly for renters living in multi-storey buildings (Tenancy Law uncertainties) and energy poor households. The Chamber of Labour, however, urges establishing and enhancing consumer rights for households who do not have the decision-making authority of choosing their own heat suppliers (Chamber of Labour, 2020a). Private individuals in semi-detached or detached houses obtain up to €5.000 for replacing a fossil-fuelled heating system with a climate-friendly one. Funding of up to €6.000 is available for the thermal refurbishment of the envelope. The subsidy amounts up to €5.000 in single-family or dual-family buildings and up to €1.000 in multi-storey apartment blocks. The maximum subsidy percentage amounts up to 35% (for leave oil and gas behind).[117]

116 Starting in 2025, a replacement of gas heating is planned. In new construction, gas boilers/ new installations are prohibited. Approximately 600.000 household heat with heating oil in Austria, predominantly in the western alpine regions of Austria (Klimaaktiv & BMK, 2020; Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology, 2021a).

117 Klimaaktiv offers an online tool, the "Hexit matrix", in order to search for customized energy provider offers.

The Environmental Subsidy Act was amended in October 2020. It incentivises investments for climate friendly heating systems in 2021/2022. The federal state allocated €100 million for income poor households to cushion social hardship and cover increased costs because of thermal and energetic renovation measures. A substantial amount of the subsidy is apportioned to low-income households, which constitutes an important turning point in policy.

The Austrian Social Democrats have criticised the fact that no definition of "low-income household" has been provided and it remains unclear who will benefit from this funding. Hence, they filed a request to the Austrian Federal Environmental Ministry to define income poor households and to relate to energy poor households (National Council, 2020).[118] Moreover, it remains unaddressed how income and energy poor households living in multi-storey buildings with different legal entities will benefit from the heating systems exchange subsidy.[119]

6.7.4 Federal Renovation Check for Building Retrofitting

Launched in 2009, the Austrian federal subsidy for **building retrofitting (Federal Renovation Check)** aims to reduce energy consumption through building insulation and heating system upgrade. The subsidy stipulates thermal retrofitting (of private detached or semi-detached houses) according to "OIB guideline 6 - Energy saving and thermal insulation" and the "Klimaaktiv-standards" (reduction of minimum 40% of heating demand) for residential buildings. Buildings older than 20 years are eligible for funding and financial support is granted for thermal insulation of roofs, external walls, floors, replacement of windows, exterior doors and for changing the heating system. The subsidy takes the form of a one-off, non-refundable payment (onetime non-repayable investment expense). The grant is worth between €4.000 and €9.000 depending on the level of renovation, but it covers up to a maximum of 35% of the overall investment costs for the thermal upgrade. Also, smaller renovation works (e.g. exchange of windows) are funded in 2021 (Renovation Check in one or two-family houses). The Federal Renovation Check specifies a target group: building owners or tenants of a one-/ two-family house or terrace house can submit an application. Since this subsidy is only available to homeowner and tenants in one-/ two-family houses, it prevents -or at least makes it difficult-

118 The Green Minister Leonore Gewessler proposed to evaluate the measures for income-poor households after one year, rather than the official reporting obligation three years after inception of the measure (Die Ökoenergie. Zeitung zur Energiewende, 2020).

119 More details on the matter of "social hardship" will be outlined in the new Energy Efficiency law (Klimaaktiv & BMK, 2020). The review of the Energy Efficiency Act 2023 ended on January 18, 2023.

for energy-poor households living in inefficient buildings to take advantage of it. The key expert from the Austrian Federal Social Ministry said

> *"subsidising alternative sustainable heating systems actually means promoting those who can afford them anyway" (I7).*

The new amendments on the Environmental Subsidy Act, however, will include income-poor households. It remains to be seen how the targeting instrument will develop in the future, as according to experts, traditionally these are middle-class subsidies designed to reach households living in their own detached houses who a.) already plan a retrofit and who could afford upfront investment costs nevertheless, and b.) for whom the subsidy is just an add up (I2; Schleich, 2019; Seebauer et al., 2019). As the fund favours rural detached houses over urban apartments, it is difficult to apply for multi-storey retrofitting funding where, in most cases, all flat owners first have to agree to undertake a retrofit in the building.[120] The current Austrian subsidy scheme does not incentivise or offer higher funding rates (or a negative tax, or a tax refund) to buildings owned or inhabited by energy poor or income poor. It also does not prioritise inefficient buildings from the 1945 - 1980 construction period, which feature very high energy demand in Austria.[121]

6.7.5 Awareness Raising Campaigns

Energy awareness campaigns for energy poor households are considered being core instrument to stipulate behavioural change in a long run (BMVIT & BMNT, 2018). The *klimaaktiv* program is a non-binding voluntary instrument to reward high quality, climate-friendly products and services through information, consultation and education, that has been in place since 2004.[122] It is a multilevel governance instrument, which coordinates federal awareness-building schemes and provides a communication and a coordination platform (Seebauer et al., 2019). The program is connected to the Austrian Energy Agency, which implements climate programs and projects. From a multilevel governance perspective, klimaaktiv coordinates the e5 program for energy-efficient towns and municipalities (e5 Austria, 2021). A weakness is the impact assessment of the measures, as only numbers of website visits or brochures printed are

120 The experts point out that homeowners/ landlords reaching a certain age do not have a high motivation to retrofit (I2), Eisfeld (2022a).

121 In accordance with the Renewable Energy Directive II, public authorities should act as frontrunners and play an exemplary role in relation to decreasing GHG emissions. The obligations include minimum heating requirements for the construction and remediation of publicly used buildings. A 3% retrofitting rate applies to public buildings owned by the Federal Government.

122 It offers counselling, training facilities, and quality assurance in four priority areas: energy efficiency, construction and renovation, renewable energies, mobility Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (2021b).

reported. Klimaaktiv refrains from estimating its actual impact on household energy consumption and saved energy (BMNT 2018a).

The Austrian Energy Regulator explains that building energy awareness is a win-win situation, because it is possible to empower all social classes. They refer to projects on energy counselling for low-income households where the consultant also had a social work background. Providing vulnerable households with necessary information to understand utility bills, useful advice and contact points (e.g. where to call in case of questions concerning energy etc.) had a positive effect of approximately 15% energy savings (I2). In contrast, another key expert from the environmental protection office presented a different perspective, stating that awareness building has not been successful in achieving sustainable impacts. According to this expert:

> *"Awareness building was yesterday. […]. We have been doing that [awareness build campaigns] for 35 years.[…] We believe that a sense of consciousness is present in the population. If you walk on the streets, environmental awareness is there. […] We need successes. Energy awareness can only go so far. And it is nice and good, but it will not lead us one meter further" (I5).*

The expert discussed in this quote to what was referred to in chapter 3 as the linear progression model, which questions the explanatory power that raising energy awareness leads inevitably to pro-environmental behaviour. One key expert brings up an important limitation of energy awareness instruments dedicated to energy or income poor households:

> *"Energy awareness measures also lead to individualisation and that structural problems are excluded." (I7).*

This quote addresses two crucial points:

1. The state of being in need for energy counselling, experiencing energy poverty (e.g. energy debts), mental stress, or feeling inferior might lead to self-stigmatisation or deprivation of dignity as previous research results indicated (Grossmann and Trubina, 2021). The expert points to the emphasise of self-responsibility of the state of deprivation (Brunner et al., 2017; Greenbaum, 2015).

2. Individualised responsibility for climate change may cause energy poor households to blame themselves for their situation, without recognising the structural constraints that might be "trapping" them in unfavourable conditions with fewer choices for change (Buzar, 2007b; Tirado Herrero and Ürge-Vorsatz, 2012). Individualisation exacerbates cognitive obstacles to pro-environmental behaviour by politicising private choices and increasing pressure on people to act.

6.7.6 Electricity and Gas Industry Act

The **Electricity** and [Elektrizitätswirtschafs- und Organisatonsgesetz 2010] **Gas Industry Act** [Gaswirtschaftsgesetz 2011] are laws that grant consumer rights for everyone and specific social policy measures for certain consumer groups (§77 BGBl. I Nr. 174/2013). Some measures serve as acute help and protection in the event of an imminent loss of supply (e.g. basic supply, ban on switching off before the weekend), while other measures have a preventive effect (prepayment counter). These measures benefit all customers as part of general consumer protection measures without formal proof of need or energy poverty conditionality. This basic supply (in German: Grundversorgung) includes measures to avoid a supply exclusion. During the COVID-19 outbreak, Austrian energy suppliers (gas and electricity) voluntarily have taken measures to help citizens paying their energy bills and provided support in their access to energy through disconnection bans and instalment payment agreements. District heating suppliers are not covered by this voluntary agreement, as they do not fall under these two laws. Cut-off bans from the energy and electricity supply have been in place between 25.03.2020 and 30.06.2020 for customers and small businesses (Nationalrat, 2020). However, during the cold winter season this instrument was not in force anymore and vulnerable households (e.g. households in short-time work) were at risk not to be able to pay for their energy as life events might occurred (e.g. sudden loss of employment and being at home for longer periods because of lockdowns).[123]

6.7.7 Eco-Social Tax Reform

An ambitious restructuring of the current tax system in Austria introduced an ecological component in order to increase climate change mitigation efforts: the Eco-Social Tax. It was introduced in October 2021 in Austria. In a stepwise increased trajectory, a CO_2 price was introduced that started mid 2022 with an initial €30 per tonne, which will rise each year and reach €55 per tonne by 2025. The Eco-Social Tax Reform includes a reimbursement of income via a 'regional eco-bonus' and it ranges between €100 to €200 and depends on the urban/rural divide in Austria (based on the EU-NUTS classification). Those who are poorly connected to local transport in rural regions will receive the highest amount.[124]

123 Also, other EU-countries reported such initiatives and intensifications of energy poverty (Mastropietro et al., 2020; Nagaj and Korpysa, 2020).

124 Raising fuel taxes or green electricity surcharges bears the risk of hitting energy poor households harder, as they spend a large share of their income on energy costs (shown in the EU-SILC analysis in chapter 9).

This is the heart of the energy poverty debate where targeted policy design is required to provide social cushioning for affected energy poor households. What remains overlooked is that there are households who have no alternative to using fossil fuels, at least in the short and medium term because they live in a flat with an oil or gas heating system and the legal framework does not allow them to change the heating system. Moreover, the Eco-Social Tax Reform did not include a CO_2 tax for property owners, hence, it does not incentivise retrofits or an exchange of the old inefficient heating system, and, consequently, climate positive investments for owners and landlords. These increased costs and responsibilities to act (restricting consumption) have been transferred fully to tenants. Research shows that a steering effect would occur from €120 per tonne by 2030 to decarbonise economies by 2050 (Kaufman et al., 2020). This allows the conclusion that the current CO_2 price is set too low and need to at least double.

This carbon tax does not take into account the energetic characteristics and the energy performance of the building. Austria, thus joins the 'polluter pays principle', to change user behaviour. The carbon tax ignores the heterogeneity of households and households with low incomes are hit by this tax particularly hard (regressive effect of taxation), if not counterbalanced with a lump sum payment (tax compensation) (Barrage, 2019; Kirchner et al., 2018). Other examples for regressivity in energy taxes are, i.e. the French carbon tax (Bureau, 2011) or the US gasoline tax (Teixidó and Verde, 2017) that apply a uniform rate to all citizens. Results of the INEQ study demonstrated that 30 to 40% of low and medium earners in Austria would fall short despite an 'eco bonus' (Humer et al., 2021). Eisner et al. (2021) found low-income households would be affected more than affluent households by a 120€/tCO_2 carbon tax, especially elderly couples in rural, lower-income deciles and couples with children who would be severely affected by a heating price increase. In the long term, the gap between high- and low-income households could worsen due to the inability of low-income households to invest in sustainable technologies and the anticipated increase in CO_2 prices. Policy action is needed in form e.g. of additional funds to cushion the CO_2 prices and to yield a socially fair energy transition by focusing on increasing the retroffitting rate (Bernhofer, 2021; Humer et al., 2021). The design of transfer schemes must, therefore, include not only household size and income, but also age the regional differences and the buildings heating system.

6.8 Dedicated Energy Poverty Instrument by the Caritas

In 2009, Caritas established the "*energy support fund*" (VERBUND-Stromhilfefonds) project in collaboration with VERBUND AG (Austria's largest electricity supplier). More broadly, this project offers a wide range of support mechanisms dedicated to energy poor households. Caritas is one of the biggest charity organisations of the Catholic Church, has a broad network around Austria, and it draws almost two-thirds of its budget from public funds (Caritas, 2019, p. 36). Embedded in the multilevel governance setting of Austria, it takes over state responsibilities, such as operating nursing homes, hospices, and facilities for people with disabilities. The "energy support fund" for energy poor households is based on three pillars:

a.) energy consultancy,

b.) supporting energy-poor households with immediate financial relief (€100-200), and

c.) material/ technical aid of free cost, such as replacing broken, old, inefficient household appliances (e.g. refrigerators, or washing machines).

People who approach Caritas for any reason and mention issues with energy are referred to the project. The charity then organises private energy counselling at home with experts who provide tailor-made energy advice to the clients (offered by the experts at "The environmental counselling" agency). Approx. 400-500 energy poor people receive support from the energy support fund per year. In 2019, "the environmental counselling" agency offered 105 energy counselling sessions on behalf of the Caritas (Die Umweltberatung, 2020). During the session, experts write dedicated energy protocols, which represent official documents the clients can use, for instance, to demand a retrofit from the property owners. They contain information on energy-related issues, as well as how to lower energy consumption. To make sure that the implemented measures are sustainable, one year later, experts approach the clients and schedule energy visits to check up on energy consumption developments. During these visits, energy coaches evaluate whether additional energy counselling or support is needed. The key expert from the Caritas assessed:

> *"in 2016, we could show that we had good energy saving results. The clients have saved over €200 on average and that is a lot of money for them" (I6).*

If an energy poor household has arrears on utility bills, the Caritas conducts negotiations on instalment payments with energy providers. In certain cases, the project supports energy-poor households with immediate financial relief (€100-200).

During the energy counselling, experts may encounter broken windows, or old, inefficient household appliances (e.g. refrigerators, or washing machines). In such cases, Caritas' provides households with new household appliances, that are provided by the courtesy of the partner Bosch Siemens (BSH Hausgeräte Gesellschaft mbH) (I6).[125] VERBUND AG pays a part of the energy counselling sessions and the transport of the new appliances. The exchange of the appliances is designed in such a way that all devices and appliances can be transported to new homes if the household is moving. Our key expert from the Austrian Federal Social Ministry assessed the instrument to increase environmental literacy positive:

> *"Yes, everyone benefits and energy counselling already exists. For example, energy advises from Caritas. But under the given circumstances, it is not enough, especially if you cannot afford new equipment. But exchanging devices makes sense, that should receive more funding." (I7).*

Who are the people that receive the energy support funds from the Verbund Stromhilfefonds?

The expert from the Caritas summarized the most vulnerable segments of the population. Drawing on quantitative internal data, they confirmed that women, people living in rented accommodations (private and social housing), people living in dwellings build between 1961-1980, people with low educational background, single mothers, individuals who experienced multiple negative life events, larger families who have higher energy consumption needs, people in precarious employment conditions (e.g. limited contracts, part-time employment), sick or ill, and old aged have an increased risk to be energy poor. Also, immigrant households, particularly where energy was inexpensive in the country of origin, leading to a "lack of awareness" of various behaviours that are energy guzzling (I6). The expert stressed that in a significant number of cases, electricity costs are included in the utility costs

> *"and that is very problematic, because the clients do not have control to reduce their costs by themselves" (I6).*

The expert highlighted that electricity prices have risen on average annually in recent years, while also emphasising a decrease in energy consumption among low-income households:

> *"compared to the average Austrian household, energy poor have a considerably lower energy consumption, because they have fewer resources" (I6),*

pointing to self-restriction behaviours of vulnerable households. The Austrian energy regulator E-Control also mentioned energy self-restriction behaviours during the expert interviews (I2). The experts recall the results from past projects where households made trade-offs between cut-offs for electricity or gas: consuming both energy resources at the same time was not affordable for some households. They illustrated households would rather choose to cut-off gas for heating

125 The collaboration with Bosch and Siemens exists since the beginning of the project and was established through cooperation partnership with the VERBUND AG (Verbund AG, 2021).

as they still could heat their living space with their oven (I2). According to another key expert, vulnerable households often face multiple challenges, including the tenant-landlord dilemma, which makes retrofitting unattainable for them. The expert suggests that it may be unrealistic to expect these households to fully engage with retrofitting topics, as they may have other pressing concerns:

> *"It is too much to demand from them. We are happy if they approach the energy providers on time if they have arrears on utility bills" (I2).*

The question of how to involve the hard to reach energy poor was mentioned by the interviewed key experts, as well as during expert interviews conducted by Berger (2011, p. 15) in Austria. Experts referred to the 'hard to reach' disadvantaged households who are not approaching Ombudsman's offices or NGO's. It was mentioned that they are often "invisible" to support programs, they do not know their eligibility to support programs, or they lack motivation to apply for support because of the fear of stigma and feelings of embarrassment (Longhurst and Hargreaves, 2019; Wamsler et al., 2020). Innovative participatory instruments involving vulnerable households are lacking in national policy frameworks (Bouzarovski et al., 2021; Gillard et al., 2017; Meyer et al., 2018).

In conclusion, Caritas and Verbund AG employ strategies such as enhancing energy literacy, offering energy counseling, providing financial aid and new appliances, and conducting annual surveys to monitor effectiveness. However, it is important to note that these measures only address short-term challenges and do not fully address the underlying structural issue of inefficient buildings.

6.9 Assessment of Federal Energy Poverty Instruments: Outcomes and Challenges

The Austrian climate targets, with the exception of the renewable energy sources target, have not been met, and efforts to retrofit housing have fallen short of goals. Energy poverty has not received sufficient attention at the federal level, and a comprehensive policy debate on the issue is yet to take place. Recently, funds have been allocated for retrofitting housing in areas where energy poor households reside, but the issue has gained attention due to high energy prices. Households attempt to reduce energy consumption through self-restriction, but they have less room to maneuver because of the building design. These households face specific stress situations and adopt various coping strategies.

The Austrian Governmental Program (2020-2024) contains the overarching goal of being climate neutral by 2040 and sets a more proactive target than the EU, which aims to be climate neutral by 2050. The 100% renewable goal by 2030 is very ambitious, and Austria aims to be a climate frontrunner. However, comparing past climate goals in relation to achievements, these climate goals constitute declarations of interest. Unfortunately, the current Governmental Program does not contain any policies, instruments or goals to fight energy poverty, despite being repeatedly criticised by the European Commission concerning the NECP (Chamber of Labour, 2020a). It becomes apparent, therefore, that discussions surrounding distribution effects and just transition are hollowed out by the lack of concrete plans on the distribution effects of the Energy Efficiency Act or the Renewable Energy Act. Although the EU Energy Efficiency Directive requires cost-effective strategies to address energy poverty and consumer vulnerability, Austria did not provide instruments to combat energy poverty living in inefficient housing (in 2021). Moreover, similarly to the Governmental Program, the NECP specified no concrete measures against energy poverty and did not mention the social housing sector as a target for renovations, *contra* the indications outlined in the Green Renovation Wave by the EC.

For energy poverty, support instruments granted for housing construction and renovation at the federal state level (e.g. minimum income, housing subsidies) are mentioned. However, concrete plans, target values, or a roadmap connected to energy poverty are notably absent. Only the most basic requirements from the EU Regulations and Directives have been translated into national laws. The only outlined federal measure that included energy poverty measurements is the Energy Efficiency Act, which hands over the responsibility to deal with energy poverty issues to large energy providers.

The section dedicated to energy poverty in the Governmental Program, however, appears to be treated as a symbolic box-ticking exercise, since only a working definition is provided, vulnerable groups are not outlined and the split-incentive dilemma is only mentioned in one Austrian federal state. It can, therefore, be summarised that programs addressing energy poverty are predominantly administered either voluntarily thorough an alliance between social NGOs and an electricity supplier (VERBUND AG) or fulfilled by large energy suppliers due to EU obligations. Both entities handle the bulk of energy poverty mitigation endeavours at the federal level in Austria.

The chapter also addressed the concept of "Greenwashing" and suggested that it might play an important role in providing support for energy poor households because energy providers are under no legal obligation to do so. Currently, dedicated instruments are ill-targeted or lacking, since measures (in the sense of consumer protection) benefit all customers. In other words, the current definition of energy poverty in Austria does not take into account households who restrict their energy consumption to save money, thus they are not recognised as being "at risk". Because dedicated mitigation policies in Austria are pending, they are not currently able to offset these negative outcomes. The lack of comprehensive mitigation policies in Austria leads to short-term solutions and further exacerbates the situation for energy poor households, as they often cannot access energy efficiency subsidies which primarily benefit mid-income households. This widens social inequalities rather than narrow them. The newly introduced instrument of exchanging oil-fired heating systems dedicates subsidies for energy poor households. How this instrument will be organised and implemented will be seen in the upcoming years. The question of how the measure is designed will be important, since tenants in multi-storey apartments will be affected by this instrument, too. As multi-storey buildings often have several living parties, renters, and owners, this challenge must be addressed.

The need for close interconnection and cooperation between the federal and state governments also constitutes another fundamental challenge that needs policy response, since the main levers for the energy transition and climate protection fall within the competence of the federal states. In Austria, households living in rented flats are at high risk of being energy poor. Moreover, they face barriers to invest in energy efficiency measures due lack of resources, institutional backing, and lack of incentivising renovation subsidies. Currently, social policy provides a general safety net for energy poor households (minimum income benefits). The Green Electricity relieve only targets income poor households and has a low uptake rate. A solution may be to automate the exemption of green electricity costs and possibly expand the group of beneficiaries to target properly energy poor households.

To summarise, a just transition must not only involve social and housing policy but also include energy and climate policies in line with climate protection integration to buffer negative outcomes for the most vulnerable households in energy inefficient housings.

7. Housing Policy in Austria

This chapter discusses the interplay of housing policies, energy poverty, and the dynamics of multilevel governance in Austria. Although, energy poverty has gained attention at the EU level, it must be addressed through targeted policies at the local level, especially in the realm of housing. However, the lack of innovative policy instruments hinders progress in retrofitting Austria's inefficient housing stock, due to institutional and legal challenges. The Tenancy Law does not incentivise retrofits, as landlords and tenants may not agree on costs or scope. For new building construction stricter energy performance requirements can be more easily introduced, in the constituent building stock, laws and its specific design challenges the implementation or at least does not provide an enabling legal context. Contextualising the legal framework of the rental sector is therefore important in understanding the nature of energy poverty in Austria.

Research indicates that energy-poor households mostly live in rented, energy-inefficient homes, making the rental sector a valuable case study for analyzing the intersection of social and climate policy and its impact on housing policy (Bouzarovski et al., 2012). The design of housing policies, such as the Tenancy Law and housing subsidies, play a key role in explaining inequalities, e.g. the tenant/landlord dilemma or the affordability of housing. These two policy instruments are located at two distinct levels of Austria's multilevel governance system. The housing subsidy scheme is an instrument used by the federal states that directly contributes to mitigating energy poverty by increasing the retrofitting rate and introducing strict energy performance criteria. The Tenancy Law, instead, determines the affordability of rented apartments and consequently affects the remaining available household income.

The central aim is to examine different approaches for reaching climate targets in the housing sector without cutting back on the social agenda. The subsequent sections thus aim to answer the following questions:

- What incentives and barriers to retrofitting the building stock exist in Austria?
- Why is the retrofitting rate in Austria low?
- How does the Tenancy Law and the rental system secure affordable rents in Austria?

The remainder of the chapter is structured as follows: sub-chapter *one* delves into the Austrian housing policies. Sub-chapter *two* introduces the Austrian Tenancy Law, which stabilises housing affordability for the general population, vulnerable groups, and energy poor households. Sub-chapter *three* details Austria's housing subsides and distinguishes between objective-based and subject-based subsidies. Furthermore, this sub-chapter provides a descriptive analysis of households income quintiles differentiated between the three different rental segments in Austria to illuminate predominant socio-economic patterns between the rental segments. Sub-chapter *four* delves into the impact of energy inefficiency and the relationship between tenants and landlords on maintenance, upgrades, and rental costs in Austria. Finaly, sub-chapter *five* concludes that current regulations and incentives for retrofitting buildings are insufficient and calls for more action to increase building efficiency and address energy poverty, particularly in multi-storey buildings and private rental apartments.

7.1 Affordable Housing as Means to Protect Against (Energy) Poverty and Social Exclusion

The current Governmental Program (2020) sets out the ambitious goal of halving the number of people at-risk-of-poverty within 5 years (currently 1.2 million people). The most recent social report by the Federal Ministry of Social Affairs, Health, Care and Consumer Protection (2019) briefly introduces the challenges of climate change and outlines negative future scenarios, such as extreme weather events and related negative health effects. For the first time, the report includes the concept of energy poverty that, while mentioned, is not currently on the policy agenda. No concrete time horizon is provided for when the Federal Social Ministry will actively engage with this issue. Climate-related challenges, justice principles and energy poverty are therefore kicked down the road. This suggests that while awareness of energy poverty is rising, its challenges and implications are not being fully explored.

The section of the Austrian Governmental Program (Federal Chancellery, 2020) dedicated to fighting poverty and social exclusion includes a paragraph on the intersection between social policy, and other policy fields. However, it fails to draw the link between social policy and climate or energy-related concerns. This omission appears surprising, since the same document explicitly identifies the avoidance of social hardship and re-distributional aspects as being central to the “just transition” efforts to mitigate the climate crisis. A confession or efforts that climate policy or increased living costs will not be transferred onto low-income households are not detailed. Policy interconnections or horizontal or vertical climate policy integration are not outlined. Multiple intersections between climate and social policy, such as housing assistance and heating allowances, however, exist. Many of these policies are connected to housing costs, which fall within the area of social policy but are directly intertwined with energy poverty.

These measures are, therefore, created to ensure simultaneously affordable and adequate housing while decreasing poverty.

In Austria, housing is widely considered being a priority, and a basic human necessity. All domestic political parties have included in their manifestos a commitment to ensuring an affordable and high-quality housing supply. When comparing the domestic housing landscape with other countries, Austria has an above-average housing stock in terms of quality (mostly in-flat central heating, in-flat bathroom facilities) and size (Amann and Mundt, 2019).[126]

In 2018, according to Mikrozensus Austria, 43% of all households lived in tenured housing, 48% in own property, and 9% in other forms of living (Statistik Austria, 2022b). Compared to other European countries, there are substantive differences: while most EU citizens in 2018 lived in owner-occupied dwellings (70%), the ownership rate in Austria is below the European average and amounts to 55% (European Commission, 2021m). In Vienna, the rental segment is even larger and amounts to 78%, while only 19% have their own property. Rental markets dominate in urban regions, whilst rural areas are characterised by large levels of ownership. In 2018, the average Austrian rent, including operating costs, was 8.3€/m^2. Privately rented flats have a significantly higher rent (9.7€/m^2) than limited-profit housing (7.03€/m^2) or municipal housing (6.8€/m^2). Semi- public housing offers long-term and rent-regulated contracts which typically ask for lower rents (Statistik Austria, 2022b). On average, energy costs make up around 24% (median) of the total housing costs for all private households. This corresponds to 115 euros per month per apartment or 1.3€/m^2 (both median).

Austria's social housing sector is internationally recognised for providing a good supply to its large population and for the progressive legislation governing regional planning and assisted housing construction. A significant number of rents fall under the Tenancy Law, which are regulated and capped, thus securing affordable housing depending on construction year and housing quality (Reinprecht, 2014). Crucially, the Austrian legislation recognises the importance of ensuring that the housing economy should not be solely regulated by market forces. Hence, Austria's housing policies aim to correct "market failures" (Oxley, 2004) and maintain a partly de-commodified sector to secure the provision of affordable housing, especially in Vienna (Brunnauer et al., 2019; Kadi et al., 2021; Marquardt and Glaser, 2020). Reinprecht (2014, p. 61) summarises the Austrian housing system in the following way:

126 However, buildings constructed between 1945 and 1960, which amount for ¾ of all existing buildings, have very low energy efficiency levels of around 200-300 kWh/m2a (AHK, 2018; Hagauer et al., 2016).

> *"Traditionally, Austria has been thought of as a country with a well-controlled and regulated housing system. Historically rooted tenancy laws, a complex financing and subsidy regime and the strong role of limited-profit housing companies are the basic elements of its housing policy, which has successfully helped constrain market forces over a long period".*

Matznetter (2002, p. 266) stated that

> *"[...] in Austria, the post-war model of social housing has been better preserved than in many other countries of the continent."*

Because Austria has a long tradition of maintaining a large subsidised municipal social housing stock, the sector has been able to stabilise overall rental prices and achieve affordable housing objectives (Marquardt and Glaser, 2020). Austria's housing policies, however, faced several challenges stemming from international developments (Amadi, 2020): the housing market demand increased, high influx of population in cities, state-owned dwellings were privatised, and the effects of the financial crisis became visible (Baumgartner, 2013; Canevarolo, 2018; Mundt, 2018; Norris and Byrne, 2018). The Tenancy Act has been de-regulated and relaxed to benefit landlords, including the implementation of more lenient rent regulations and temporary rental agreements (Kadi et al., 2021). This has resulted in a general rise in the cost of private rentals. Over the previous decade, rising rents have made it difficult for low-income people to find affordable accommodation (Dawid and Heitzmann, 2015; Kadi and Musterd, 2015).

7.2 Austria's Tenancy Law

Austria's housing policies are complex, with multiple levels of government sharing authority and responsibility, leading to a diverse regulatory and administrative landscape. This complexity is recognised internationally and is further challenged by the involvement of other relevant parties such as non-profit organisations and limited-profit housing associations (Ahn and Mocca, 2022; IIBW and Ministry of Economics, 2008, p. 11). Tensions between the federal government and federal states in Austria result in fragmented policy responses for e.g. housing, as seen in legislation and implementation. Over the last 30 years, housing competences have progressively shifted from the federal to the federal states level, thus limiting the role of the central government (Marquardt and Glaser, 2020). Tenancy Law in Austria is governed by the ABGB and the MRG, with additional regulations for the non-profit sector under the WGG. The ABGB emphasises private autonomy, while the MRG provides mandatory tenant protection provisions, mostly favoring tenants. The Austrian legal system applies different levels of tenant protection based on the rental object and the contract's age. Austria's multilevel governance regulations divide the housing landscape into three clearly different legal frameworks (see also Figure 17):

- Private market (WEG and MRG)
- Communal (social) housing (MRG)
- Limited profit housing (WGG).

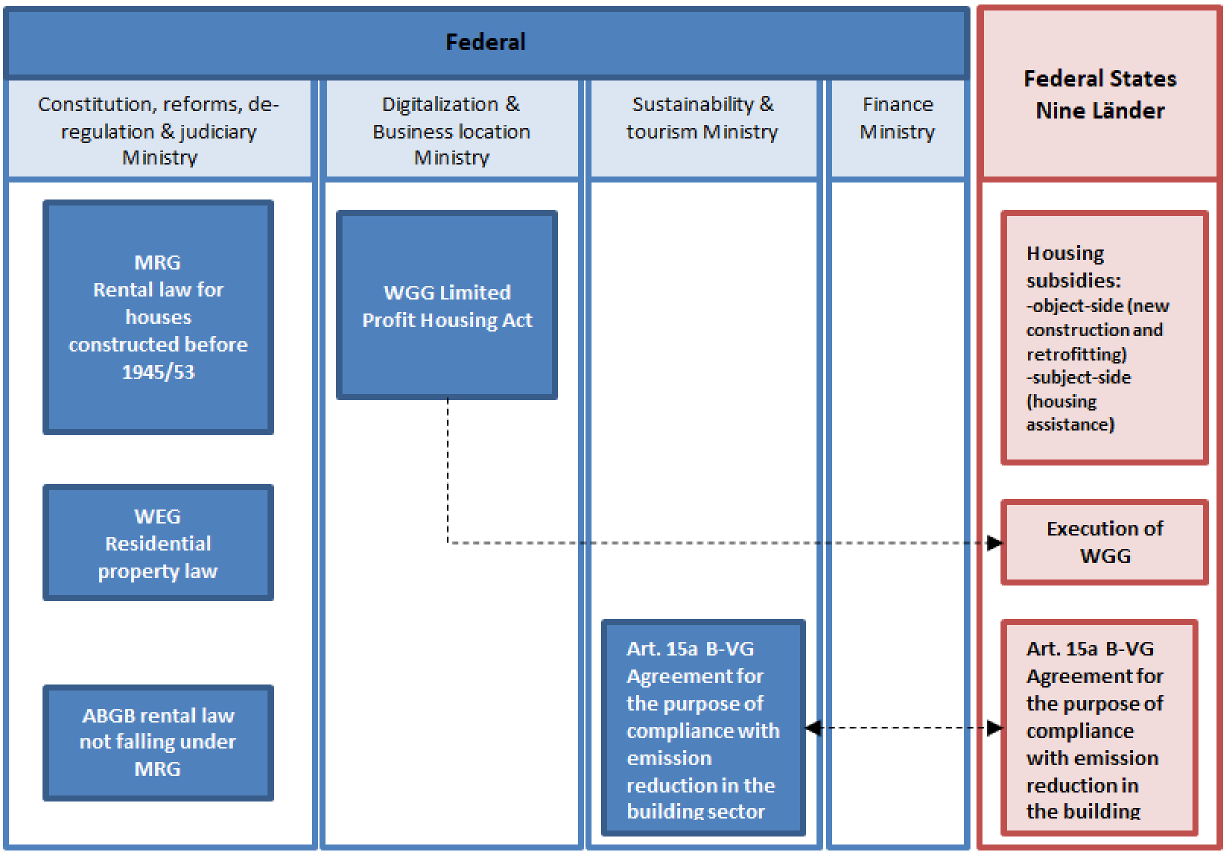


Figure 17 Housing Related Policy Competences. (Source: Adopted from IIBW and Austrian Ministry of Economics (2008, p. 6).)

Questions related to housing are organised in five central laws: Tenancy Law (MRG), Residential Property Law (WEG), and Limited Profit Housing Act (WGG), the housing subsidy laws of the federal states, and spatial planning laws. The Austrian Federal Government holds competences for implementing the Tenancy Law (MRG), Residential Property Law (WEG), and Limited Profit Housing Act (WGG). It can also intervene through tax regulations and social benefits (Marquardt and Glaser, 2020).

The federal states, instead, have competences in regional planning (land use and zoning), housing subsidies, and Construction Law. The federal states have significant scope to coordinate climate related regulations through housing subsidies, which are co-financed by contributions from the federal government budget (Lang and Stoeger, 2018). The multilevel housing policy setting between the federal and federal states level is visualised in Figure 17.

The complex Austrian framework that is concerned with rental prices depends on when the house was build, when the apartment was rented (contract signed), whether public subsidies were granted for the construction, whether there was a retrofit, or whether a conversion of new living space was created.

In Austria, the main instrument regulating rents, and therefore securing affordability, is the Tenancy Law (MRG), which can be a.) *fully applicable*, b.) *partially applicable*, or c.) *non-applicable*. The fully applicable[127] and partially[128] applicable MRG both have strong tenancy protection against dismissal in favour of tenants.

a.) The Tenancy Law is *fully applicable* to old buildings (constructed before 1953) having more than two apartments, rented apartments in buildings that were constructed prior to 1945 with two or more apartments, and newly constructed subsidised buildings with over two apartments (e.g. social housings constructed after World War II). The Tenancy Law is also applicable to subsidised rental apartment buildings with over two rental objects. There is an exception if the housing subsidy loan has been repaid prematurely. In this case, the rent regulation in the MRG does not apply and the property owner can demand a so-called "adequate rent" (angemessener Mietzins).

b.) Tenancy Law is *partially applicable* (concerns deposit, limitation and protection against dismissal) for buildings constructed after 1953 with *no* state subsidies, rooftop extensions, rented apartments in buildings constructed after 1945, and add-ons constructed after 2006.[129] Contrary to the fully applicable Tenancy Law, *rent caps are not applicable here*. As the Tenancy Law was de-regulated, loopholes were generated; these include rooftop extensions that can ask for higher rents.[130]

c.) If the Tenancy Law is *not applicable*, the ABGB (Austrian Civil Law Code) regulates rental contracts (duration, notice period). These free, non-capped rents are not subject to the arbitration body of housing research magistrate 50. Instead, they are subject to free market forces of supply and demand, which results in comparatively higher rents.[131] This mostly

127 The tenant is protected by strict rent limits ("Preisschutz") and against unwarranted eviction ("Beendingungs- bzw. Kündigungsschutz").
128 The tenant is protected only against unwarranted eviction.
129 Apartments that are converted attics or an extension for which a building permit was issued after December 31, 2001 (§ 1 Abs. 4 Z MRG).
130 For this very reason, in Vienna we can observe a substantial increase of new construction of rooftops' apartments that are predominantly inhabited by high-income households. We can see a shift from a horizontal to a vertical segregation in some districts in Vienna (Reinprecht, 2017).
131 Condominiums build after 1945 with state subsidies also have free rents.

concerns rental contracts in detached and semi-detached houses with a contract signed after 2001. Hence, there is a significant degree of contractual flexibility for flats held by private owners constructed after 1953 without state subsidies.

For ***fully*** applicable Tenancy Law, it is possible to distinguish different rent setting systems (BMSGPK, 2023):

- **Category rent** (Kategoriemietzins) applies if rental contracts are signed before 1994 (so called old contracts "Altverträge"). The quality of the apartment determines the amount of rents to be paid. There are four distinguishable housing quality categories A (4.23€/m²), B (3.18€/m²), C and D-usable (2.12€/m²), D-unusable (1.06€/m²).
- **Reference value rents** (Richtwertmietzins) are applied to rental contracts signed after 1994. Rents differ by federal states and can be adjusted by premiums and discounts for housing quality and location (only category A, B, and C apartments). Rent increases cannot be collected in retrospective. Since April 2022, in Vienna the reference rent is 6.15€/m².
- **Adequate rent** (angemessener Mietzins) applies if housing is larger than 130 m^2, has the category A or B, the rental contract is signed after 1994; apartments in new builds or an extension that was built after 1945 or building up. The amount of the rent depends on size, quality, location, equipment and condition of the rental property. Comparative objects are usually used to assess appropriateness. These apartments correspond to free rents, however, in contrast to the free rents an inadmissible amount of the reasonable rent can be sued at the arbitration board.

The Limited Profit Housing Act constitutes a special legal framework case that regulates rents in housing built by non-profit property developers and property development legislation (Friesenecker and Kazepov, 2021). Here, cost covering principles are implemented.

To summarise, the housing landscape in Austria offers a mixed picture regarding tenure security: free rents are valid in the partially applicable Tenancy Law and in apartments where the Tenancy Law in not applicable (in the ABGB). The Tenancy Law, however, is not applicable in houses with one or two rental apartments/houses. Almost all old buildings fall into the fully applicable Tenancy Law, excluding the newly constructed Limited-Profit housings with low rents. For rental contracts signed before 1994, "category rents" are applied while, if contracts are signed after 1994, rents follow the "reference value". For buildings larger than 130m^2, instead, "reasonable rents" are set (corresponds roughly to free rents).

This brief introduction into the Austrian Tenancy Law was essential to understand the context of the rent setting system in Austria. The rent setting system in Austria has a significant influence on energy poverty, particularly for households residing in energy inefficient housing built after 1945. These housing units are not subject to rent caps, resulting in higher-than-average rents for tenants. Low-income households, who are more likely to experience energy poverty, often reside in this housing segment and do not benefit from the regulated housing market (see chapter 9.4 Table 13). The combination of low energy efficiency and high housing costs has adverse implications for energy poor households, as it puts additional financial strain on them and reduces the affordability of energy. In contrast, households in the social housing segment, where lower rents are enjoyed, may face different challenges. Understanding the differences in the rent setting system in Austria is essential to grasp the context of energy poverty and its impact on households living in energy inefficient housing.

7.3 The Structure of Housing Subsidies in Austria

While Austria spends around 20% of its GDP on social protection, in comparison housing benefits play only a minor role (Eurostat, 2021e). Housing subsidies play a vital role in securing affordable, adequate housing and can be considered as the most important instrument in Austria's housing policy landscape. When originally conveived, Austrian housing subsidies were primarily an economic and social policy instrument. However, in the 1990s, climate and energy related aspects entered the policy discourse and began shaping the design of the subsidy (Amann, 2014).[132] Housing subsidies are located at the federal states level and the budget is composed of financial contributions from employees and employers' wage payments (in each case 0,5%; The Federal Ministry of Social Affairs, Health, Care and Consumer Protection, 2018, p. 44).[133] Since 2018, the regularities changed through the financial equivalisation and budgets for housing subsidies are entirely the responsibility of the federal states, meaning that they can freely determine the level of the tax (BGBl. 144/2017, 2017)(Amann, 2019). The Austrian housing subsidies are mainly divided between (Mundt and Amann, 2015):

- **Subject-based subsidies:** subsume personalised housing grants (Wohnbeihilfe), minimum income grants (since 2019 Sozialhilfe), rent grants (Mietbeihilfen), credit subsidies (Eigenmittelersatzdarlehen), or heating cost benefits (Heizkostenzuschüsse);
- **Object-based subsidies**: funds and grants for the construction of new buildings, renovations of the housing stock.

In the aftermath of the financial crisis, the Austrian Federal Government abolished fixed purpose (earmarked) for the housing subsidy. Whereas funds from the Federal government were

132 Housing subsidies are based on five pillars: 1. Housing subsidies (Wohnbauförderung); 2. Non-profit principle (Gemeinnützigkeit); 3. Housing banks (Wohnbaubanken); 4. Building societies savings/banks (Bausparkassen); 5. Tenancy Law.

133 The reflows from earlier loans are another major source of housing subsidies (Marquardt and Glaser, 2020).

previously earmarked for housing, federal states now decide autonomously how to allocate the money. This shift opened the doors to budget cuts and subsidy stagnations (Kadi, 2015, p. 252; Streimelweger, 2010, p. 548).[134] At the same time, the City of Vienna continues to use its housing subsidy budget for residential construction (housing subsidy law of Vienna). From a multilevel governance perspective, there is no unified regulation for housing subsidies in place, with the federal states having individual building-related policies and regulatory frameworks (e.g. building regulation, regional planning procedure).[135] Municipalities contribute with the provision of building land to affordable housing. Experts pointed out that the constellation of different subsidies is very complex and the federal states "*have a wide range to manoeuvre what they are doing*" (I2).

To further compound an already complex situation, the minimum income thresholds to receive subsidies are different not only *between* different federal states but they can also differ annually *within* a same federal state. Following a retrofit, subsidies can contain specific requirements, which even force tenants to use a certain energy provider or energy system. This constitutes a lock-in effect:

> *"they have their own conditionality, and their own criteria and also what kind of technologies I can use to retrofit. In the extreme cases they can oblige an energy provider after the retrofit" (I2).*

The federal states have complete autonomy over how to distribute the money obtained from the housing subsidies. One interviewed expert stressed that "*there are also particular interests behind it*" (I2). The expert continues and explains that some federal states promote photovoltaic systems:

> *"from the mandate of housing subsidies, which completely ignores the topic. But they say, well, photovoltaic that is super good [in German "super leiwand"]. We can argue about the meaningfulness of this measure. We discuss renovation quotas and then I take a considerable amount from the housing subsidy and construction of photovoltaic systems, which definitely does not affect the socially disadvantaged, because they have no access to such things at all. So everyone is designing their own model"(I2).*

Generally, housing subsidies can be divided into:

a.) loans for personal means („Eigenmittelersatzdarlehen"),
b.) repayment grants („Zuschüsse bei der Rückzahlung der Finanzierung"),
c.) non-recurring grants ("einmalige Zuschüsse") that do not have to be paid back.

134 In the case of the province Salzburg, the money for housing subsidies was used for speculation trading and the political mandate was not fulfilled (Steurer and Clar, 2015).

135 Building policies were in the hands of the Provinces for long time, even before climate change policies became a predominant discourse (Steurer and Clar 2018).

In all federal states, housing subsidies systems differ, but they are conditioned on the following aspects:

a.) Applicants have to be either Austrian or EU/EWR citizen (after 5 or 10 years of residency, depending on the federal state).
b.) Set incomes thresholds cannot be exceeded (differing arrangements in the federal states).
c.) The maximum amount of subsidies is limited to a certain sum (approx. €50.000- €60.000).

The conditions are based on sustainability and energy criteria (exceptions are Upper Austria and Salzburg, where the supporting system is currently under revision) or social indicators (e.g. family, children) in the majority of the federal states. Compared to other European countries, Austria’s housing subsidy scheme is characterised by more *object-side* subsidies to provide affordable housing and lower amount of *subject*-side subsidies (IIBW, 2021). In 2020, the expenditures for *object-side* housing subsidies amounted 55% in construction for new (multi-storey) buildings (approx. €1.145 million), 8% single-family houses (approx. €160 million) and 23% for retrofitting (approx. €470 million). Retrofitting subsidies continued to shrink and decreased by 43% compared to 2010.

Subject-side housing subsidies have less importance in Austria compared to other European countries, such as the UK, Sweden or France, and constitute essentially housing benefits (and loans for personal means).[136] They include minimum income benefits, renting grants, and housing grants, which are designed to assist people to pay their monthly rents or secure a minimum standard of living.[137] Subject-based subsidies account for 14% (approx. €300 million) of the overall housing subsidies in 2020 and have been declining over the past years (see Figure 18).

Regarding climate goals, subsidies are not triggering intensive retrofitting activities in Austria, due to steady annual cuts in the budget. In 2018, retrofitting activities that received housings subsidies amounted to 0.5% p.a. and the total retrofitting rates (including individual measures) in Austria totalled 1.4% (Amann et al., 2020b). Ten years ago, subsidised retrofits had a dominant role. However, unsubsidised and, in particular, individual retrofitting measures currently outweigh subsidised retrofits (IIBW, 2020). A further caveat is that less than half of

136 According to Leubolt (2020), subject-based subsidies are most relevant in liberal welfare regimes, such as the UK, where vulnerable households have to pass a means tests to prove the eligibility for social benefits.

137 Housing grants are typically means tested (household’s income, household’s size, and net dwelling area) and differ significantly across federal states.

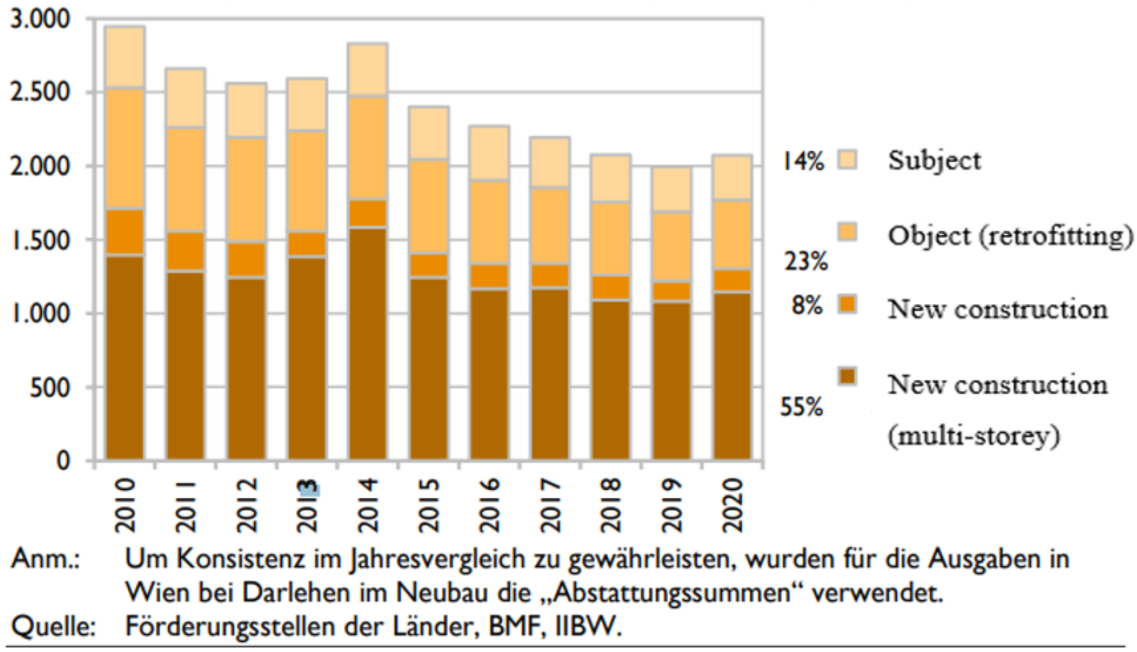


Figure 18 Expenditures for Housing Subsidies (2009 - 2020) in Million € (Source: IIBW 2021).

the housing subsidies are used for thermal or energy-saving retrofits, with most subsidies allocated to repairing derelict buildings or improving building safety, without explicit energy benefits (Amann et al., 2014).

Construction of new buildings received larger subsidies compared to retrofitting activities (see Figure 18)[138]: 64% of the overall housing subsidies addressed new construction in 2020. Similarly, more than half of the funds (55%) are spent on new construction in Vienna (Amann et al., 2017). Although governmental subsidies for new construction have slowly decreased, the total amount allocated to them is higher compared to retrofitting or subject-based subsidies. The experts pointed out:

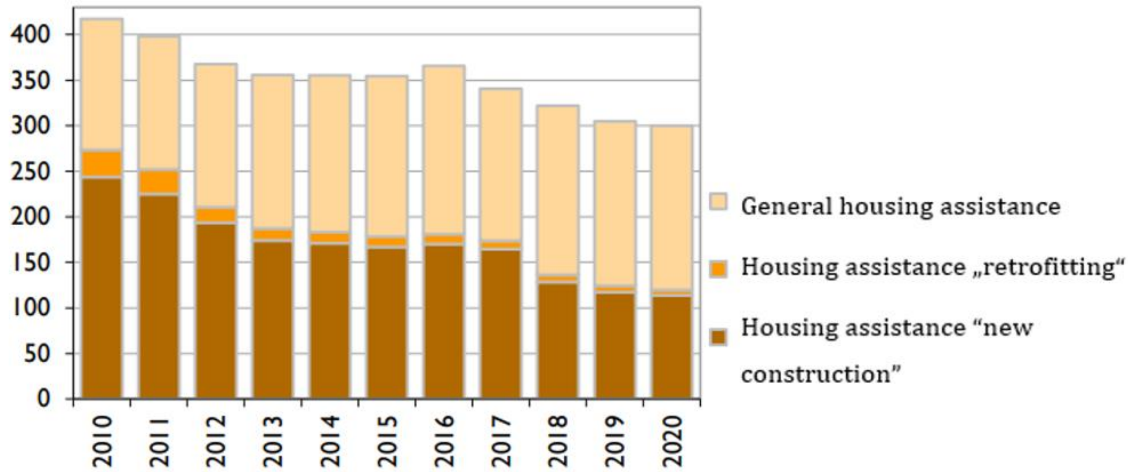
> *"And that is the problem. It is not the case that money is not used or there. It is a highly political question" (I2).*

Since the last Tenancy Law reform in the 1990s, the promotion of property and ownership interests became a policy priority. This is underpinned by efforts to promote home ownership in the Governmental Program, which are aimed at avoiding old age poverty (Federal Chancellery, 2020, pp. 41–42). Over the last decades, while governmental subsidies for private homes/multi-storey buildings have declined, building permits and new multi-storey constructions have increased, especially in Vienna (Amann, 2021). This points to the fact that new buildings and privately financed apartments/houses are typically constructed without state

138 One expert remembers that one of his first work-related activities was to evaluate the first climate strategy and already back then the dilemma about the balance of the distribution between new construction and retrofitting subsidies existed (I2).

subsidies and, in the case of tenancy, they are not subject to the rent-capped Tenancy Law. This trend illustrates the need for an increased housing supply -especially due to Vienna's enormous population growth of the last decade (Franz and Gruber, 2018) - but it is highly contested whether this newly constructed housing segment is affordable for low-income or energy poor households.

Figure 19 indicates a decreasing trend for subject-based housing assistance. According to Mundt and Amann (2015) this can be traced back to stricter regulations of the federal states (Länder) and a shift to the social departments, which introduced new social benefits schemes (means-tested minimum income scheme "Sozialhilfe Neu"). Subject-based housing assistance aims at social redistribution (Stagel, 2007), as confirmed by a housing expert from the municipal authorities in Vienna who considers it a social welfare instrument rather than a climate or housing policy instrument (I8).



Anm.: Einige Bundeländer haben mittlerweile die Unterscheidung zwischen allgemeiner Wohnbeihilfe und Wohnbeihilfe im geförderten Neubau aufgegeben, daher ist die Abgrenzung im Zeitverlauf nur eingeschränkt konsistent.
Quelle: Förderungsstellen der Länder, BMF, IIBW.

Figure 19 Expenditures for Housing Assistance (2009-2020) in Million € (Source: IIBW 2021).

Contrary to subject-based subsidies, *object-side* related subsidies were criticised for not being effective in addressing social hardship. Mid and high-income households profit from these subsidies, as only property owners or homeowners can apply for the scheme. Most of all object-side subsidies are granted for households with a higher-than median income (Klien, 2019; Seebauer et al., 2019). Low-income and energy poor household with limited independent resources, instead, on average do not claim these subsidies, since in most cases these only cover a fraction of the renovation costs. Moreover, the subsidies are often conditional upon minimum levels of income, which low-income household typically do not reach. Hence, most of the object-side housing subsidies are dedicated to owner-occupied property promotion (Eigenheimförderung), which typically excludes energy poor or income poor households (Austrian Institute for Economic Research, 2019). The housing subsidy loans for home ownership therefore have a distributive effect in favour of higher incomes.

In comparison, subject-side subsidies are just a minor supporting instrument but a more likely to reach their target, as 85% of lower income households (under the median income) receive it (Austrian Institute for Economic Research, 2019; Klien, 2019). It is conditioned on several criteria, such as low income or small and expensive housing. It must, however, be underlined that an extensive amount of object-side related subsidies (conservation and new construction) are also dedicated to limited-profit and communal/social housing (2015: 70% of the object subsidies; Klien, 2019) where tenants benefit from rent caps compared to the private rental market that is not subject to the fully applicable Tenancy Law.

Household Income Quintiles	Private	Limited-Profit	Social Housing	Total in
1 (lowest)	41.52	31.99	26.49	100
	26.88	20.93	**40.49**	26.83
2	41.1	42.8	16.1	100
	20.29	21.35	18.77	20.46
3	37.36	46.09	16.55	100
	17.47	21.78	18.27	19.38
4	40.69	46.9	12.41	100
	17.15	19.98	12.35	17.47
5 (highest)	47.54	41.26	**11.2**	100
	18.20	15.96	**10.12**	15.86
Total	41.44	41.01	17.56	100

Table 7 Household's Income and Tenancy Structure in Austria (Source: EU-SILC 2019); Household Data N: 2307. Column and Row Percentages.

A more in-depth analysis utilising EU-SILC household data (year 2019) indicates clear differences between the social housing and limited-profit housing segment. Proportionally, lower income quintiles live in social housing or in the expensive private housing segment (see Table 7: 40.49% compared to higher income quintiles 10.12%). Higher income quintiles predominantly live in limited-profit housing (41.26%) or in the private housing segment (47.54%). Additionally, the limited-profit housing sector has easier conditions to retrofit than other housing segments because renters pay an obligatory maintenance and enhancement contribution (please see next sub-chapter). This instrument, in combination with housing subsidies, stabilises housing costs as rents are comparably low, and the quality of the housing is high (energy performance) resulting in lower heating costs.

However, as Table 7 indicates, predominantly mid- to high-income households live in the limited-profit housing segment. This is due to the fact that potential residents are required to make significant downpayments for land and construction prior to their occupancy. Low-income or energy-poor households dispose fewer means to afford this equity capital and access to this housing segment is, therefore, a major obstacle.

To summarise, in terms of redistribution, predominantly higher incomes benefit from the object-based housings subsidies (loans, construction promotion, limited profit housing). Overall, expenditures for housing subsidies have have been comparatively low, constantly declining and significantly below the EU-average (2019: only 0.4% of GDP) (Amann et al., 2020b). Austrian object-based housing subsidies, particularly for retrofitting activities, are at risk to become negligible because the subsidy scheme is not effective in achieving the desired annual retrofitting rate of 3%, nor is it characterised by a high up taking rate. Moreover, proportionally the gap between privately financed and subsidised housing continues to widen: more retrofits take place without housing subsidies, resulting in rent in-affordability. Low-interest bank loans were easily available in recent years, which made building owners less dependent on public subsidies for financing retrofits (I9). Moreover, it allowed "*to avoid the strict energy-efficiency standards required for subsidies*" (I5).

This crowding-out of subsidies by low-interest loans have led to under-exhaustion and subsequent cuts in retrofit subsidy budgets. Amann et al. (2020a) explained that the typical incentives did not bear fruits and they recommend tax subsidies/reliefs to reward retrofitting activities.[139] Reinprecht *(2017, p. 216)* summarises object-based subsidies in the following way:

> *"From this point of view, housing subsidies are broadly spread, but the social and socio-political goal of participation in prosperity and status security for everyone favors full-time workers, locals and the conventional family-centered care model, while atypical living situations, migration and manifest poverty are disadvantaged in access to the system [own translation from German]."*

Energetic requirements in buildings stemming from the EU Energy Performance of Buildings Directive (2018/844/EU) are implemented through the **OIB guideline 6** - Energy saving and thermal insulation (Bundesgesetzblatt)**.** The guideline lays down construction standards regarding the energy demand of new residential and non-residential buildings, and criteria for

139 With a comprehensive renovation, the heating requirement or the overall energy efficiency should be improved by at least 60%. For this, 65% of the costs can be deducted from taxes. In the case of partial renovations, the respective components must achieve the thermal standard of new buildings. There is a tax deductibility of 40% of the costs (Amann et al., 2020a).

the renovation of buildings.[140] The OIB (Austrian Institute for construction technology) acts as a platform to coordinate building requirements, as according to Article 15a (B- VG) of the Austrian Federal Constitution between the Austrian Federal Government and the provinces of climate protection in the building sector. These guidelines build the basis for the harmonisation efforts for building regulations, as all Austrian Federal States implement the OIB guidelines in their respective building codes. The OIB 6 guidelines formulate requirements for energy performance certificates, which need to be provided by sellers and property owners in real estate transactions or renting. The guidelines state that new or retrofitted buildings must have a minimum of 80% of their heating and hot water demands met by renewable sources, such as district heating, biomass, or a heating pump (Austrian Institute for building engeneering, 2019).

7.4 Maintenance and Improvement Work to Retrofit the Austrian Housing Stock

In Austria, the landlord is required to perform maintenance and may choose to undertake improvement works. The subject of maintenance and improvement work falls under the legal framework when the Austrian Tenancy Law [MRG] fully applies. **Maintenance** (Erhaltung) (§ 3 MRG) and **improvement** (Verbesserung) (§ 4 MRG) work are climate relevant terms outlined in the MRG. The distinction has significant legal consequences, including financing, enforceability, the tenant's obligation to tolerate, and the potential for a rent increase. Measures to decrease energy consumption, measuring own energy consumption, and heating-insulating investments are recognised as maintenance work (§ 3 Abs. 3/5 MRG). It is typically financed through the so-called "rent reserve" of the past 10 years (balance between rental incomes, maintenance and improvement expenses of the last 10 years minus tax relief of 40%).[141]

The retrofitting costs can be distributed over the next 10 years to the tenants only if the rental income does not cover the retrofitting expenses in the next 10 years (§ 18 MRG). If the property owner is able to prove insufficient rent reserves from the rental income of the past ten years, and cannot set aside enough rental income within the next ten years, then he/she can ask for higher rents. In order to enforce a legally effective rent increase due to modernisation work or maintenance measures, property owners, however, face several barriers: after retrofits, the property owner may only raise the rent after a so-called "rent increase procedure" at the

140 Standards for heating demand have been supplemented by standards for the total energy demand of buildings (including, e.g. warm water and cooling).

141 Rent reserves: property owners have full disposal over the rent reserve and do not need to build them. The rent reserve is not a real amount of money (§ 20 Abs 2 MRG).

arbitration board or court. This is called the § 18 – procedure, in which the property owner must prove insufficient reserves.[142] Only rental contracts that fully apply under the Tenancy Law or the limited profit law are concerned with the § 18 procedure. As property owners have full disposal over the rent reserve and are not obliged to build rent reserves, they are de facto often non-existent. The rent reserve is only a hypothetical accounting number and not a real existent amount of money.

Property owners have a duty of maintaining their buildings. Hence**, maintenance work** must be executed even if assets through rent reserve are non-sufficient or non-existent. If the property owner is inactive/unwilling to retrofit, renters (majority renters according § 6 Abs. 1 Z 2 MRG) can enforce maintenance work through the arbitration board (or court) (Amann and Weiler, 2009). Maintenance work underlies economic feasibility criteria and must be balanced with the expected savings. In order to assess the economic viability, a cost/benefit calculation must be made, which must clarify whether the investment will be amortised within the remaining useful life of the building (e.g. payback method).[143] Major criteria are the eligibility of the energy saving measure, and renters must not necessarily benefit from the incurred energy savings (although they may even pay higher rents).

Several experts stressed negative consequences of gentrification due to rent increases and pointed out that retrofitting may lead to social exclusion of vulnerable households (I4; I6). This is also known from previous research results under the term “renovictions” or “low-carbon gentrification” (Baeten et al., 2017; Bouzarovski et al., 2018). The expert from energy supplier explained that in the private renting segment, a majority of the clients faced not only debts on utility bills but also rent debts. At the same time, their clients were worried to make renovation claims to the landlords because they

a.) don’t aim to harm the relationship and have issues with the landlords
b.) were afraid of rent increases
c.) have limited rent contracts (3 years), which the landlords can decide not to extend (I4).

The § 18 MRG procedure is unclear and causes many uncertainties (for renters and landlords) in terms of the economic feasibility and cost- benefit comparison criteria (Mayr, 2017). When it comes to debates about reforms in the Tenancy Law, § 18- procedure is not mentioned and it does not provide a social or other income stratification in social housings.

142 In the § 18 – procedure, the existing rent reserve, the need for maintenance work and the appropriateness of the costs are examined. In addition, the arbitration board or the court assesses to what extent the costs of the maintenance work are not covered by the main rent reserve and the expected income in the next ten years.

143 Please see ÖNORM EN 15459: 2008 for various cost/benefit calculation methods.

In case a building is retrofitted with object-based state subsidies, rents are capped for 15 years as they can only be increased by the costs for the expenses of the retrofit (kostendeckende Miete) excluding all subsidies (incl. €0,50 for future instalment fees).[144] After the funding period, the cost covering rent (protection period) does not apply, and rents can increase substantially. Nevertheless, this circumstance is not very lucrative for property owners, as they only profit from value increases in the building/apartment but not higher profits through the rents. According to key actors, many building owners instead turn to the private loan market as it offers low-interest rates without explicit rent or energy conditions. This development undermines the policy's aim of protecting vulnerable households.

The reference value rent ('Richtwertmietzinssystem') applies after a retrofit for buildings/apartments built before 1945 and if rental contracts are signed <u>after</u> 1994. For this housing segment, rents cannot increase, which gives little incentive to even start a retrofit. In case of a retrofit, it occurs that these old, but retrofitted buildings have lower rents than newer buildings from the 60ies or 70ies. During the expert interviews, the design of the Tenancy Law and the limited possibility to increase rents after renovations was discussed as a main hindrance and low incentive to invest in energy efficiency. This was pointed out as one of the main reasons of the low Austrian retrofitting rate.

Moreover, a disadvantage of the Tenancy Law is that it does not cover the energy critical segment of private buildings constructed in 1945–1980 (Eisfeld and Seebauer, 2022). The Tenancy Law neither regulates rents here nor does it provide renters protection after retrofits; rents can increase immeasurably after a positive decision at the arbitration board or the court. For social housing residents, the §18 rent increase procedure would lead to considerable rent increases in existing tenancies. One expert sums up:

> *"The big sinners are the single-family houses from the 50s, 60s, 70s and 80s, and tenancy law and housing law matters are irrelevant there".* The expert adds up and explains: *"You have to adjust the Building Regulation [...]. But, I don't think any politician dares to do that for single-family houses; instead, the costs are passed on to the tenants, who cannot defend themselves (I9).*

Improvements work (§ 4 MRG) can only be financed with sufficient rent reserves from the past 10 years. In any case, maintenance work is prioritised over improvements work. If the rent reserve is insufficient and most of the renters agree on capped costs (renters cannot be financially disadvantaged), rents can be increased by the property owners. Economic feasibility

144 However, it is permissible to agree on a different main rent - in accordance with the provisions of the MRG - already during the subsidy period for the time thereafter. However, according to § 1 Abs 4 MRG, a free rent agreement is possible for newly created attic conversions.

is the core classification mechanism, whether the work falls under maintenance or improvement.

According to the MRG (§ 3), the landlord has merely to ensure that the house, the rented items, and those of the common use of the facilities serving the residents of the house in the respective local standard and significant health risks to residents are eliminated.

In case the Tenancy Law is partially applicable or not applicable, maintenance work is regulated in the Austrian General Civil Code (§ 1096 ABGB). In these cases there are no fixed benchmarks or deadlines. Here, a rent increase with a retroactive effect of up to three years is also possible. The property owner is responsible to make efforts to preserve the apartment in useable condition. The ABGB provides a comprehensive maintenance obligation to the property owner.[145] Particularly interesting for the landlord are contractual flexible options with regard to the transfer of the building's maintenance obligation to the tenant.

In What Ways is the Limited-Profit Housing Segment Different?

A different picture evolves in the limited-profit housing segment. A substantial capital contribution for land and construction costs is required to have access to this housing segment. Therefore, it is rather middle-class oriented (Franz and Gruber, 2018; Litschauer and Friesenecker, 2022). Tenants contribute to a regular rent surcharge to a reserve fund (maintenance fee); this reserve fund may be used for maintaining, as well as, for improving housing quality. Renters pay a regular maintenance and improvement amount every month for newly constructed buildings (0,5€/m^2 starting 5 years after moving in).[146] This rent reserve is not just a hypothetical amount of money, as outlined in the Tenancy Law, but it is an obligation, and the reserve has a fixed purpose (§14d WGG). It means that limited profit associations are not allowed to the redistribute maintenance and improvement fees between the buildings but they are strictly dedicated to the respective building (Berger and Höltl, 2019). Consequently, heating costs and poor housing conditions are lower in this segment. In 2016, WGG laws concerning increasing rents, rent reserve and maintenance work were amended so that the retrofitting costs can be distributed now for 20 years (instead of 10 years). An opting-out solution was also included that foresees if the lifetime of e.g. the newly installed heating system is longer than 20 years, rent increases can be distributed for that specific time (I9). Hence,

145 The landlord is responsible for maintaining the dwelling to a medium standard, unless otherwise agreed upon, and must perform all necessary maintenance to keep it usable.

146 The amount increases up to 12% p.a. to a maximum 2€/m2.

renters in limited-profit apartments benefit from adequate housing quality, and substantially lower rents than in the private housing segment.[147]

7.5 Conclusion

This chapter has argued that Austrian housing policies influence energy poverty through the Tenancy Law, object- and subject-based housing subsidies, and rent caps. It was reasoned that Austria is characterised by a complex system of housing regulation that spans multiple levels of government. This sub-chapter illustrated that housing policies and key housing subsidies (e.g. buildings codes, subject- and object-side subsidies) are mainly the responsibility of Federal States level. Rent increases after renovations are repeatedly the cause of disputes because of different case constellations. Especially the energy inefficient housing stock, which is constructed between 1945- 1980, rental prices increase after a retrofit. Similarly, this problematic housing stock predominantly belongs to the municipality, where rents are low before the retrofit, but can increase heavily after a retrofit.

In jurisprudence, maintenance work is an elastic and a dynamic concept. This flexibility causes grey zones of rent setting after a retrofit. The Federal Level holds jurisdiction for implementing the Tenancy Law, which lacks effective mandatory regulations that prescribe energy standards similarly to those applied to newly constructed buildings. Such regulations would have to be included in the existing building regulations and would also affect the privately owned residential sector (Köppl, 2001).

Recent statistics have indicated that housing subsidies for thermal and energy retrofitting measures are not sufficient and lack incentives, *inter alia*, for the general population and especially for energy poor households. Since 2010, the renovation rate in Austria has not increased in accordance with climate targets, but has instead decreased by approximately 25%. Housing policy is a key climate change mitigation tool which needs a clear direction and a realignment as a climate protection instrument.

147 Köppl (2001) provided some proposals to adjust the Tenancy Law to foster retrofitting rates. Although his suggestions are dated back to the year 2001, they are not outdated and could still offer ways to encourage energy efficiency upgrades. An idea would be to design the Tenancy Law similar to the WGG (Limited profit housing act) so that maintenance and improvement contributions are earmarked. Moreover, clear criteria could be developed during profitability and cost/benefit comparisons in the case of rent increase procedures (§18 MRG). Moreover, an abolishment of the 40% tax flat rate reduction in the rent reserve can be considered. This freed up fund could be used for renovation without placing additional burdens on tenants.

Retrofits in multi-storey buildings are particularly difficult to implement due to the challenges in reaching agreement between multiple property owners.[148] The retrofitting potential in Austria remains high: in total, almost 40% of the Austrian housing stock has an inadequate thermal standard. There is a particularly high need for retrofitting private rental apartments and social housing apartments, while non-profit segment is essentially renovated (Amann et al., 2020b). The intersections between energy poverty and the allocation of housing subsidies for inefficient buildings are not sufficiently leveraged and barriers to retrofit are evident in Austria.[149] The private housing segments with comparably high rents and bad energy ratings, where most of the energy poor live are not directly addressed by object-based subsidies. Instead, the bulk of object-based subsidies is curently granted to new construction in Austria. There is therefore clearly room for improvement and adequate targeting.

148 In such contexts, different economic conditions and social backgrounds can lead owners to be more or less willing to retrofit a building. For instance, older property owners may prefer to maintain the status quo, foregoing renovations or block retrofits due to high costs and lack of incentives.

149 Due to the global COVID pandemic, in April 2021, a 3% increase of the reference value rents and category rents have been suspended (Chamber of Labour, 2021). This affects tenants and energy poor households positively.

8. Vienna's Housing Policies Meet Climate Policies

Taking the multilevel governance lense, this chapter moves one level down and analyses housing and climate policies in Vienna. The focus on the city is because although cities have limited power to address the root causes, they have options to mitigate the impacts of climate change as "*European cities have been at the forefront of taking sustainability and climate policy initiatives*" (Kern, 2019, p. 127). Austria's multilevel government structure has delegated much of the implementation, e.g. of the energy transition to its Federal states and municipalities, which play a crucial role in implementing social welfare policies, including addressing energy poverty. This chapter examines the various instruments used to address energy poverty and connects them to the broader climate and housing policies. The critical role played by the social housing sector in fulfilling the city's decarbonisation targets is also highlighted. A nodal governance framework is used to analyze how the magistrates, corporates, and non-governmental institutions form a cooperative network to tackle energy poverty. The active participation of NGOs, civil society groups, local social initiatives, and the private energy sector is crucial in providing local knowledge and support for policy direction.

The following aims are pursued in this chapter:

- to outline the particular role of the City of Vienna and its various programmes in place to cut emissions and energy poverty;
- to elaborate and examine Vienna's energy support scheme to combat energy poverty;
- analyse object-based and subject-based subsidies to increase the retrofitting rate;
- to describe the social housing sector as a special case to target policy endeavors to retrofit;
- to outline potential pitfalls of district heating contracts.

This chapter will show that studying urban climate change governance constitutes an important research agenda to understand the emerging partnerships and networks that tackle energy poverty. Following the same pattern as in chapter 7, it is possible to map and divide the relevant actors in charge of energy poverty measures, and also to divide *object*- and *subject*-based related subsidies to increase retrofitting rates and ease energy poverty.

The structure of this chapter is as follows: first, major Viennese frameworks and strategies in the field of climate and energy policy are introduced and the question is raised whether the city was able to perform well on the major indicators. Based on this, sub-chapter *two* provides an overview of the governance framework and current object-based and subject-based subsidies. Sub-chapter *three* describes the collaboration activities between key stakeholder that offer the energy support scheme. The sub-chapter *four* deals with the social housing sector/arrangements in Vienna and the rent system securing affordability. Sub-chapter *five* focuses on the practical perspectives of retrofitting procedures and potential rent increases in social housings in Vienna. Sub-chapter *six* discusses district heating and its potential disadvantages connected to self-restricting behaviours. Lastly, sub-chapter *seven* highlights that social housing requires additional government subsidies and investments to retrofit the housing stock and securing affordable rents and suggests that financial assistance is vital in easing income and energy poverty.

8.1 Austria is not Vienna, and Vienna is not Austria

Horne (2018, p. 6) opens his book on urban housing sustainability with the claim "*that housing, climate change and cities currently remain separate in policy, scholarship and discourse*." This quote highlights a gap in ongoing urban studies, the need to deepen knowledge and establish a interdisciplinary research agenda. This chapter thus illustrates the areas of overlap between housing policies, energy poverty and climate change mitigation effort in Vienna. International climate change agreements, such as the United Nations Framework Convention on Climate Change and the Paris Agreement are key agreements to fight rising level of GHG emissions. However, national governments are unable to deliver internationally agreed climate targets without local/regional action. Cities play a fundamental role in reaching climate objectives, since they are responsible for achieving more than a third of the national targets and produce over half of the EU GHG emissions (Azevedo et al., 2013; Roumet, 2017). Local approaches have also shown to be more successful in reducing energy poverty than national approaches, as found by Kyprianou et al. (2019) in their comparative study on energy poverty policies. At the same time, action at this level is particularly urgent since the consequences of climate change are most likely to impact those living in cities (Bulkeley, 2013; van der Heijden, 2019). Depending on the national context, local governments, regional authorities, and cities can have a substantial influence in shaping GHG emissions and climate change policies (UN Habitat, 2011). Many European cities have grasped the urgent problem, establishing horizontal collaborations of international city networks (e.g. Covenant of Mayors, Climate Alliance) to foster knowledge exchange, sharing best practices and innovative measures (Melica et al., 2018).[150]

However, achieving collective objectives requires effective horizontal and vertical coordination between various levels of government and between public and non-public actors to avoid “spatial mismatch" (Azevedo and Leal, 2017; Böhme et al., 2015; Melica et al., 2018). This thesis follows Kazepov (2010, 2005) argument that cities and their specific context are crucial to analyse their embeddedness into institutional arrangements, which provide actors facilitating or constraining conditions to implement climate change mitigation strategies. This approach is then used to analyse the case of the city of Vienna, which has positioned itself internationally as a leader in terms of climate policies as any innovative approaches are tested in Vienna (Cucca and Friesenecker, 2021; Hermis, 2020; Mocca et al., 2020):

> *“So it's a try out, yes. Oslo has something similar, yes. You can study and analyse it and then see how that might look for Vienna”(I3).*

> *„The strong role of the public sector – and the inherent resilience of institutions – have mitigated the impact of neoliberal tendencies, not only slowing down the processes of change but also buying time to experiment with innovative solutions (most prominently in housing, but similarly on the labour market) (Kazepov and Verwiebe, 2022, p. 11)“*

Because the capital of Austria is simultaneously a Federal State and a municipality, it has more legislative power than other Austrian cities (Brandl and Zielinska, 2020). The political context and history of a country can influence its climate and social policies. In Austria, the long-standing dominance of the Social Democratic Party has played a significant role in shaping these policies. As a result,

> *“the local dimension is becoming more important in regulatory terms. This can occur in different ways. On the one hand, the state can decentralize some of its functions to lower levels of government, reforming the existing system. On the other hand, there might be an implicit decentralization resulting from a shift in the relevance of different policies, operating one at the national and the other at the local level (Kazepov, 2005, p. 22).”*

This rescaling process (Oosterlynck et al., 2019) in Austria took place through the federal agreement (“Article 15a (B- VG) of the Federal Constitution between the Federal Government and the provinces of climate protection in the building sector”). A transfer of key tasks and responsibilities from the national level to the Federal States characterises this rescaling process,

150 Some cities climate goals even more ambitious than their national governments or the EU (Kern, 2019; Roumet, 2017; Smeds and Acuto, 2018). Vienna is embedded in the city network Climate Alliance which serves to generate knowledge, exchange of ideas and instruments. This is done by uploading policies and/or upscaling local best practices.

e.g. greening the buildings sector and providing support for energy poor households through subsidy schemes and encouraging public-private cooperation.

The following programmes and strategies are currently in place in Vienna to increase energy efficiency, decrease GHG emissions and reduce energy poverty: the Smart City Framework Strategy 2050, the Energy Framework Strategy, and the Climate Protection Programme II of Vienna[151] are strategic documents containing the main climate and energy goals for Vienna, and some outline measures against energy poverty.[152] All these instruments illustrate that Vienna has developed an ambitious green agenda in an attempt to lower GHG emissions.

With the **Smart City Framework Strategy 2050** (inception: 2019), Vienna committed to a path of decarbonisation. It is an umbrella strategy and an overarching orientation framework for the city.[153] Energy poverty, vulnerable households, and affordability are alluded to in this strategy document. An interviewed expert summarised that, while the Smart City Strategy is very broad, its strength lies in effectively establishing networks business groups and public authorities by facilitating sectorial integration of different stakeholders, both in the public and private sector (I3). Greater collaboration and linkages are clearly identified as new modus operandi by the expert (I3). The Smart City Framework designed a comprehensive approach that aims to strengthen smart governance, and establish an integrated approach (Castelnovo et al., 2016; Meijer and Bolívar, 2016; Roblek, 2019).

> *"[…] and the Smart City Wien strategy - it is very general, you can write a lot into it, but what is special about it… it's strength is that it is supported by the business groups and that it is thought across business groups. Because the organisation of the magistrate is like a silo, but precisely the strategies such as the Smart City or climate protection program and the new climate change adaptation strategy that is currently drafted - so I notice that more and more business groups are being thought of and worked here together. Competence centres have also been set up in the City Planning Department on certain topics, i.e. on green space, infrastructure, and buildings. And the fact that competence centres have been set up and no longer just called "X and Y" already shows the active will to network and work together (I3)".*

Vienna's Climate Protection Programme II has been established in 1999 to contribute to Austria's commitments under the Kyoto Protocol (KliP II 2010- 2020)].[154] The expert underlined that

151 The Urban Development Plan Vienna- STEP 2025 also entails the goal at guaranteeing that social segregation tendencies are recognized so that measures can be taken to prevent the displacement of low-income groups.

152 All these initiatives and strategies are based on voluntary commitment and legal or financial consequences in case of failure are not included.

153 It aims to achieve a 50% decrease in local GHG emissions (compared to 2005) by 2030 and an 85% reduction by 2050 (City of Vienna, 2019c). The goal is to decrease final energy consumption in buildings for heating, cooling and warm water by 1% and CO_2 emissions by 2% per person per year.

154 It contains approximately 385 individual measures and the goal to achieve a 21% per capita decrease in GHG emission by 2020.

> *“they [measures] were concrete and not just political memoranda” (I3). Energy poverty is not mentioned in the climate strategy of Vienna and vulnerable groups were, also, not specifically addressed as it was not a focus of the KliP II” (I3). It, however, “always aimed to be socially acceptable, meaning that everyone could afford to lower the GHG emission in Vienna” (I3).*

Many proposed initiatives and measures have been successfully implemented and in 2018 emissions in Vienna decreased by 37% per capita compared to 1990. The GHG emissions goal has, therefore, already been achieved at this point (Magistrat Climate Protection and City of Vienna, 2020). The KliP II also introduced the retrofitting order for old buildings.[155] KliP II expired by the end of 2021 and Viennas Climate Guide continues the roadmap of KliP II (City of Vienna, 2022) .

The Energy Framework Strategy 2030 for Vienna (inception: 2019) established the energy policy goals for the city until 2030. The strategy is oriented towards achieving energy efficiency and, security of supply while having due regard to its social impact and economic viability. As the vast majority of energy in Vienna is used by transportation and housing, these two sectors are identified as major priorities by the City’s Administration, also in relation to tackle energy poverty. The strategy sets the social goal to meet the energy demand at affordable prices and highlights that energy prices and respective bills should be made as transparent as possible to end consumers. Two of the main strategic issues concern the need to combat energy poverty through greater energy efficiency and distribute the costs for the transformation of energy systems using the *polluter pays principle.* Moreover, structural improvements that tackle the causes are preferred over financial equalisation measures (City of Vienna, 2017).

The Urban Energy Efficiency Programme 2030 of Vienna [SEP 2030] (inception: 2019) has the overarching goal to reduce overall energy consumption by 30% per person in comparison to 2005 for households, private services, public services, industry and manufacturing sectors. The program also supports social and economic goals, including the elimination of energy poverty in Vienna. It is a continuation of the Energy Framework Strategy 2030, and it is specifically dedicated to increasing energy efficiency. Cross-sectorial measures are outlined to tackle energy poverty, which focus on building energy awareness and energy counselling for low-income households through the Viennese energy support system (City of Vienna, 2019a). During the expert interview at the climate coordination office of the City of Vienna, the lack of synergies between climate and social policies was mentioned in the following way:

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155 The housing sector had the highest sectorial improvements: compared to 1990, per capita emissions decreased by -49.6% in 2018 (Magistrat Climate Protection and City of Vienna, 2020).

> *"Until now, the city of Vienna's climate policy goals have ignored social aspects. But, what we are now trying to do with climate change adaptation is to take the social aspect into account. For the simple and pragmatic reason, because we can then sell it better. We say adaptation is not just about adaptation, it is also specifically about health, mobility issues and social issues" (I3).*

The importance of crafting local measures that enable cities to deliver emission reductions was also highlighted by the expert:

> *"The special thing about adaptation, or rather, you should say climate crisis, is that we only have 10 years left, and that's damn short. Climate adaptation involves local measures and the City of Vienna can take locally defined measures. When it comes to climate protection, we have to think globally (I3)".*

The City of Vienna shoots high with self-imposed climate goals – but can it also deliver? Considering current climate achievements and trends, Vienna does not rank as one of the top performing Austrian Federal States. An analysis by Baumann et al. (2021) found that, in the period 1990–2018, all Federal States were lagging in reaching their climate targets and instead witnessed significant increases in their final energy consumption (+48% on average). In line with the national picture, Vienna increased, on average, its final energy consumption by 33% between 1990 and 2018. In relation to overall GHG emissions, the capital also increased its emissions by 5% in 2017 compared to 1990 levels.[156]

Considering the housing sector, Vienna's GHG emission reduction ambitions could not catch up the Austrian averages: while Austria's total GHG emissions decreased by -33% between 2005 and 2017, in Vienna they decreased "only" by 19% (Baumann et al., 2021, p. 24). Moreover, Vienna lags national efforts to employ renewable energy sources: compared to the Austrian average (33%), Vienna had the lowest share of renewable energy relative to overall consumption (9%) compared to all federal states with most of its supply in electricity mainly coming through fossil fuels or net imports (86%). This makes Vienna the worst performing federal state on several metrics. While the city of Vienna has set ambitious targets and effectively established various strategies, it is far from the best performing Austrian state when it comes to reducing energy consumption, lowering GHG emissions and transitioning to renewable energy sources.

156 Vienna, however, had the lowest energy consumption per capita with 20 MWh and the lowest per capita emissions with 4.7 tonnes of CO_2 (Baumann et al., 2021).

8.2 Energy Poverty Measures and Ensuring Affordable Housing in Vienna

EU top-down policies aimed at addressing energy poverty provide a general direction, but implementation is challenging due to varying national and local factors. Energy poverty can be approached as a social, health, or climate change issue, but there is a concern that it may be allocated to a single governmental silo. The subsidiarity principle, often cited as a reason for EU climate inaction, can be utilized to enhance regional autonomy and flexibility, allowing for better-tailored policy adaptation to local contexts. It can be framed as a means of adapting supranational policies to local/regional contexts. However, the level of climate mitigation ambition is heavily determined by the political and legal context in which a city is situated (Boswell and Mason, 2018). Therefore, in cases where there is a high degree of autonomy, local experimentation can create opportunities for new policy instruments and coordination between different paths of governance (Bulkeley and Betsill, 2013). Through new public management developments, the City of Vienna decentralised and contracted-out public services, which are now provided by third parties or non-profit actors (Grossi et al., 2020; Kazepov, 2005; Reinprecht, 2017). Creutzfeldt et al. (2020) introduced the concept of *nodal governance*, according to which local actors respond to energy poverty by introducing innovative local initiatives that are part of a broader collaborative governance network (e.g. Smart City Framework, Grätzeleltern[157]). Bulkeley and Betsill (2013) addressed the importance of multilevel governance of local actors and municipalities in implementing climate and energy policies. They highlighted the growing importance of non-state actors in shaping urban climate governance, as well as municipal voluntarism. The City of Vienna, for instance, surpasses the federal level targets by introducing more progressive climate goals (Benz et al. 2015; Kammerzell 2019) and enacting them through a "self-governing" agenda (Bulkeley and Betsill, 2013). Figure 20 provides an overview of the main actors identified in the governance framework of Vienna.

157The 'Grätzeleltern' are volunteers who undertake home visits and advise competently and free of charge on various topics, such as high electricity bills, rental law, mould, neighbourhood conflicts. 'Gesund Wohnen im Grätzel' is a project of the Caritas Vienna in cooperation with the Urban Renewal Offices Caritas (2021).

Figure 20 Governance Framework in Vienna (Source: Own Visualisation).

Next, object-based and subject-based subsidies are introduced to gauge the design of aid for households that aim a renovation or are energy poor.

Object-based subsidies

- The municipal authority for housing research MA 50: Its focus lies in supervising and granting subsidies for retrofitting activities in detached and semi-detached houses, as well as in the provision of social housing. The major goal of the MA 50 is to meet the demand for affordable living space in Vienna through newly constructed buildings and retrofitting. MA 50 handles the overall management of housings subsidies in Vienna,[158] including supervision over the non-profit building associations and it has responsibility over § 18 procedures outlined in chapter 7. During the interview, the housing expert from the MA 50 explained that energy-related topics, such as energy poverty or climate policies, are not the focus of the MA 50 (I8). Consciousness for these intersecting topics can, therefore, be strengthened. Lechner and Wala

158 The Viennese Housing Promotion and House Renovation Act (WWFSG) is the legal basis for subsidy procedures and regulates the amount and type of funding (LGBl. Nr. 69/2018). Further laws that tangle the housing subsidies of the MA 50 are: New building directive (LGBl. Nr. 27/2019), retrofitting directive (LGBl. Nr. 33/2018), equity substitute loan directive (LGBl. Nr. 03/2016), and housing assistance (LGBl. Nr. 20/2000).

(2005) concluded that Austrian low-income households are actually the target group for housing subsidies, but they are prevented from accessing them due to high income thresholds.

- The **municipal authority for energy planning MA 20** provides subsidies, such as eco-power plants, solar thermal energy, or photovoltaic. It also offers local energy counselling and information concerning retrofitting, urban renewal, housing and building law, energy and building technology.

- The **municipal authority for urban renewal and inspection body for buildings MA 25** handles thermal renovations (so-called Thewosan, see sub-chapter 8.4), solar thermal energy and heating pumps. On behalf of MA 50, the MA 25 examines housing retrofitting projects from a technical and economic point of view for compliance with the Vienna Housing Promotion and House Renovation Act (WWFSG) and to coordinate retrofitting projects.

- **wohnfonds_wien** is a non-profit public enterprise owned by the City of Vienna which is responsible for large-scale subsidised retrofitting projects by preserving the historic housing stock on behalf of the MA 50.[159] In 2019, wohnfonds_wien granted €216.6 million for finalising retrofitting projects (wohnfonds_wien, 2020). Wohnfonds_wien confirmed that apartments have substantially lower heating requirements in Vienna after a retrofit: before a retrofit 106 kWh/m^2a; after a retrofit 29.7 kWh/m^2a (City of Vienna, 2021).[160]

The Austrian Court of Auditors (2021b) reported that the revenues of the City of Vienna for housing subsidies decreased between 2013 and 2018 by 35% from €335.55 million to €217.01 million. The total expenses for housing subsidies also decreased between 2013 and 2018 by 20%, amounting to €506.87 million in 2018. At the same time, another trend is noticeable: while between 2006 and 2010 only 24% on the buildings in Vienna were constructed with no subsidies, the amount increased drastically to 63% between 2011 and 2014. These newly constructed buildings are not subject to tenancy regulations and thus promise more investment returns as they do not have rent caps. These buildings translate into higher rents (as outlined in the previous chapter). In comparison, buildings that are built with state subsidies stipulate stricter rules (e.g. Vienna's building and thermal retrofitting law WWFSG) for energy efficiency.

159 wohnfonds_wien also provides properties and land for social housing, residential building blocks, and reconstruction in buildings and residential homes. The wohnfonds_wien also delivers recommendations for possible retrofitting projects to the City of Vienna.

160 To submit an application for a retrofit, the most important document is the so-called retrofitting concept that contains calculations of the heating demand before and after the retrofit, which must not exceed 1.65-times that of a low-energy building. The most important eligibility criteria to receive a subsidy are: the dwelling has to be older than 20 years; it must be an apartment with a surface area of maximum 150m2.

The **Viennese building code** is a core legislative instrument to increase energy efficiency and use efficient alternative energy systems. It stipulates the minimum requirements for retrofitting and new construction, while the WWFSG contains stricter energy requirements for retrofits.[161] For new buildings and those where at least 25% of the building surface has been changed or repaired, the installation of a heat supply system that runs on solid and liquid fossil fuels is not permitted. The amendment of the building code foresees a mandatory insulation of the top floor ceiling (§118 Abs. 7) in case of renovation activities included conversions or renovations (> 25%).[162]

With introducing the dedicated category of "subsidised housing" in 2019 in Vienna's building code, the city established a new approach to secure affordable housing (Austrian Court of Auditors, 2021b). The City of Vienna has taken a major step to circumvent increasing rents in Vienna by allocating two-thirds to subsidised housing space to properties that are being converted into residential areas. The city tries to secure affordable living space with rents that amount to a maximum of 5 €/m^2.[163] This new category captures all areas of Vienna that are converted into residential areas (GBV, 2020).

It is possible to distinguish between different retrofitting activities and subsidies in Vienna that are regulated in the WWFSG: renovation of the base (Sockelsanierung)[164], total retrofit (Totalsanierung),[165] block renewal (Blocksanierung).[166]

Vienna's Climate Protection Plan and KliP I introduced the so-called THEWOSAN- Thermal energy renovation of housing subsidy scheme [inception 2000], and it constitutes the largest subsidy that the wohnfonds_wien granted in 2019 (€82.8 million). It aims to reduce significantly heat energy demand and the consumption of fossil fuels, such as minimising energy losses and switching to sustainable air conditioning systems in existing residential buildings (apartment buildings and single-family houses). Sustainable and environmentally friendly systems are used. Gas heating and electric heating are not funded at all. The subsidies are provided as a non-repayable contribution and depend on the energy indicators achieved.

161 The building code regulates regional planning, land use, zoning and technical construction standards.

162 The construction of a decentralized heating supply system for gaseous fossil fuels is also not permitted in new buildings. However, an existing heating system does not have to be removed.

163 The regulation applies to areas of 5,000 square meters or more.

164 This measure includes necessary maintenance work according to § 3 MRG (e.g. facade, repairing ceiling).

165 The building is thoroughly renovated during the total renovation to reach category A, but unlike the base renovation, buildings are completely empty and not inhabited by renters.

166 The block renovation is a thorough renovation of several neighbouring buildings or large residential complexes. The aim is to improve the urban development of the area and to upgrade a neighbourhood. As the individual buildings are also being improved, some may be demolished and rebuilt entirely.

They cover up to two-thirds of the total investment costs, depending on energy performance. Since the amendment of the Retrofitting Directive in 2008, THEWOSAN introduced new retrofitting concepts: comprehensive thermal energy renovation[167], individual improvements [Einzelbauteiverbesserungen][168], delta subsidy.[169]

Besides subsidies, the City of Vienna introduced new housing programs to ensure an affordable supply. Since 2012, the *SMART* housing programme financed by the City of Vienna provides low-income households with affordable new housing in line with the UN sustainable development goal 11.1 to ensure access to adequate, safe and affordable housing. It is mostly aimed at assisting young families, couples, single parents, and singles.[170] Access to these limited SMART apartments depends on providing urgent need. In 2018, 830 SMART apartments have been completed (Austrian Court of Auditors, 2021b). Since 2013, subsidised property developers must offer at least a third of the apartments as SMART apartments per building site. From October 2019 on, at least half of all apartments per building site have to be SMART apartments.

Another program by the City of Vienna which aims at securing affordable rents is the *Social Housing New* [German: Gemeindebau NEU] program. By 2020, 4,000 affordable social housing units are planned. Rents are capped to 7.50€/m^2 and access is provided for people with a Viennese housings ticket. A down payment to access these new social housings is not required. The supply of newly constructed buildings is, however, too limited and can be considered as having a negligible effect in providing new affordable housing for low-income or energy poor households.

167 If at least 3 parts of the building envelope and / or the building services are jointly renewed: window surfaces, roof or top floor ceiling, facades, basement ceiling and / or energetically relevant building services system (target buildings: 1950ies – 1980ies).

168 Enables a staggered renovation and excludes overall retrofits (e.g. new heating system or installation of central heating system, increasing living quality). A retrofitting concept and U-values (§ 2 Abs. 3 of retrofitting directive) must be submitted.

169 The delta funding is a thermal and energetic renovation in which the reduction of the heating requirement is in the foreground. Delta funding may only be granted where, for technical, legal, or economic reasons, the minimum standards for comprehensive thermal and energetic renovation cannot be achieved. Application example: 'Gründerzeit' houses with facades worth preserving.

170 The maximum rent amount is around 7.5€/month (including utility costs and taxes) and one third of all new subsidized constructions in Vienna have to be so-called SMART dwellings. The financial contribution from the City of Vienna to the construction is 72€/m2 (building cost contribution and basic cost contribution). For example, a 2-room SMART dwelling with 55m2 costs 412.50€/month (including utility costs and taxes). The financial contribution is approximately €3.300 (Wohnservice Wien, 2021). Applicants must be at least 17 years old, have a primary residence in Vienna for the previous two years, must have Austrian citizenship, and a maximum household income of €44.700 p.a.

Subject-based subsidies

- The **means-tested minimum income scheme** (social office) in Vienna falls under the federal state's responsibility. It aims at tackling poverty and social exclusion for households who have limited (at-risk-of-poverty threshold in 2021) or no income. In 2021, it comprised two parts: 1.) a maximum of €688,01 maintenance payment and 2.) a maximum of €229,34 to cover monthly housing costs. Therefore, the scheme amounts to a maximum amount of €917,35 (fixed tax allowance on assets per needs unit: EUR €4.586,76). Within Austrian's social security system, the share for housing and social exclusion amounts to 2% of direct money transfers and expenses (€1.179 million) and 6% of contributions are in kind (€1.923 million). These include expenses such as housing allowances or benefits of the needs-based minimum benefit system.[171] Welfare benefits concerned with housing are in 92% of the cases subject to means-testing criteria (Austrian Social Ministry, 2019).
- The **Magistrate for social services** (MA 40) offers rent allowances for pensioners who receive a minimum pension. This instrument offers a relief to secure affordable housing.
- **MA 50 provides housing allowances for low-income households**. The eligibility criteria and allocated amount of housing allowance depend mostly on household income, the size of the household, housing costs and the size of the apartment. The subsidy is granted for a.) apartments constructed with subsidies, b.) retrofitted apartments that received state subsidies, and c.) unsubsidised private apartments (general housing assistance). In Vienna, 5% of households receive rent allowances that decrease the cost of accommodation. The maximum duration to receive housing allowances is *two* years. This implies that eligibility checks are frequently performed.

For all three benefits above, the allowance is conditioned on having residency in Vienna and Austrian citizenship or equal to Austrian citizens.[172] It is important to note that providing housing allowances for low-income households does not guarantee that the funds will be used specifically for housing expenses.

- The municipal authority for social matters (MA 40), the municipal authority for energy planning (MA 20), the environmental counseling (Die Umweltberatung) and the energy utility "Wien Energie" provide the so-called **"Viennese energy support"** for vulnerable households who have difficulties to pay their energy bills. The City of Vienna replaced the

171 The largest amount of the expenses goes to pensions (44%), followed by illness and healthcare (26%), and family benefits (9%)

172 EU citizens and third-country residents with a main residence of at least of 5 years in Vienna are eligible for receiving support.

winter fuel benefit scheme in order to reach energy poor households more accurately. Various actors and stakeholders are embedded in this nodal governance structure (Creutzfeldt et al., 2020). As this instrument constitutes an extraordinary support instrument for energy poor households that is one of a kind in Austria, it will be detailed in the next sub-chapter.

8.3 Vienna's Energy Support Scheme

Similar to the Verbundstromhilfecheck by the Caritas (see chapter 6.8), the scheme is based on three pillars: 1.) financial support, 2.) energy counselling, and 3.) energy efficiency measures. The Social and Health Magistrate 40 handles the operative management of the Viennese energy support. The energy planning Magistrate 20 finances the environmental counselling sessions (executed by the environmental agency "Die Umweltberatung"), which are free for households in complicated life situations, such as sickness, bad housing situation, and debts.

The municipal authority 40 coordinates and finances the recommended measure by the energy counsellor. It includes installation of district heating, support paying gas or electricity bills, exchange of refrigerator, maintenance of the gas boiler, insulating glass and windows. People receiving means-tested guaranteed minimum income or beneficiaries with minimum pension with a so-called "Mobilpass"[173], and with a principal residence in Vienna are eligible to receive the energy support. Over 2,400 social hardship cases received energy consultations at home since 2014 (Environmental consultation, 2021).

During the consultation, energy consumption is analysed and the causes of high consumption are identified. Concrete energy-saving measures are developed together with the household, which can be implemented without investment costs. Customer behavioural changes are among the non-investment measures that are addressed. Energy consultants also ascertain the potential for saving energy and costs through measures that require investments, such as, heating system replacement, repairs, device replacement or installations. In an advisory protocol, the recommendations for energy-saving investments are sent to the municipal department 40, which organises the implementation of the recommended measures and follow-up support.

173 The 'Mobilpass' entitles to discounts for public services (e.g. public transport, and public swimming pools) and to benefit payments for winter fuel. Eligibility for the 'Mobilpass' is determined by permanent residence in Vienna, household size, income, and whether the household receives other social security benefits.

The energy support scheme is linked to the means tested minimum income scheme. If households do not receive a minimum income, it is impossible to receive any energy support. Furthermore, attention is mostly placed on households with high energy costs rather than on those that, to compensate for inefficient or derelict housing, skimp on energy consumption to lower their overall energy costs.

The “Viennese energy support” is closely tied to the state-owned regional energy supplier “Wien Energie/ Wiener Stadtwerke Holding AG”, which has limited liability.[174] The two municipal bodies, the environmental counseling company and the energy supplier form a support network based on cooperation to support vulnerable households. This collaboration between state and non-state actors are important features of a nodal governance framework.

“Wien Energie” established a dedicated Ombudsman's office for clients concerned with district heating, gas and electricity.[175] Through intense consultation with other social institutions (e.g. Fonds Soziales Wien and Caritas) and experts, the energy supplier ‘Wien Energie’ developed criteria to evaluate whether a household should be considered as a “social hardship case” that would make it eligible to receive support.[176] The criteria are transparent and Wien Energie provides a self-check for prospective clients to verify their eligibility for support on their internet platform.

The energy provider assesses whether the customer is eligible to suspend, re-assess, or waive outstanding energy payments. This assessment follows a multi-criteria list of income, health, housing, family, debt situations, and life crises. If customers meet 3 out of 27 indicators, the four institutions (energy provider, social services and municipal authorities) agree on a course of action tailored to the particular client (see Appendix A Table 41). For instance, if the household is behind in rent payments, the provider may suspend energy payments to avoid renter displacement. This approach accounts for multiple deprivations and precarious living conditions and aims to provide individually tailored, long-term solutions instead of one-off quick fixes (Wiener Stadtwerke 2013). Such successful collaboration can be traced back to

174 In 1999, the Wiener Stadtwerke were split off from the municipal administration, the magistrate, and renamed Wiener Stadtwerke Holding AG. Their business domains were liberalised in the years that followed (1999–2003: electricity market liberalisation, 2000: gas market liberalisation, 2002). Wiener Stadtwerke's energy sector was restructured in 2011 and separated between a regulated area (gas and electricity network) and a competitive area (district heating, sales, energy comfort). Furthermore, Wien Energie continued to compete with integrated district heating in 2013, and the new firm "Wiener Netze," responsible for networks for electricity, natural gas, district heating, and telecommunications, was established.

175 Note, that the obligation to establish a counselling possibility for large energy suppliers exists since 2014 (Wien Energie, 2013). Already in 2011, ‘Wien Energie’ developed this Ombudsman’s office before law prescribed it.

176 Since 2011, the Wien Energie Ombudsman service received over 21,000 inquiries from social agencies and provided aid to about 14,500 households (Wien Energie, 2020).

institutional proximity between the municipal administration, NGOs and the energy provider, since the latter is a public enterprise owned by the City.

Wien Energie considers energy poverty as a multidimensional issue that requires an overarching approach for deprived households. However, an important eligibility indicator for support services is neglected in this approach, namely living in poor, energy-inefficient building fabric. During the interview with the energy supplier "Wien Energie", the expert resisted committing to an energy poverty definition. The expert said

> *"what is the point? It is all about concrete help; the The Federal Ministry of Social Affairs, Health, Care and Consumer Protection, and E-Control use very quantitative numbers" (I4).*

A challenge stated by the expert was how to filter out people in need from the over one million clients of the energy supplier. They use a pragmatic approach and begin with identifying the life situations of the energy poor. Information on clients struggling with energy bill payments is obtained from Caritas or other institutions such as MA 40 (I4). This allows for targeting those who require support. The expert emphasized that following alternative definitions could risk including households that may not actually be in need, resulting in 'false positives'. The expert describes that, during their time in this department of the Ombudsman's office, they have not encountered a single case that was "only" energy poor, rather than presenting multiple intersecting problems. This quote is echoes with the empirical results of Großmann and Kahlheber (2018).

Although the energy provider intends to remedy energy poverty, they do not have access to client's personal information due to data protection. That is why coordination with social services, Magistrates and NGOs are of major importance for the work of the Ombudsman's office. The Viennese energy supplier highlighted that "*these personal data have lost nothing there [at the energy supplier]*" (I4). 'Wien Energie' forwards their vulnerable consumers to the expert team at the "environmental counselling" (German: Die Umweltberatung) agency.[177] The experts propose possible measures and notify the energy Magistrate 20 for their implementation. In their annual report, the 'environmental counselling' agency states that, in 2019, 185 households with arrears on utility bills in Vienna have been provided with energy support (Die Umweltberatung, 2020).

177 'Environmental Counselling' is funded by the City of Vienna – Environmental Protection Magistrate.

However, echoing the criticism levelled by the Austrian Court of Auditors, 'Wien Energie' can be considered as lacking in transparency with regards to the number of people receiving support. Moreover, details about the Ombudsman's office are difficult to find on the respective website. The Austrian Court of Auditors (2020) therefore recommended improving access to information and providing simpler ways to access the customer centres and the Ombudsman's office.

Who Receives Support by the Energy Provider?

During the expert interview with the energy provider, certain social segments were highlighted, such as chronically ill and elderly people, who have higher energy needs but are often unrecognised. Pensioners are a identified also as a vulnerable group, being familiar with energy restricting behaviours and live frugally because of their socialisation. While the expert described that "*it is their normal attitude towards life*" (I4), they also cautioned against subsuming all pensioners in this group, as there are some that predominantly live frugally and some who are not self-restricting at all (I4). Another expert from the Caritas explained that elderly often avoid going to counselling or refuse to receive help:

> *"they come from another generation, where you do not want help. […] What will the others think of me? Often, also illnesses add up, which makes it difficult to go to the social counselling agencies. Many people who are not familiar with the internet who cannot open Google and receive help"(I4).*

Other energy poor groups that were mentioned are single parents, needs-based benefit recipients, subsistence level recipients, young adults with low energy literacy and low education. These vulnerable groups closely mirror those identified by the assessment from the climate coordination office in Vienna. The expert mentions:

> *"especially with the climate crisis, the social point of view comes into play, since it is very much about vulnerable groups: pensioners, chronically sick, households with children" (I6).*

Similar to the energy supplier in Vienna, the Caritas identified intersecting problems, multiple vulnerable groups, and difficulties to provide help to some deprived population groups:

“The fates can differ significantly. The reasons why someone falls into energy poverty are very diverse. So we often have elderly people, who are experiencing old aged poverty, or sick people. It is, of course, difficult to get in touch with them. It’s people who have difficulties and who cannot come to social services counselling. Then we have personal destinies like work-related accidents. People who have been self-employed and cannot work anymore and who have nothing left. In general, it's people who experience personal misfortunes and are often overwhelmed by the general situation. We have often single parents, not only mothers but predominantly. Large families have higher energy consumption, because they have five kids. And, of course, people from educationally disadvantaged backgrounds, who have precarious working situations, and groups of people with a migration background, who have difficulties orienting with all the technical equipment, because they didn’t have these appliances in their country of origin. In addition, if you come from the Middle East, oil and electricity were not a matter of discussion and suddenly it is prominent.[…]. In general, it is an intermixed situation (I6).”

To sum up, identifying energy poor households remains a core challenge. traditional energy counselling approaches have not always proven effective, as they may fail to reach households that do not meet eligibility criteria or simply because people do not approach support services. In some cases, households may even become ineligible for support due to overall low energy consumption, even if this is caused by self-imposed restricting behavior aimed at reducing energy costs to affordable levels. The limitation of this approach is that it focuses solely on the inability to pay for high-energy bills, overlooking the fact that energy poverty can also manifest in underconsumption and inefficient buildings. Although local government efforts to address energy poverty are generally strong, they are constrained by the absence of a national framework and lack of a clear mandate.

8.4 Vienna a City of Tenants - Social Housing as a Case Study

As the primary data analysis focuses on the social housing segment in Vienna, this sub-chapter introduces this particular sector in more detail and put it in context to understand interrelations to the climate goal of increasing the retrofitting rate and how the city of Vienna secures affordable rents. The focus on this housing segments stems from previous research results that demonstrated that many housing problems tend to occur more often among social housing[178] tenants, which points to vulnerability to rising energy costs and a high risk of energy poverty (Boomsma et al., 2019). The availability of social housing plays a crucial role for energy poor households because it eases available household income and secures affordable rents. According to several interviewed experts, “Wiener Wohnen” was illustrated as a key actor to

178 Social housing is defined as a housing segment that refers to housing that is offered at a lower-than-market price to specific sections of the population.

achieve the national retrofitting target. The expert from the municipal authorities for climate coordination evaluates the current renovation activities*:*

> *„The 2% [retrofitting] goal is of course important; it is written everywhere. However, in reality it was always said that it will be difficult to implement. At the moment, we stand at approx. 1%; doubling the amount will be complicated. But the City of Vienna is the biggest residential property owner"(I3).*

The city of Vienna is the leading homeowner in Europe and makes use of the majority of the housing subsidies to retrofit their housing stock (I13; Lang and Stoeger, 2018). State intervention in housing is high and looks back to a long tradition. Most of the population (77%) lives in rented properties, representing Vienna as a city of tenants (Statistik Austria, 2021c). This exceptionally high share compared to the rest of Austria and Europe traces back to the internationally renowned "Vienna model of housing", which was adopted since the 1920s to provide affordable and inclusive "housing for all" (Förster and Menking, 2016; Statistik Austria, 2019). Active housing policy in Vienna is a tangible political commitment by all parties. It has a long corporatist tradition known as "Red Vienna". In international housing research debates, Austria is classified as a conservative, corporatist housing welfare regime (Canevarolo, 2018; Esping-Andersen, 1990; Matznetter, 2002). Irrespectively of current post-neoliberal housing developments, the achievements of "Red Vienna" have until now a price-dampening effect on the housing market prices also because municipal housing did not undergo comprehensive privatisation, as compared to e.g. Berlin (Kazepov and Verwiebe, 2022, p. 10). The city of Vienna is often described in international debates as a "best practice" example for successful housing policy (Marquardt and Glaser, 2020). The complex housing structure and its Tenancy Law, however, also produce inequalities and must be analysed carefully to avoid jumping too fast into conclusions.

During the large-scale social housing expansion, which started in 1917 and ended in 1934, 63,000 apartments were built by Wiener Wohnen (Wiener Wohnen, 2021). Until now, the Viennese social housing stock is dispersed over all 23 city districts in an effort to mitigate segregation processes (Lévy-Vroelant and Reinprecht, 2014). Social housing in Vienna is an umbrella term for municipal housing, subsidised flats and renovated buildings that have been retrofitted as a part of the "gentle urban renewal" programme (since the 1970ies) (today: wohnfonds_wien), such as the THEWOSAN. The policy of the "gentle urban renewal" pursued the goal of renovating existing buildings while keeping the social follow-up costs as low as possible, i.e. without changing tenants (Reinprecht, 2017). The City of Vienna owns a significant amount of affordable social housing (approx. 57% of all rented dwellings in Vienna) that secures high levels of de-commodification (Esping-Andersen, 1998; Statistik Austria, 2019). Because of the high social housing rates, the proportion of tenancies without rent regulation amounts only to 19.8% and is significantly lower than the Austrian average (26.7%)(Thomas et al., 2020). Social housing in Vienna is differentiated between two housing segments:

1.) About half of the units (total share of 22% in Vienna) belong to the municipal housing segment “Wiener Wohnen”, which is owned by the City of Vienna. “Wiener Wohnen” manages approx. 220,000 apartments. The rent prices fall under the fully applicable MRG, and are capped.

2.) The other half of the social housing units belong to limited-profit housing (total share of 21% in Vienna). They are managed by non-profit housing associations, which are funded by public (non-repayable) grants/ subsidies and public loans. Rent prices fall under the WWG law and are also capped (Litschauer and Friesenecker, 2022).[179]

For municipal social housing, the income limits in Vienna are broad to avoid trends of segregation (Friesenecker and Kazepov, 2021; Mundt and Amann, 2015). To be eligible for social housing, applicants need to be Austrian citizens or have a permanent residence permit, have their primary residence in the city where they apply for two years or longer, and earn an annual net income of less than €47.210 for a single household or €69.220 p.a for two people household in 2020. The income requirements to access municipal social housing are set high intending to promote a diverse mix of tenants. This approach, known as the "housing for all" approach, seeks to provide social housing to a broad range of people, rather than just low-income households, as seen in Berlin (Marquardt and Glaser, 2020). However, to access social housing, a justified need (often also referred to as a reason for reservation) must be present (e.g. homelessness, sickness, old age, overcrowding). If the conditions are met, the applicant receives a Viennese housings ticket (“Wiener Wohnticket”) that provides access to municipal social housing. Waiting list to enter social housings are however long.

Since 1994, Austrian housing market became intensively deregulated, as the reference value rent in the Tenancy Law was introduced and the soft urban renewal program liberalised the regulated housing stock by offering low-interest loans to private landlords (however with 15 years rent caps after retrofits) to buildings constructed before 1944. Contracts signed after 1994

179 Limited-profits do not pay corporate income tax. In return, the "cooperatives" charge only cost rents for the life-time of the building. The rent amount is regulated in the WGG and is capped at a very low level (even under the MRG), especially after full repayment of the loans that were taken out for the construction. However, the tenant often has to contribute significantly more than €25.000 in construction costs beforehand.

were not unlimited (three years) anymore and landlords could raise rents (Kadi, 2015, p. 29). For municipal social housing, the City of Vienna applies reference value rents, and for old buildings category rent applies according to housing quality (Kunnert and Baumgartner, 2012). The introduction of the market-based mechanism constituted a paradigmatic shift of the well preserved Tenancy Law that secured low rents. The City of Vienna decided not to include location surcharges within the reference value rents for the municipal housing stock, which resulted in overall lower rent rates in this segment.

A wide disparity between the privately rented apartments and municipal housing evolved which Kadi (2015) named as a “dualization” trend: on the one hand side, newcomers (after 1994) in Vienna are pushed to the expensive private rental segment with temporary and deregulated contracts. In the same period, municipal housing stock in Vienna did not expand and access to social housing is difficult, also due to the long waiting list once the Viennese housing ticket is obtained. In 2004, the City of Vienna shifted all the subsidised housing construction from municipal housing to the non-profit housing developers, which can be classified as a key housing policy paradigm shift.

On average, Austrian rents increased from 2005 to 2017 by 47%, in Vienna by 55%, respectively, while the consumer prices increases in this period only by 27% (Thomas et al., 2020). Long established residents often have unlimited rental contracts with limited (adaptable to inflation) rent increases (adaptable to inflation). For newcomers, the new rental contracts are on average higher than the Austrian averages and rental prices increased significantly over the last decade. Hardly any other Austrian federal state had such high levels of immigration as Vienna, and housing costs were larger because of the division between old and new rental contracts.

Research results indicated that newcomers in Vienna are pushed to the private and more expensive rental housing segment, because access to social housing is granted when the applicant proves at least two years of residency in Vienna at the same address. Furthermore, access to the limited-profit housing sector is challenging due to the substantial down payment that students or young adults rarely can afford. Kousis et al. (2020, p. 113) highlighted that “students are one of the most under-reported and under-supported groups of the population that frequently lives in fuel poverty”. Newer research results on energy poverty started to acknowledge that young people and students leaving their parents’ home are often at higher risk of experiencing energy poverty because they are often displaced to inefficient housing

(Fong et al., 2021; Kousis et al., 2020; Morris and Genovese, 2018; Petrova, 2018). They are more likely to enter poor quality housing with a high housing cost burden. Registered students' numbers increased drastically in Vienna (Stadt Wien, 2021c). However, given the wide disparities in rental prices in Vienna's housing market, research on young people and energy poverty is outstanding.

Controversy in the housing research discussions exists concerning the eligibility criteria to access social housing (Thomas et al., 2020): once living in municipal housing, tenants do not need to provide income changes (or substantive increases) and can remain in the apartments. Income checks are performed only prior to moving in and not annually. Direct rental contract transfers to family members are possible, even if the family member would not be eligible for social housing (e.g. income thresholds are passed). To avoid social hardship, old rental contracts ('Altverträge') of Wiener Wohnen signed before 1994 have not been transferred to the reference value rent system and they remained in the more affordable category rents system. According to an estimation by Simons and Tielkes using the Austrian Mikrozensus (2020, p. 29), Wiener Wohnen apartments that are rented after 1994 and fall under reference value rents cost approx. 5.81€/m^2 (netto without utility costs; category A). Old rental contracts, which are subject to category rent and signed before 1994 cost approx. 3.60€/m^2 (netto without utility costs; category A). The ability to inherit access rights and old contracts that offer low rents to long-term residents emphasise the significance of family and the institutional framework that favors them (securing the status quo).

Since municipal social housing is more often rented to lower-income families, the social acceptability of additional rent increases to finance thermal insulation investments constitutes a problem, especially for buildings constructed after 1945 and contracts signed after 1994. For all apartments managed by "Wiener Wohnen", the MRG fully applies because they are built before 1945/53 or they are built with housing subsidies by the City of Vienna after 1945. As all social housing rental contracts are unlimited and capped, these low rents reduce the rental income (and the rent reserve) for "Wiener Wohnen". However, with § 18 rent increase procedure, this could lead to considerable rent increases in existing tenancies signed after 1994.

8.5 Retrofitting Procedure in Social Housings in Vienna

End of 2018, approximately 17% of the total housing stock of Wiener Wohnen (36.335 apartments) were in a retrofitting phase. Between 2013 to 2023, renovations comprised an annual average of 3.286 rental properties which corresponds to only 45% of Wiener Wohnen's target renovation rate of around 7.300 rental properties per year (Austrian Court of Auditors, 2021b).

Wiener Wohnen established two subsidiaries owned by the City of Vienna to perform certain tasks: "Kundenservice GmbH" and "Hausbetreuung GmbH" (house and external care, property cleaning, property technology, graffiti removal, pest control etc.), whereby "Kundenservice GmbH" provides services connected to retrofitting activities and making urban dwellings usable.

The project management regulation[180] is the "*bible of retrofitting*" (I13). It contains an evaluation catalogue and several working packages. Since the inception of the project management regulation, Wiener Wohnen could achieve a considerable professionalisation of retrofitting projects. Since 2016, Wiener Wohnen evaluated buildings by own employees due to identified deficiencies in the condition assessment by the external experts.[181] Based on the assessment, buildings are chosen for retrofitting. According to the assessment, 9% of the objects were in poor condition. Annually, Wiener Wohnen has set an own proclaimed goal to retrofit 7.300 objects per annum. In 2021, 7.684 objects were planned to be retrofitted, in 2022 4.457, and in 2023 3.419, respectively (Austrian Court of Auditors, 2021b). However, according to an evaluation of the Austrian court of Auditors, only 26% of the apartments fall into the "good" category. For 65%, the condition is good or bad, and the Court of Auditors reports a further nine percent in poor condition (Austrian Court of Auditors, 2021b).[182]

If a building block is chosen to be retrofitted, the subsidiarity "Kundenservice GmbH" handles the resident's open questions. There is a presentation for the renters when a retrofit takes place. The "renters advisory council"[183] has substantive power and influence to object the reconstruction plans and to bring own proposals to be table (Wiener Wohnen, 2018). From a

180 This document is not publicly available.

181 Seven areas are investigated on a 4-point Likert scale from 1- very good to 4- poor condition: technical infrastructure, roof, windows, facade, general areas, garage, outdoor areas, energy certificates, and key energetic numbers.

182 Following a concrete project management plan, five phases of a retrofit are outlined (please see Appendix E; I13; Wiener Wohnen, 2021b).

183 Elected person for the building who communicates and has rights to propose suggestions.

sustainability point of view, there is no post-hoc information on energy saving behaviours or energy counselling sessions available for the inhabitants shortly before, during or after a retrofit.

A retrofit of Wiener Wohnen buildings is financed through the rent reserves of the residential complex and the ongoing rental income of current tenants. "Wiener Wohnen" collects for all buildings own accounts for the rent reserves, which are used for maintenance and improvements works. However, if the costs of the retrofit cannot be completely covered by the rental incomes or governmental housing subsidies,[184] the arbitration board can decide on a temporary rent adjustment. The revenues and rent reserves are in most cases not sufficient for the necessary work, so rents are typically increased. "Wiener Wohnen" explicitly tries to avoid §18 proceedings because they are time intensive, the outcome is uncertain, and they usually cause more costs in the long run (I13). However, according to MA 50, most §18 procedures affect municipal social housing (80%) compared to private landlords (20%) (Dossier, 2016). If the renovation costs have been paid back, the rent falls back to the previous levels (Wien Energie, 2020). The expert highlights that

> *"we [Wiener Wohnen] are very much dependent on the housing subsidies as the rents are low. Otherwise it would not work".*

Concerning possible rent increases, the expert of "Wiener Wohnen" explained that they try not to increase rents substantially as Wiener Wohnen has some room to manoeuvre through the long-term duration and their long-term social agenda. Social aspects and tenants' interests are of key importance and taken into consideration:

> *"we could theoretically ask for nine euros per square meter. We will not do that because we know we have tenants who have paid two Euros before. Then we would not go up to three times that amount" (I13).*

As retrofitting brings an upgrade of the apartment category, rents can increase up to 3.60€/m² (category A; called "Aufkategorisierung" § 15a MRG). An internal rent ceiling of 1.50€/m² above the respective reference value rent should not be exceeded for §18 procedures (City audit office Vienna, 2010). The expert confirmed that rental costs increase typically by approx. €1.20 or maximum €2 (I13).

To sum up, because tenants in the social housing sector are more vulnerable than the general population, investment expenses cannot be readily passed on without worsening affordability. Access to funding, as well as well-balanced minimum energy efficiency criteria, is thus critical for social housing providers. Wiener Wohnen is well aware of this pitfall and tries to include

184 Wiener Wohnen acquires subsidies not only through the wohnfonds_wien but also on the free market (I13).

tenants' views and provide affordable rents by keeping rental prices after retrofits as low as possible in order to avoid significant prices increases. However, low retrofitting rates are pertinent in the social housing sector. The fact that Wiener Wohnen lacks the necessary money for retrofitting is understandable given the low rental income that is not cost-covering.

8.6 District Heating with Pitfalls?

The district heating sector is anticipated to play a significant part in the low carbon transformation of the EU with high shares of renewables (2018/2001/EU in Article 23 and 24). District heating is widespread in the Viennese social housing segment and offered by Wien Energie.[185] Among the several choices available, district heating is typically considered as the most promising strategy for decarbonising the heating sector, as it is an environmentally friendly, and energy efficient way of heating.[186] Wien Energie is one of the largest district heating companies in Europe and known for its pioneering role science the 1970ies.[187][188]

Gas is the primary form of heating in private households in Vienna, followed by district heating (City of Vienna, 2021, p. 119). It has a share of 36% in Vienna, and 27% in Austria, respectively (FGW, 2020). Whether district heating is environmentally friendly depends on the origin of the heat. Most of the district heating in Vienna comes from waste heat (incineration) and from power generation (Wien Energie, 2021). The Austrian energy regulator and the Chamber of Labour critically stressed disadvantages of district heating:

- compared to other forms of heating, district heating is more expensive because of high base fees and
- consumers do not profit from the liberalised EU energy market, leading to the lack of consumer rights (Austrian Chamber of Labour, 2020).

The energy regulator's responsibilities (E-Control) concerns gas and electricity, and does not include district heating. Therefore, it is not subject to price controls. As expressed by

185 Heat production in Vienna takes place through 65% cogeneration (CHP) and thermal power plants, 33% waste incineration and 2% from waste heat (Arbeiterkammer and Klima- und Energiefond (2016)).

186 The Renewable Energy Directive II (2018/2001/EU in Article 23 and 24) and the Austrian Governmental Program outlined the expansion of district heating networks as one key pillar of the phase-out of fossil fuels (Federal Chancellery, 2020, p. 110). Moreover, the RED II established a renewable heating and cooling objective: each Member State must raise its renewable share of heating and cooling by 1.3 percent each year.

187 "We've had that since 1969, yes. At that time it was still called "Heizbetriebe Wien", and that was slowly built up and it was kind of the nucleus of the district heating"(I3).

188 In 1969, the city of Vienna took over 100% of the company shares with the aim to expand the district heating supply in Vienna, to ensure heating of all new urban residential buildings. Nowadays, Wien Energie has a 1.200-kilometre-long district heating network with a capacity of 2.500 MW and supplies over 400.000 apartments in Vienna (Wien Energie, 2021a).

interviewed experts, the sector was criticised for not being as regulated and transparent as the gas and electricity sector. The Federal Ministry of Social Affairs, Health, Care and Consumer Protection outlined on their consumer protection webpage that usually long-term contracts are signed with district heating companies. In the case of apartments that are rented, the property owner often demands that the district heating contract must not be terminated at all for the duration of the tenancy. This is legally not permissible, but in practice there is usually no alternative to using district heating (Federal Social Ministry, 2021). Moreover, often a direct contract between end consumer and energy provider does not exist. Instead, a mediating third party is involved (usually property owners or homeowner association). In such cases, the property owner/ homeowner association is responsible for billing. The heating cost tariff is divided into two parts: a.) the base consumption-independent part and b.) the consumption-dependent part. In Vienna, district heating prices are relatively high (Kreutzer Fischer & Partner Consulting GmbH et al., 2016) and the exchange, especially for social housing residences from gas to district heating, comes typically with increased energy costs.[189]

For income or energy poor households, a major shortcoming of district heating is evident: the base fees are on average higher than for other energy services and bills and tariff structures are complex(connection fees, maintenance fees, and other charges) (Hvelplund et al., 2019; Sernhed et al., 2017). This, in turn, limits their ability to restrict energy consumption to lower costs. For energy poor households with limited financial resources, these fixed costs can become a burden and add to their overall energy costs. The expert refers to the problem in the following way:

> *"For the people the costs are not particularly low, […] I cannot benefit from the liberalisation of the market. In Vienna, I can save several hundred of Euros a year if I have a gas heating system. […] District heating has relatively high basic fees that you have to pay. In other words, here I may soon be at the limit of my potential for self-restricting and energy saving practices (I2).*

Recognising the inability to cope on a given energy source, Tirado Herrero and Ürge-Vorsatz (2012) call this phenomenon 'the thermal trap'. Despite this, the most serious problem is that it is impossible to change the district heating provider to a cheaper tariff. Households can experience an energy service lock-in effect, resulting in high heating prices (Hellmer, 2010; Odgaard and Djørup, 2020). This means that tenants have little or no influence on the future prices and costs of heating, as they cannot change the tariff or supplier because the property

189 Based on the BALANCE survey data heating costs significantly differed in the not retrofitted sample between district heating and gas. T-test results indicated that households paid on average €71.3 per month for district heating, while households paid €63.4 per month for gas (t-test= 1.6(d.f. 148); $p < 0.5$).

owner has a long-term contract. The supplier also does not need to explain or justify increased price decisions.

The lack of transparency of bills, subcontracting, and the inexistent consumer protection have been heavily criticised, in Austria and the EU, leading many to label this situation a “monopoly structure” of a local nature with little space for competition between producers and retailers (Austrian Chamber of Labour, 2020; BEUC, 2021, 2021; Gorroño-Albizu and Godoy, 2021; Winner, 2016). Power cut regulations, power cuts during weekends or holidays, as well as postal warnings and activation and deactivation fees are opaque. If a household is switched off from district heating due to late payment, it is forced to heat with other energy sources -in most cases expensive electrical devices with a bad energy rating- despite all coping and sufficiency strategies, and despite the existing district heating connection in the house. As a result, household’s energy costs may rise sharply, which -in turn- could drive households further into the vicious circle of debt or energy poverty.

The Austrian Chamber of Labour proposed to widen the responsibilities of the energy regulator (E-Control) to the district heating sector, which may prohibit certain tariffs or terms and conditions (such as price escalation clauses) in contracts. The establishment of an arbitration board, an independent advice centre at the Association for Consumer Information, would reduce the complexity of the contractual relationships, and extent the protection provisions for consumers (Austrian Chamber of Labour, 2020).[190]

8.7 Conclusion

The chapter highlighted the importance of cities in achieving climate targets and emphasizes the need for local action to realize national commitments. Vienna, with its greater legislative power, has an advantage in establishing innovative policies to tackle climate and energy challenges. However, its effectiveness has been limited due to the lack of strong enforcement mechanisms. The city has designed a unique framework to tackle climate and energy challenges, based on effective horizontal policy coordination across multiple business groups, stakeholders, and ministerial departments. However, Vienna's effectiveness has been limited, as it did not perform particularly well in comparison to other Austrian federal states in terms of

190 A possibility of action is to replicate the Electricity Directive (mirroring of Article 10, 18 and Annex I of the Electricity Directive) and applying it to district heating, as well as heating oil, or liquid petroleum gas sector to expand consumer protection for energy poor households (BEUC, 2021).

climate achievements. The chapter argued that there is further room for maneuver in housing subsidies, which are the responsibility of the Federal States. They are the central instrument with which the affordability of residential space can be regulated, energy poverty rates kept low, and retrofitting rates increased. The Austrian Federal Government has important instruments at its disposal, such as the non-profit housing law (WGG), Tenancy Law, indirect funding programs, and the federal constitution. Further efforts to achieve climate goals in the housing sector are needed since social housing requires additional government subsidies and investment to retrofit the housing stock and securing affordable rents.

The nodal governance network of Vienna comprises municipal authorities, Wien Energie, CARITAS, and an energy counselling agency that offers aid for energy poor households. However, support is only provided to those with high energy costs and minimum income thresholds, leaving out hidden energy poor households from available schemes. The existence of a difficult-to-reach population further complicates the problem, and multiple institutions being involved in energy poverty measures may result in a complex and bureaucratic process. While short-term relief is provided, long-term structural solutions are necessary to address the underlying causes of energy poverty. Financial assistance may alleviate income poverty, but it can be expensive and its targeting may be questioned, with little impact on reducing carbon emissions. To this end, Vienna has established the 'Viennese energy support' program that includes energy counselling to promote energy behavior change, covers repair costs (e.g. windows or doors), and provides assistance for the replacement of large appliances for low-income or energy poor households. Financial investments in structural instruments that address the root causes of energy poverty could be extended, as only a limited number of households currently receive support.

Vienna's social housing segment offers low rents but is difficult to access for newcomers, and deep renovations are often not feasible without additional subsidies. Long-established tenants benefit from old rental contracts as they request lower rents. However, several key experts have highlighted the potential of this housing segment in achieving major climate targets, which could also benefit energy poor households.[191]

While the electricity and natural gas markets are liberalized and switching tariffs are easy and transparent for consumers, district heating services pose more challenges. District heating is

191 The Renovation Wave and the Winter Package dedicated targeted funds and instruments (e.g. Just Transition Fund, the Affordable Housing Initiative, Recovery, and Resilience Facility) to this housing segment.

seen as a sustainable heating form but has lock-in effects for customers (tenants) with limited rights to switch.

To sum up, Vienna has institutionalised instruments to address energy poverty. Current measures have effectively eased short-term financial pressures on households while key actors have established a wide interconnected network. The current instruments, however, do not target the root causes of the problem to its full extent. Considering households that skimp on energy, and opening the debate for other energy poverty approaches would benefit the discussion and ease energy poverty in Vienna. Hence, assuming that households already skimp on energy by themselves -as outlined by experts- it is questionable whether energy counselling is the correct tool to ease energy costs.[192]

192 Awareness building measures were not a significant driver for energy savings (see chapter 3).

9. Energy Poverty in the EU and Austria: An Overview of Trends and Developments

By outlining the three tenants of energy poverty, low income, high energy prices, and inefficient housing, this chapter seeks to analyse the key developments in these three areas. Where possible, the latest comparative data for EU-28, Austria and Vienna, is provided from various sources (EU-SILC, Odyssee-Mure). As vividly illustrated by experts in the previous chapter, energy poverty is a multifaceted and intersecting problem in which households face inequalities across multiple dimensions in their lives. This chapter frames this research agenda systematically by focusing on wider structural living conditions, such as the predominant living situation of energy poor households, and also their socioeconomic and demographic background that together constitute several lines of inequality. These new findings and insights into the situation of energy poor households in Austria provide an intersectional analysis of energy poverty instances. The analysis will reveal the multidimensionality of energy poverty by determining various intersections of energy poverty, such as structural building characteristics, housing conditions, and various vulnerable groups in Austria.

This chapter aims to provide the results of the main research question of the thesis *how can we explain energy poverty in Austria and who suffers from energy poverty*. The objective is to quantify and differentiate between predominant definitions of income and energy poverty at the household level. Thereby, Austria will be compared to European average energy poverty incidences.

The *first* sub-chapter presents the quantitative results of the main three drivers of energy poverty. For the first tenant, low-household income, latest statistics on the at-risk-of-poverty and social exclusion indicator and the unemployment rate are provided for the EU, Austria, and Vienna. For the second tenant, high energy prices, an overview of the current energy pricing system is provided and data on electricity and gas prices for private consumers is presented. To discuss the third tenant, low energy efficiency will be investigated, analyzing trends and progress in energy efficiency throughout the EU, with a specific emphasis on Austria's efforts to increase the energy efficiency of its housing stock through retrofitting rates. The second sub-chapter moves on to break down the latest EU-SILC aggregated data to analyse energy poverty in the EU and Austria over time. The analysis will be accompanied in sub-chapter *three* and *four* by a microdata analysis of EU-SILC 2019 of structural (housing) and socio-demographic intersections of typical definitions of energy poverty. Sub-chapter *five* analyses intersections of vulnerable groups with energy poverty indicators. Sub-chapter *six* ends with a summary of the chapter of key empirical results and the answer to the research question. Figure 21 provides the reader with a visualization of the chapter's main topics and reading flow.

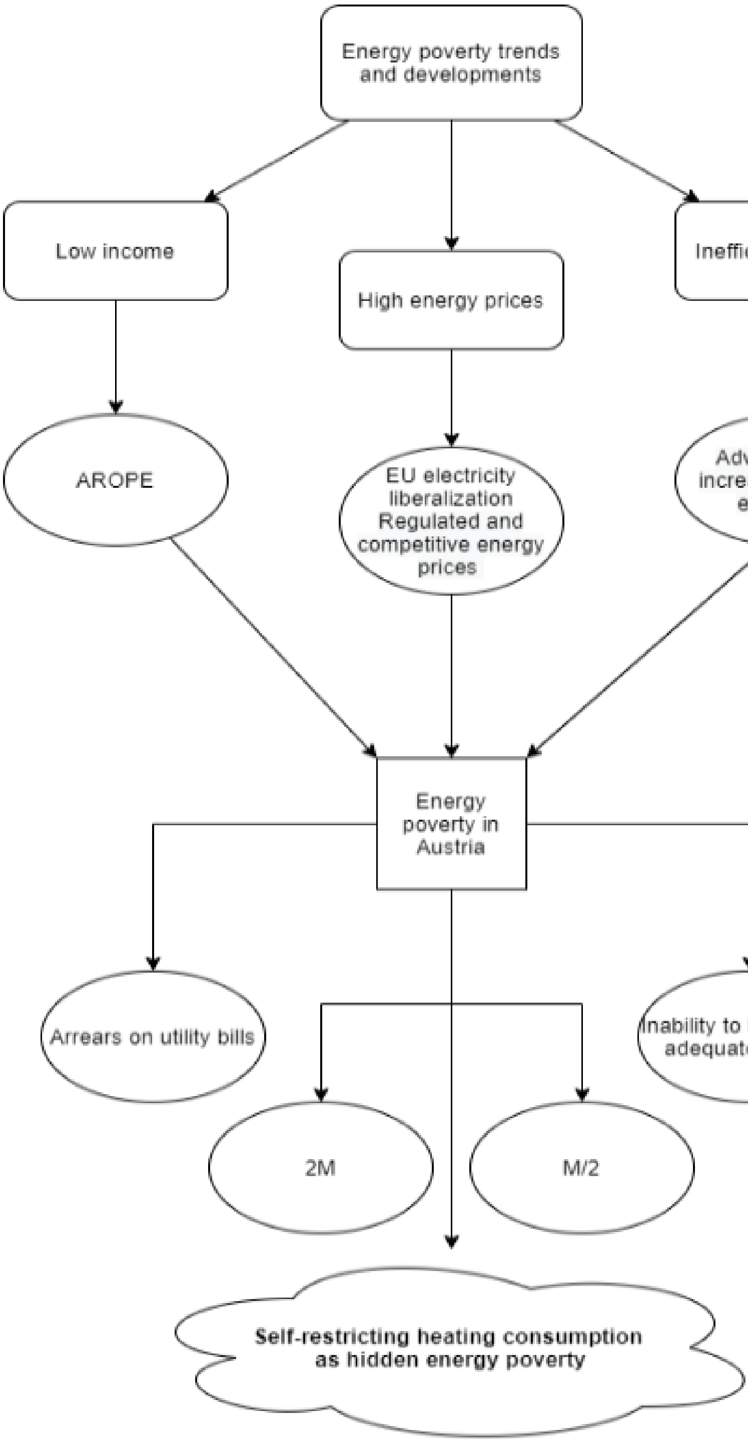


Figure 21 Chapter Overview (Source: Own Visualisation).

9.1 Trends of the Three Energy Poverty Drivers

(1) Low Household Income

Household income is a central indicator to assess energy poverty. The study results indicate that low household income is the main determinant which increases the probability of living in energy poverty (European Fuel Poverty and Energy Efficiency Project, 2009). To measure the share of the population with low income and households living in poverty, the ‘at-risk-of-poverty or social exclusion (AROPE)’- rate is commonly employed (European Commission, 2020j, p. 10). In 2019, 21.1% of the EU-27 population was at-risk-of-poverty or social exclusion (approx. 92.4 million individuals).

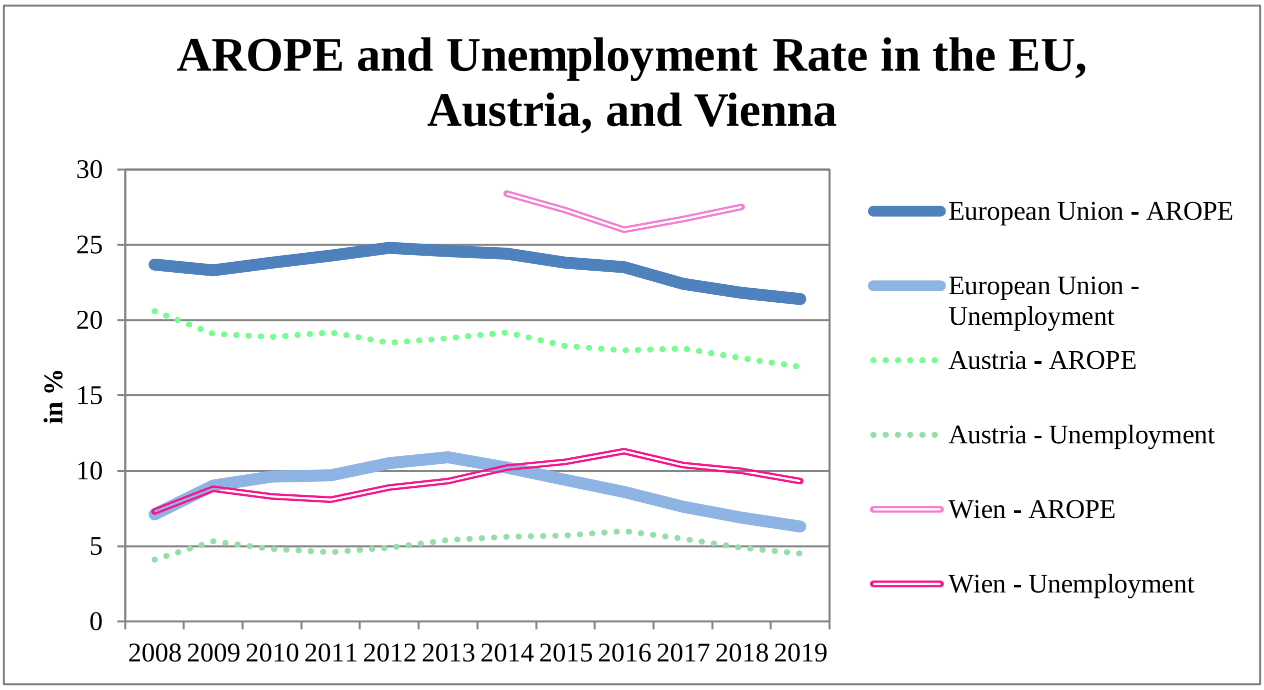


Figure 22 AROPE and Unemployment Rate in the EU, Austria, and Vienna (Source: Eurostat 2019). Note: Indicator Unemployment Rate [une_rt_a] and [lfst_r_lfu3rt]. From 15 to 74 Years and Percentage of Active Population; Indicator for AROPE [ilc_peps01].

Austria’s AROPE rate amounts 16.9% in 2019 and is in comparison lower than EU average (see Figure 22). This number did not fluctuate substantially in the previous 10 years. The latest results for Vienna are provided for 2018. The AROPE rate in Vienna is significantly larger compared to the EU and the overall Austrian rate. It amounts to 27.5%. Hence, Vienna’s position appears rather less favourable in international comparison. Considering the unemployment rates, the deviation between Austria and Vienna becomes visible again: while overall Austrian rates are considerably smaller than EU average unemployment rates, Vienna has a far higher unemployment rate than the EU and Austria. Moreover, the deviation between Austria and Vienna increased over time. In 2008, it accounted 3.2 percentage points, whereby in 2018 it accounted 5.1 percentage points. Hence, the gap widened over the 10-year period. Women are more at risk of poverty or social exclusion, as well as single adult households living with dependent children (40.3%)(European Commission, 2021f). Moreover, poverty in Austria also affects the elderly, children, immigrants, unemployed, and working poor (European Anti Poverty Network and Die Armutskonferenz, 2020).

Austria was not affected dramatically by large wage and salary decreases after the global financial crisis compared to other European countries. Typically, the powerful role of the social partners, collective bargaining negotiations, and strong trade unions positions is attributed to favourable conditions (Astleitner and Flecker, 2017). Vienna - frequently portrayed as a high resilient "European City" (Le Galès, 2004) - was not so much affected by the financial crisis, because most people in employment age didn't work in sectors that were hit by the crisis.

> *"The degree of freedom Vienna retains as a Bundesland has allowed the City to develop a partly autonomous labour market policy, complementing and compensating for the impact of structural changes and federal labour market reforms (Kazepov and Verwiebe, 2022)"*

(2) High Energy Prices

In line with the Sustainable Development Goal 7 "affordable energy for all", energy price is another indicator that increases the risk of being energy poor, as high energy prices reduce the affordability of fuels for households (Roberts, 2008b). R*egulated* or *competitive prices*, levels of taxation and subsidies, cost and supply, and energy security influence the price of energy [193] (Pye et al., 2015b). A regulated price is one that is subject to regulation by a public institution, as opposed to one that is solely determined by supply and demand. Price regulations can take various forms, such as price settings or caps. Although the phase-out from regulated to competitive energy price system is part of the EU Winter Package (European Commission, 2019a), some EU Member States (e.g. debates in France and yellow vests) have reservations to fulfil this step.

Regulated and Competitive Energy Prices

Historically, the rationale of a common European internal electricity and gas market and the introduction of regulated energy prices was to provide cheaper energy services to European consumers to counterbalance the dominant monopoly structures of energy providers that used

193 Energy security is defined as "the way of equitably providing available, affordable, reliable, efficient, environmentally benign, proactively governed, and socially acceptable energy services to end-users, is gaining ever more prominence on contemporary policy agendas. Energy security has supply-side and demand-side components" (Goldthau and Sovacool, 2012, p. 235).

its power and imposed higher prices on consumers (Simon, 2018a). Regulated energy prices were initially implemented to ensure economic stability and support financing for large-scale energy projects, such as nuclear power stations or hydropower dams. Currently, the objective of energy price regulations is to protect households from energy poverty. Therefore, energy price regulation, justified by concerns of consumers or unions, aims to counteract high energy bills. Proponents of regulated prices argue that in several EU countries, the energy market does not work properly.

The goal of price regulation is to prevent prices from becoming too high, making energy unaffordable for vulnerable households, and counteracting unfavorable consequences such as energy poverty and lack of access to a warm home. However, the European Commission ("EC") argues that energy price regulation comes with several side effects. It slows down the transition to clean energy, and the creation of jobs. Moreover, it has been argued that it jeopardizes security of supply and undermines efforts to fight climate change (EURACTIV, 2018). The energy market liberalisation is based on the basic idea of free trade of energy in the EU across Member States. However, artificially low energy prices prevent clean energy from developing, as they require dynamic energy prices that puts consumers at the centre of the clean energy transition to react to price signals (e.g. through switching to lower priced energy tariffs). Opponents of regulated energy prices argue that the system hinders energy customers from actively seeking and switching suppliers, inhibits competition, and prevents new companies from entering the market. Based on this perspective, the Commission's argument emphasizes the benefits of free markets, which include increased competition, lower energy prices, and positive incentives for consumers. On these grounds, regulated prices have been cited as a key impediment to the development of the single energy market in the EU.

Opponents of competitive energy prices argue that electricity and gas prices, as well as overall energy poverty, have risen in the EU in recent years. In this respect, regulating prices to prevent fluctuations may offer more protection to energy-poor households (EPSU, 2018). Opponents of competitive energy prices point to official statistics that reveal countries with liberalized electricity markets have some of the highest electricity prices. For example, in the UK, which has the most liberalized electricity market (EPOV, 2021a), prices grew so sharply that the government was forced to introduce a price cap in 2018 to address the uncontrollable rise. The UK has the most liberalised electricity market; prices grew so sharply that the government was forced to introduce a price cap in 2018 against the uncontrollable rise (EPSU, 2018).

From the perspective of energy poverty, research results have indicated that low-income customers fare worse in deregulated markets due to lower engagement in switching energy providers (Littlechild, 2019). Some MS, however, regulate energy prices for all customers (instead of targeted social tariffs), which include also wealthy, high-income households; this has been criticised because "rich people win most from regulated energy tariffs" as they are typically consuming the largest amounts of energy and profit from low prices (Simon, 2018b). Certainly, precise targeting or progressivity concerns must be raised when designing regulated

European Energy Market Liberalization

The EU liberalization of the energy market for electricity and natural gas was part of the First Energy Package. The primary aim of the Energy Market Liberalization was to provide affordable energy prices, higher energy efficiency by introducing competitive forces, competition between contractors, improving energy security, and tackling the power of big energy companies, such as France's EDF, Germany's RWE, and EO.N, or ENEL in Italy. Furthermore, fair access and a high level of consumer protection, better protection of energy-poor households are also at the center of the package. The EU fosters the emancipation of consumers to be so-called active customers and "energy prosumers". Greater efficiency and open markets should lead to easier access to cheaper and more efficient sources of energy. Starting in 1996 (electricity) and 1998 (gas) with the first energy liberalization directives, the EU Member States underwent the process of electricity market liberalization, which has finished for several years (with some exceptions like Bulgaria and Malta). Austria's liberalization of the electricity market was finalized in 2001 and one year later the gas market was completed. In the course of the liberalization, in Austria, the regulatory authority E-Control was established in 2001, which supervises the open electricity and gas market. It is equipped with competition, monitoring, and regulatory competencies. The latest development for further liberalization in the energy market has been the adoption of the EU "Clean Energy for all Europeans" package in 2016.

Figure 23 European Energy Market Liberalization (Source: Own Visualization based on Pepermans 2019 © Pexels by Hoye Sanges & LED Supermarket).

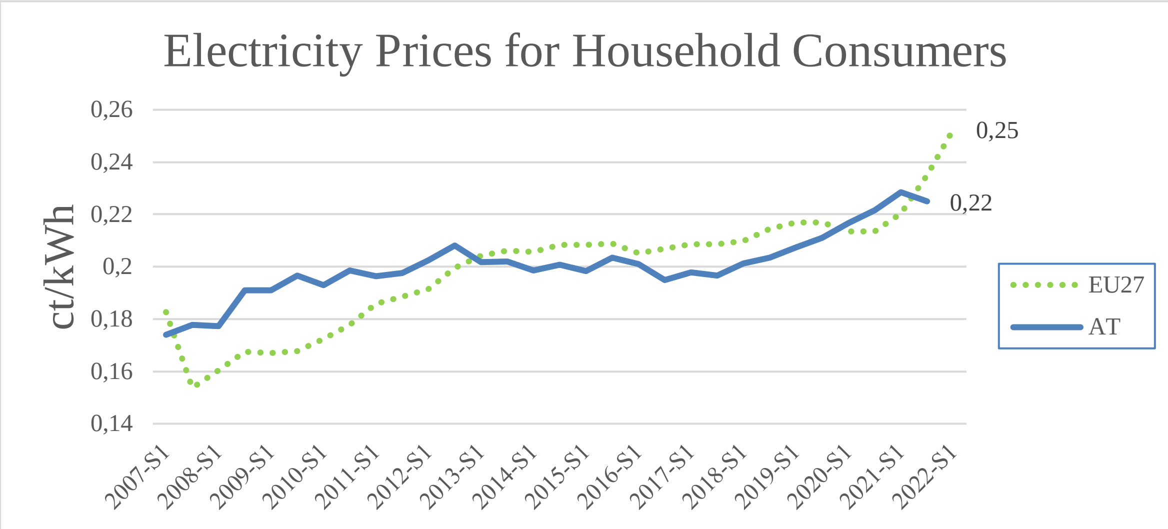
energy prices. Pepermans (2019) illustrated that in comparison, industrial final energy prices have not risen so sharply as the prices for consumer households: industrial prices increased by 5.8% between 2008 and 2016 in the EU, while consumer end-user prices have grown by more than 26% in the same period. Particularly, the energy expenditure difference between the first and the fifth income quintile shares indicates strong pressures on low-income households: in 2015, the share of energy expenses for the first income quintile was 5.7%, while for the fifth income quintile, it amounted to 3.9% (EPOV, 2021b). This implies that lower income households spend a higher proportion of their income on energy compared to high-income households. Volatile energy prices, especially globally set fossil fuel prices, have increased the most, and energy price increases constitute a strong rationale for decarbonizing the EU, reducing dependence on imports from non-EU countries, and tackling energy poverty (European Commission, 2019e).

The EU heavily depends on imports of oil, gas and solid fuels from non-EU countries (Eurostat, 2021b), with an import dependency rate of 57.7% in 2020, which has not substantially changed over the last decade(Eurostat, 2023b). Primary energy production within the EU-28 has steadily decreased in the past decades (Eurostat, 2020b), and Austria is also exposed to volatile oil and gas prices and is dependent on global economic developments. The Austrian Court of Auditors (2019) refers to experts who predict further price increases due to the decommissioning of coal-fired and nuclear power stations. Electricity prices for household consumers[194] have accelerated over the past 13 years and are expected to further increase, also to finance energy and climate policy objectives (European Commission, 2013; S&P Global Ratings, 2021). The issue of energy security, energy markets, and fuel pricing is often overlooked in discussions about energy poverty. This is a complex issue as energy prices are affected by global prices, as well as taxes and subsidies that are determined by national governments. The EU's reliance on energy imports and the volatility of prices from certain regions, such as Russia, Nigeria, and the Middle East, are important considerations. These regions are often affected by political instability and conflict, which can result in economic uncertainty and decreased investor confidence. Overall, energy security and pricing are crucial factors to consider when addressing energy poverty (Haber, 2018; Kerr et al., 2019; Summerton, 2016).[195] Figure 24 shows the

194 Technical note: household consumers, are defined for the purpose of this thesis as medium-size consumers with an annual consumption within the range of 2 500 kWh < consumption < 5 000 kWh.

195 The OSCE is a key international organization that is concerned with energy security as the 56 participating countries subsume several major energy producers, consumers, and key transit countries. The OSCE promotes “a broader concept of energy security encompassing all stages of the value chain and involving countries of origin, transit, and destination as well as all relevant stakeholders, including the private sector and civil society” (Dreiski (2011).

development of electricity and gas prices in the EU-27 and Austria. The average cost of a kilowatt-hour of electricity in the EU-27 has risen from 0.16 cent in the second semester of 2007 to 0.22 cent in the second semester of 2019.[196] The same pattern arises for the EU-27 gas price, where a kilowatt-hour amounted to 5.3 cents in the first semester of 2008 and increased to 6.7 cents in the second semester of 2019. Both electricity and gas prices increased by 30% and 37%, respectively.



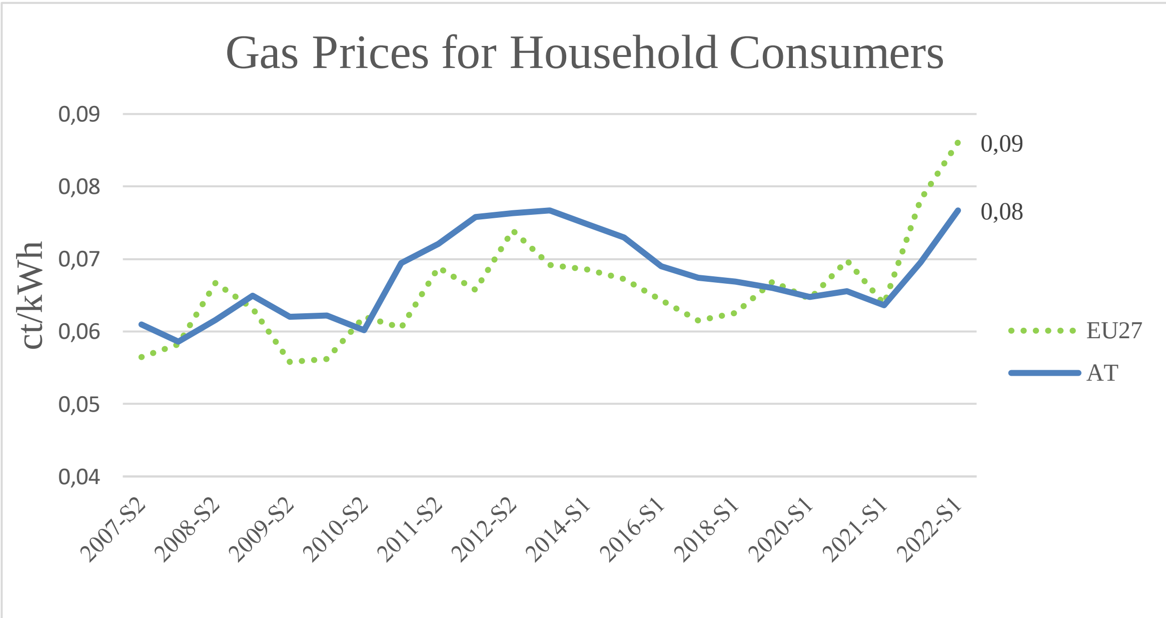


Figure 24 Gas and Electricity Prices (Source: Eurostat 2022). Indicator Household Electricity Prices [nrg_pc_204] and Household Gas Prices [nrg_pc_202]: Natural Gas Prices for Household Consumers, band 20-200GJ Consumption, all Taxes and Levies Included; Electricity Prices for Household Consumers, band DC 2500-5000 kWh/yr Consumption, all Taxes and Levies Included (own visualization).

196 The price of electricity is to a certain degree influenced by the price of primary fuels and, more recently, by the cost of carbon dioxide (CO2) emission certificates.

The Latest Developments

Due to recent geopolitical circumstances, such as Russian military aggression in Ukraine, average household electricity and gas prices increased sharply in all but five EU Member States in the first half of 2022, compared to the first half of 2021. Electricity prices increased from 0.22 cent per kWh to 0.25 cent per kWh, and gas prices increased from 0.64 cent per kWh to 0.86 cent per kWh (Eurostat, 2022b).

The EU-27 renewable energy sources share amounted to 18.9% in 2019, which is close to the 2020 EU target of 20% renewable energy. Austria ranks high in EU comparison and is well on track to meet the EU-2020 target of 20% of gross final energy consumption, as the renewable energy sources share amounted to 33.6% in 2019 (European Commission, 2021c). Although, Austria exceeded the EU- 2020 target, the national target of 34% could, however, not be met.

Figure 25 presents the Austrian energy mix in 2017/2018. Fuel-wood, natural gas, and electricity are almost equally distributed (around 25 - 30%) with an increasing trend towards district heating (~ 12%)(Statistik Austria, 2020). The most energy consumed in the residential sector is used for space *heating* (63.6%) and 14.8% for water heating (European Commission 2020). If the source of the energy is differentiated between fossil fuel or renewable energy, the average European household primarily uses fossil fuels for space heating, with only a quarter (27%) coming from renewable energy, while Austria has a higher proportion of 29% (Eurostat, 2020a). In the EU, the average consumption per square meter for residential buildings reaches around ~300 kWh/m^2 per annum (Odyssee-Mure, 2018).

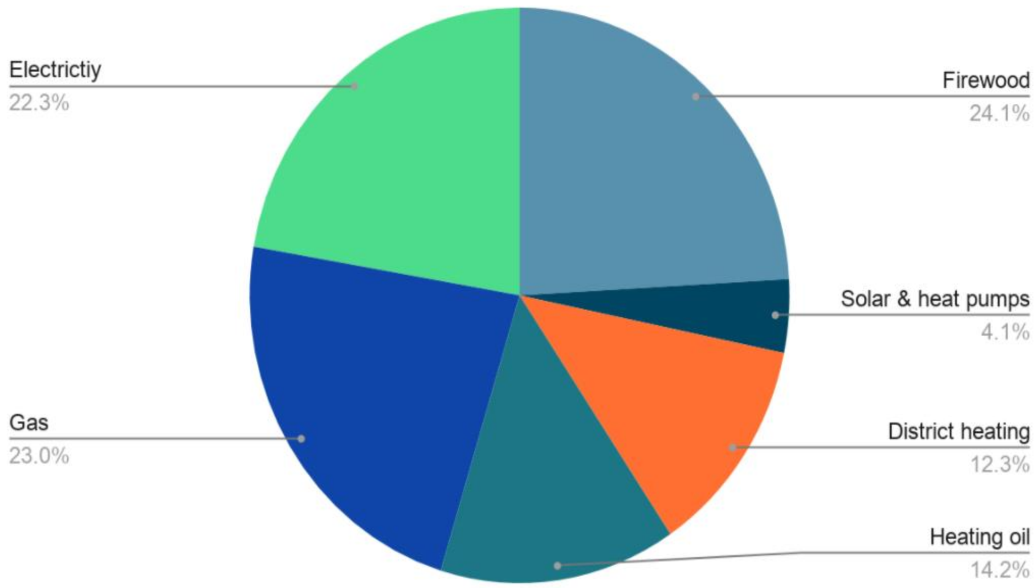


Figure 25 Energy Mix in Austria (Source: Own Calculation Based on STATISTIK AUSTRIA, Energiestatistik: MZ Energieeinsatz der Haushalte 2017/2018).

The energy demand in Europe is steadily increasing due to society's growing economic affluence, and this trend is predicted to continue (Meier and Rehdanz, 2010; S&P Global Ratings, 2021). However, there has been a shift in the perception of what is considered a "normal indoor temperature," frequency of activities like laundry washing, hygienic standards, and showers, which has contributed to changes in European energy consumption patterns (Shove, 2003).[197] Therefore, reducing household energy consumption has become a primary target for policy agendas aimed at mitigating climate change. Technical solutions and advances need to be accompanied by citizen involvement and acceptability (Valkila and Saari, 2013).

In Vienna, greenhouse gas (GHG) emissions increased by 5% in 2017 compared to 1990, while final energy consumption decreased by approximately 15.8% per capita in 2017 compared to 2005. For space heating, hot water and air conditioning, the final energy consumption per capita in Vienna decreased by 19.5% between 2005 and 2017, respectively (City of Vienna, 2019b). However, when comparing final energy consumption in 2018 to 1990 levels, all federal states in Austria have experienced a strong increase in the past 30 years, with Vienna experiencing an increase of 33% (Austrian Energy Agency, 2021a).

A closer look at the average heating costs in Vienna for different types of buildings, such as retrofitted apartment buildings, new multi-storey buildings, and inefficient multi-storey buildings, reveals interesting insights. Overall, district heating is the most expensive energy source in all building types. Retrofitted and new multi-storey buildings have lower energy costs per annum. Table 8 demonstrates that retrofitting lowers significantly heating costs, with detached housing seeing reductions of up to 55% (Austrian Energy Agency, 2017).

	Multi-Storey Not-Retrofitted Building Per Annum in €	**Multi-Storey Retrofitted Building Per Annum in €**	**Multi-Storey New Building Per Annum in €**
Natural Gas	1339	922	708
Fuel Oil	1339	888	685
District Heating	1362	937	738

Table 8 Heating Costs in Different Housing Segments in Austria. Calculations are based on the assumption that heating costs do not change in the following 20 years (Source: Kranzl et al., 2017).

For renewable energy not to be costly for households, fossil fuel subsidies must be reallocated to give the price signals, also to be in line with the Regulation on the Governance of the EU. Current fossil fuel subsidies for petroleum, coal, natural gas amounted €673 in 2015 in the EU

197 In the UK, for instance, average internal temperatures in houses increased from 13.8°C in 1970 to 18.2°C in 2004 (Martiskainen, 2008).

per citizen, and €446 per Austrian citizen (Hayer, 2017, p. 13).[198] Considering the overall energy subsidies by energy carrier, 32% went to fossil fuels, and 27% to renewable energy sources (biomass, hydropower, solar, wind, and others) in 2018 in the EU-27. At the same time, fossil fuel subsidies remained on average the same and did not decrease since 2008 (European Commission, 2020o).

(3) Low Energy Efficiency

Low energy efficiency is the third driver of energy poverty. Some households spend more of their incomes to reach the same level of services and comfort due to older, energy inefficient housing stock. Hence, there is a disproportionately high loss of useful energy in households, as energy needs are higher in inefficient homes. The energy demand of households is contingent on the one hand side, household's energy behaviours and, on the other hand side, structural characteristics, such as the type of building, age of construction, level walls, floor and roof insulation. Low-income households are negatively affected as they cannot afford to invest in energy efficient building retrofitting measures or energy-efficient appliances due to lack of sufficient capital (Bouzarovski, 2014; Seebauer et al., 2019).

Why is the Building Stock So Relevant?

The building stock is relevant in the context of energy poverty because a large portion (75%) of the EU's building stock is old and energy inefficient. Over 40% of the European building stock is built before 1960, which typically features larger energy demand. Buildings accounted for 41% of the EU's energy consumption, 36% of its CO_2 emissions in 2016, indicating a high potential for energy savings through retrofitting (European Commission, 2019g; Odyssee-Mure, 2018). In 2017, the residential energy consumption amounted 27.2% of the EU's final energy consumption, representing the second largest consuming sector after transport (Eurostat, 2020c). Retrofitting the building stock offers the biggest energy savings potential in the EU, as almost 85-95% of today's buildings will still be in use in 2050 (Artola et al., 2016; European Commission, 2021k).. Results of the study "Renovation tracks for Europe until 2050" implicate that a

> *"deep renovation of the existing stock together with new buildings that are nearly zero energy, can save 80% of the final energy use for space heating by 2050, compared to 2012" (Boermans et al., 2015, p. 8).*

198 Most fossil fuel subsidies are provided in form of tax expenditures, price and income support were lower. The largest share of subsidies goes to industry, while households receive significantly lower redemptions.

However, retrofitting requires large-scale upfront investments and capital, which may be a barrier for low-income households. Nevertheless, in a long run, it is a cheaper and more efficient solution to fight energy poverty, securing health of EU citizens and be more independent from increased energy prices (Colli, 2020).

The ODEX index designed by Odyssee-Mure indicates an energy efficiency improvement of 29% in the EU-28 between 2000 and 2019 (or 1.8%/year). Space heating has achieved the largest energy efficiency improvements over time, but the rate of improvement has slowed down since 2014, possibly due to occupants' behaviors, less construction work, and a slowdown of renovation activities (Odyssee-Mure, 2015; Rousselot et al., 2020). Overall, the following developments in energy consumption and energy efficiency have been reported:

- Increase in the number of households, especially the increasing number of one-person households. Single-person households consume on average 38% more products and more electricity per person, compared to a four-person household (Gram-Hanssen et al., 2009).
- Increase in average square meters and large homes: in 2004 average Austrian living space per residence amounted 96.4m^2, 73.6m^2 in Vienna, respectively. In 2020, average living space increased and amounted 99.9m^2 in Austria, 74.7m^2 in Vienna, respectively (Statistik Austria, 2021d).
- Increase in higher comfort levels (indoor temperature) (Martiskainen, 2008).
- Increased household electricity consumption for small electrical appliances. However, electrical appliances became overall more energy-efficient (Odyssee-Mure, 2021).

According to the information provided, Austria has seen improvements in energy efficiency in households due to various factors such as stricter building regulations, energy certificates, more efficient heating appliances, retrofitting of existing dwellings, and the diffusion of more efficient electrical appliances (Odyssee-Mure, 2015). These improvements have led to a decrease in the share of space heating (climate corrected) in total residential energy demand from 74.4% in 2000 to 70.7% in 2016, attributed to better insulation. However, despite these improvements, the total residential energy demand by fuel in Austria increased by 4.6% from 2000 to 2016 (Austrian Energy Agency, 2018).

Moving to renovation activities in the EU-28, they are estimated close to 1% per annum and deep renovations amount approximately 0.2% (Hermelink et al., 2019). Renovation activities in Austria are estimated to be at 1.4% per annum, including small individual measures and comprehensive renovations (Amann et al., 2020b), with a peak in 2010 at 2.1% and a declining trend since then (see Figure 26).[199]. The highest retrofitting demand is observable for privately rented apartments and social housings (Amann et al., 2020b). To achieve the EU targets for energy efficiency and decarbonization of the housing stock, higher retrofitting rates are necessary as approximately 40% of Austria's housing stock requires a retrofit (Amann et al., 2020b). The IIBW (2020b) estimated that 2.6% p.a. until 2025 and then 3.2% p.a. retrofitting activities are necessary to decarbonise the Austrian housing stock by 2040. Currently, Vienna ranks at the bottom among the nine Austrian federal states in terms of retrofitting rates, indicating that current rates are unsatisfactory to achieve EU targets.

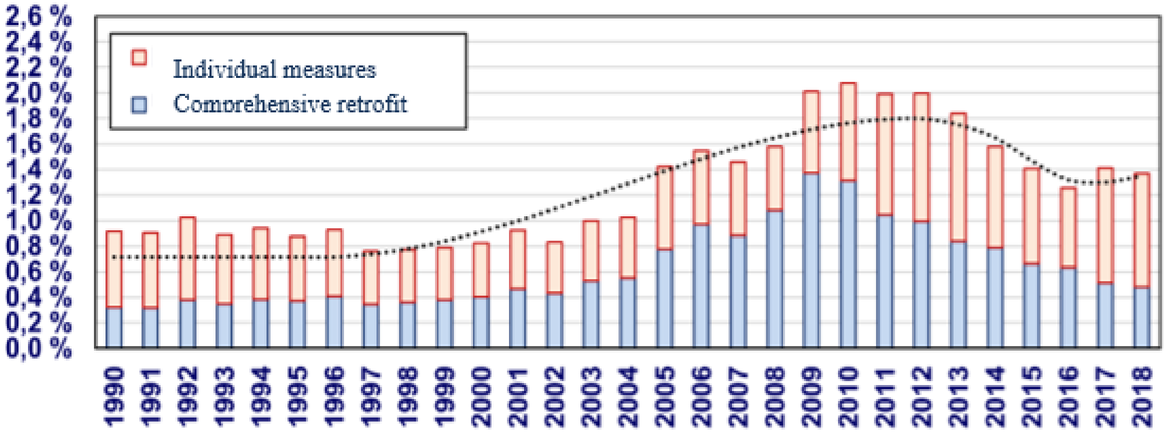


Figure 26 Austrian Retrofitting Activities 1990-2018 (Source: Amann et al., 2020b, p. 30). Note: In blue comprehensive rehabilitation (minimum of 3 thermal- energetic relevant measurements) and in red individual measures (4 cumulative individual measures). For a detailed description of retrofitting activities please see (Amann et al., 2020b, p. 14).

9.2 Current Energy Poverty Trends – EU-SILC Aggregated Data Analysis

This chapter provides current aggregated energy poverty trends in EU-28 and Austria.[200] This aggregated data is extracted from EU-SILC. Four primary indicators are employed to determine whether a household is energy poor: the most relevant subjective and objective indicators are presented. For the consensual-based indicator i. arrears on utility bills, ii. inability to keep home adequately warm, and iii. presence of leak, damp, rot is employed. For the expenditure-based indicators, i. low absolute energy expenditure (M/2) and ii. high share of energy expenditure in income (2M) are presented. These two indicators are provided by the Household Budget Survey

199 For decades, the "renovation rate" was not clearly defined and it has been not used uniformly in Austrian governmental documents (e.g. whether individual small-scaled measures can be included in the rates) (Amann et al., 2020b).

200 Aggregated data on NUTS-level 2 for Vienna is not available and cannot be presented.

every 5 years.[201] A combined analysis of these primary energy poverty indicators is necessary to avoid over- or underestimating the extent of the problem.

Considering the three consensual energy poverty indicators, namely arrears on utility bills (EU - 1), inability to keep home adequately warm (EU - 2), and presence leaking roof, damp walls, floors or foundation, or rot in window frames or floor (EU - 3) in the EU, keeping the home adequately warm is the most pressing problem over the period 2004 – 2019 in the EU (see Figure 27). Since 2004, the incidences have slightly fallen, but showed a small peak in 2005, where 20% of the EU population reported housing faults. According to most recent data from 2019, 13% of the EU population reports having housing faults. 6.1%, and 7.0% of households encounter arrears on utility bills and inability to keep homes adequately warm, respectively in 2019 in the EU. These two indicators (EU - 1 and EU - 2) follow almost the same trend over the period under consideration.

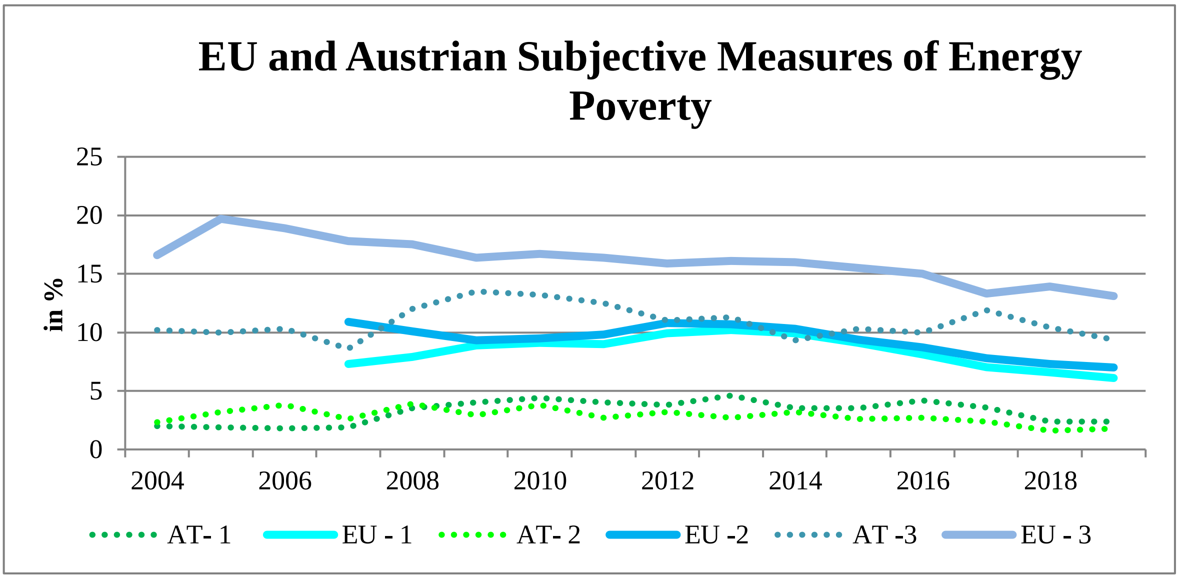


Figure 27 EU and Austrian Subjective Measures of Energy Poverty
Note: AT -1 / EU -1: Arrears on utility bills: Share of (sub)population having arrears on utility bills, based on question "In the last twelve months, has the household been in arrears, i.e. has been unable to pay on time due to financial difficulties for utility bills (heating, electricity, gas, water, etc.) for the main dwelling?" Source: EU-SILC 2019, HS020/HS021; AT -2 / EU – 2: Inability to keep home adequately warm: Share of (sub)population not able to keep their home adequately warm, based on question "Can your household afford to keep its home adequately warm?". Source: EU-SILC, HS05. AT - 3 / EU -3: Presence of leak, damp, rot: Share of population with leak, damp or rot in their dwelling, based on question, "Do you have any of the following problems with your dwelling/accommodation?" Source: EU-SILC 2019, HS04.

In Austria, having arrears on utility bills and the inability to keep home adequately warm (AT - 1 and AT - 2) follow overall the same trend as the EU average, but incidences are slightly

201 As the Governance Regulation (2018/1999/EU) obliges Member States to assess the number of households in energy poverty, the data for the EU and Austria are provided by the EU Energy Poverty Observatory.

lower: having arrears on utility bills or keeping home adequately warm experienced 2.4%, and 1.8% of the Austrian population in 2019, respectively. Similarly to the EU rates, a more widespread problem in Austria are housing problems. In the trend, the shares have not decreased: in 2004, it amounted 10.2% and in 2019, 9.4% referred to housing faults. To summarise, Austria is overall better off compared to the EU averages on the subjective energy poverty indicators.

Figure 28 summarises the two expenditure-based indicators high share of energy expenditure in income (2M), and the low absolute energy expenditure (M/2). The low (M/2) and the high (2M) share of energy expenditure are based on the Households Budget Survey and data is only available every 5 years. Figure 28 illustrates that the share of households with low absolute energy expenditure (EU- 4) has fallen slightly from 16% in 2010 to 14.6% in the EU. The high share of energy expenditure in income (2M) remained unchanged over that respective period at 16% (EU - 5).

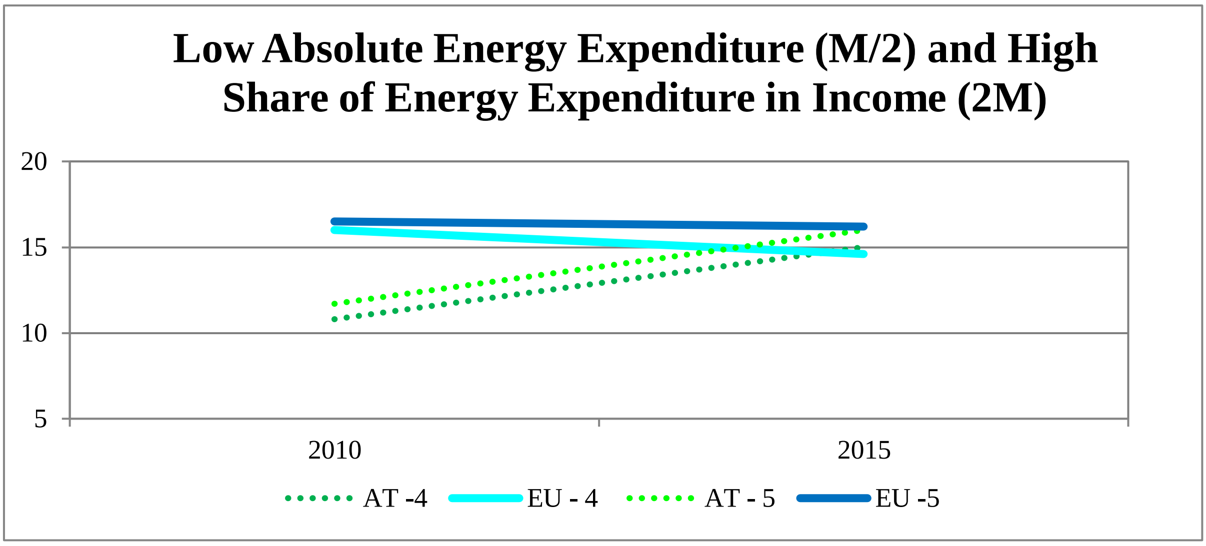


Figure 28 Low Absolute Energy Expenditure (M/2) and High Share of Energy Expenditure in Income (2M). Note: AT -3/ EU -3: Low absolute energy expenditure (M/2): The M/2 indicator presents the share of households whose absolute energy expenditure is below half the national median, or in other words abnormally low. This could be due to high energy efficiency standards, but may also be indicative of households dangerously under-consuming energy. Source: HBS; AT-4/ EU – 4: High share of energy expenditure in income (2M): The 2M indicator presents the proportion of households whose share of energy expenditure in income is more than twice the national median share.

Over the 5-year period, in Austria both the low absolute energy expenditure shares and the high share of energy expenditure in income have increased: in 2010 the M/2 indicator amounted 10.8% and increase to 15% in 2015; the M2 indicator amounted 11.7% and increased to 16%, respectively. Considering these two indicators, Austrian and EU averages do not differ substantially from each other in 2015. Based on these two expenditure-based indicators, energy poverty affects approximately ~15% of the Austrian and EU population.

9.3 Energy Poverty in Austria – An EU-SILC Micro-Data Analysis

In international discussions on energy poverty, there is a long-lasting debate on various indicators of energy poverty whereby authors overall suggest considering multiple indicators to overcome weaknesses of single metrics (Bouzarovski and Tirado Herrero, 2015; Healy and Clinch, 2002; Nussbaumer et al., 2012; O'Sullivan et al., 2015; Thomson et al., 2017a). The limitations of energy poverty indicators and its arbitrarily chosen thresholds of energy poverty lines have been critically evaluated by Tirado-Herrero (2017). Composite indicators constitute a single numerical subsumed from several variables that represent a concrete dimension. The rationale for creating a composite indicator in this thesis stems from the aim to capture the multidimensional nature of energy poverty and to indicate household-based, as well as structural housing vulnerabilities to assess objective and subjective energy poverty definitions in Austria.

While the previous sub-chapter examined aggregated energy poverty indices in the EU and Austria, and answered the question of the extent of energy poverty in Austria and the EU, this sub-chapter utilises EU-SILC micro data to provide a more fine-grained analysis of energy poverty in Austria by decomposing relevant building-related, and sociodemographic determinants. This paragraph, therefore, aims to answer the research question *of what types of households are likely to experience energy poverty in Austria*. Four composite indicators are developed to analyse EU-SILC micro-data from 2019 comprising 5,983 households (provided by courtesy of Statistics Austria). This section has two purposes: to illustrate the Austrian situation in the realm of *housing* and *vulnerable groups*. In more detail, intersections are provided between *housing market structures and housing conditions.* The secondary data analysis results of EU-SILC are provided in Table 13 and Table 14. The following survey variables are employed for this evaluation:

<u>*Housing market structures*</u>: legal/ tenure status, construction period, rental segments (private rental, limited-profit, and communal housing), dwelling type (multi-storey or detached), residential areas/ degree of urbanisation (densely populated, intermediate populated, and thinly populated areas).[202]

<u>*Housing conditions:*</u> total housing costs (in €), heating costs (in €), equalised floor area.

202 The EU-SILC degree of urbanization variable divides all local administrative units into three categories, which are compatible with NUTS: densely populated areas are those with a minimum population of 50,000 and minimum density of 1,500 inhabitants per square km; intermediate populated towns and suburbs defined as clusters of contiguous one square km grid cells with a minimum population of 5,000 and minimum density of 300 inhabitants per square km; and thinly populated areas are defined as the remnant area.

Poverty and low-income: income quintiles, at-risk-of-poverty (households with an income below 60% of the national median income), and at-risk-of- poverty and social exclusion, which additionally includes households with very low work intensity or severe material deprivation.
Socio-demographics and –economics: gender, rural-urban segregation, migration background, being a single parent and age.

The selection of these outlined determinants is guided by insights from the literature review and the expert interviews. For the analysis, the following energy poverty indicators are constructed:

Variable	**2019 Annual Austrian Median in €**
Gas	820
Heating oil	1500
Wood	400
Coal	270
District heating	720
Electricity	720
Median energy costs (electricity and heating)	1420
Median total disposable annual household income	37.650
10% Boardman energy poverty indicator (weighted)	**10.0 (in %)**

Table 9 Boardman's Energy Poverty Indicator
(Source: EU-SILC 2019).

The ***first*** energy poverty indicator is based on Boardman's 10% rule. The EU-SILC variables for annual actual (not theoretical) electricity and heating costs (including gas, oil, wood, coal, and district heating) are summed up and divided by the total disposable annual household income.[203] If the share exceeds 10%, this household is considered energy poor. On average, Austrians pay 3.7% of their household's incomes for energy and 10% of the Austrian population is considered energy poor following the 10% rule of Boardman (see Table 9).

The ***second*** energy poverty indicator is the benchmark indicator for Austria as outlined in the National Energy and Climate Plan:[204] in 2019, the AROPE threshold was €15.437 (equivalised), while the equivalised median energy costs were €998.[205] The limit for above-average equivalent

203 Total disposable household income is the sum for all household members of gross personal income components, plus gross income components at household level, minus regular taxes on wealth, regular inter-household cash transfer paid, tax on income and social insurance contributions.

204 A household is energy poor if its income is below the at-risk-of-poverty threshold and, at the same time, it has to cover above-average energy costs.

205 Above-average energy cost is defined as expenses on energy (electricity and heating) that are considerably above the median expenses (140%).

energy costs amounts to 140% of the median value of €998 and is, therefore, €1.397 per year. According to this energy poverty indicator, in 2019, 3.9% of Austrian households are energy poor (see Table 10).

Variable	2019 Annual Austrian Median in €
Median energy costs (electricity and heating)	1420
Equivalised energy costs	998
140% equivalised energy costs	1397
At-risk-of poverty threshold	15.437
Expenditure-based NECP energy poverty indicator (weighted)	**3.9 (in %)**

Table 10 Austria's Energy Poverty Benchmark Indicator (Source: EU-SILC 2019).

The ***third*** composite energy poverty indicator is based on the subjective energy poverty assessment that has been used, for instance, by Bouzarovski (2014) or Thomson and Snell (2013). Households agree to one of the three statements:

a.) presence of a leaking roof, damp walls or rotten windows, or
b.) inability to pay to keep home adequately warm, or
c.) arrears on utility bills (one, two or more payments delayed in the last 12 months).

This subjective indicator provides a higher incidence of energy poverty in Austria than the latter two indicators. While arrears on utility bills are reported rarely in Austria (1.6%), more often respondents reported housing faults, e.g. leaking roof, cold floors (9.1%). Based on self-reported thermal discomfort, 2.2% of the Austrian households could not pay to keep home adequately warm. According to the subjective energy poverty indicator, 12% of Austrian households are energy poor (see Table 11).

Variable		2019 Austrian Average (in %)
OR	Leaking roof, damp, or rot	9.1
	Inability to afford to keep home adequately warm	2.2
	Arrears on utility bills	1.7
Consensual/ subjective indicator energy poverty indicator (weighted)		11.8

Table 11 Construction of Subjective Energy Poverty Indicator (Source: EU-SILC 2019).

Lastly, the ***fourth*** composite indicator classifies households as energy poor who are at-risk-of-poverty and social exclusion **or** if their actual energy expenditure exceeds 10% of their income **and** they experience at least one of the subjective energy poverty conditions (i., ii., iii.). The rationale to include at least one subjective indicator is to capture household' own perceptions of the presence of an energy burden, rather than focusing only on energy costs. The combined indicator indicates a share of 6.6% energy poor Austrian households (see Table 12).

Variable		2019 Austrian Average (in %)
OR	At-risk-of poverty and social exclusion	14.6
	10% Boardman rule	10.0
AND		
OR	Leaking roof, damp, or rot	9.1
	Inability to afford to keep home adequately warm	2.2
	Arrears on utility bills	1.7
Combined energy poverty indicator (weighted)		6.6

Table 12 Construction of Combined Energy Poverty Indicator (Source: EU-SILC 2019).

9.4 Energy Poverty Intersections with Housing Characteristics Using EU-SILC Micro-Data

As policies do not affect everyone equally, this section has two purposes: by applying several energy poverty and income poverty indicators to the Austrian housing market structures and conditions, critical segments in buildings and residents are revealed for potential targeted climate and housing policy measures. The overlapping intersections aim to provide reasons to understand energy poverty as a multidimensional concept. Table 13 demonstrates how housing conditions intersect with common poverty and energy poverty definitions.

Energy housing costs/ housing cost burden

· Disadvantaged households spend a third or more of their income for housing.

· The lower the incomes, the higher the housing cost burden. Energy poor, as well as, household's at-risk-of-poverty have disproportionally high housing and heating costs, especially the AROPE households are burdened above average; they pay 44% of their disposable income for energy. The lowest income quintile pays 39% of their disposable income for energy.

· Excessive energy housing costs are more related to income poverty and the expenditure-based energy poverty, however, less to subjective indicators such as housing faults, inability to keep the house adequately warm. Lower rates for the subjective energy poverty indicator might stem from self-restricting energy behaviours that in consequence result in lower heating costs.

Heating costs

· Similar to the housing cost burden, all indicators exhibit a clear degression by income: the lowest quintile and households captured by the combined energy poverty indicator spend more of their households income on heating costs (6%), compared to the highest income quintile (2%).

Owner vs. renter vs. other

· Energy poor households defined by disproportionately high heating expenditures predominantly live in owned, detached houses with comparatively larger floor areas. Typically, more households that are homeowners have higher energy expenditures (55.5% not captured in table).

· The share of renters in low income (53%), at risk of poverty and social exclusion (56%) and energy poor households (68%) is usually higher and typically exceed 50%. Renters in the private rental market are more exposed to structural disadvantages (iii). Only the figures in relation to heating costs observed for Boardman's 10% suggest that only 21% of households who have high energy expenditures are renters (i).

· For the Austrian official benchmark indicator, which refers to energy expenses and the at-risk-of-poverty rate (ii), most energy poor household are home owners (55.1%), less are renters (23.2%).

· Considering both objective and subjective indicators, the combined indicator (b/i+ii) showed that 68% of energy poor households are renters. Income and energy poverty is, therefore, a renter's issue.

Dwelling type: multi-storey apartment vs. detached house

· Households living in multi-storey homes are more affected by low income, poverty and energy poverty than those living in detached houses: 60% of households at risk of poverty (and social exclusion) and in the lowest quintile (59%) are living in multi-storey houses. For the subjective indicator, the same trend is observable (59%).

· However, high heating expenses conditioned on the household's income (Boardman's 10%) are found for detached houses, following a similar trend as the tenure status of homeowners. 33.1% of households who are considered energy poor by exceptionally high heating costs live in multi-storey apartment.

Equivalised floor area

· Living space depends on income, poverty levels and energy poverty. Households from lower income quintiles live in smaller dwellings compared to households from the highest income quintile (86m² compared to 120m², respectively). Proportionally, low-income households have higher housing costs compared to high-income households. Energy poor following Boardman's 10% indicator live in average sized (105m²) homes.

· Energy poor households defined by the subjective indicator (93.7m²) and the combined indicator (74.9m²) live in the smallest homes.

Rental segments: Private rental vs. limited profit vs. municipal

· Energy poor and income poor households predominantly live in the private rental market (e.g. according to Boardman's indicator 52.8%).

· More low-income households (26.6%) live in municipal housing than the highest income quintile (10.2%).

· Most mid- and high income groups in Austria live in private (47%) and limited-profit segment (43%).

· The shares of energy poor households according to the self-reported energy poverty indicator are equally distributed between the rental segments.

· The combined energy poverty indicator is almost equally distributed between the private (35%) and communal housing segment (39%), and less of a problem in the limited profit housings.

Year of construction

· Disproportionally more households who have difficulties to pay energy costs, keep their homes adequately warm or live with housing faults in dwellings between 1945 and 1980.

· Most low income quintiles (43%), and households at-risk-of-poverty and social exclusion, live in the housing segment constructed after WWII between 1945- 1980.[206]

· 52% of the households in the highest income quintile group live in dwellings constructed after 1981 (not indicated in the table), which typically features better energy efficiency that also leads to lower energy expenses and consumption.

Degree of urbanisation

· Considering Boardman's 10% indicator, only 23.5% of households with high energy costs live in cities, whereas most households with excessive energy costs live in rural areas (46.4%; not stated in the table). Inspecting Austrian benchmark definition from the NECP, affected households predominantly live in thinly populated areas in Austria and least in densely populated areas (19.8%).

· Taking the combined energy poverty indicator or the subjective energy poverty indicator into account, another picture evolves: energy poor households are predominantly living in cities.

206 This housing segment is characterized by low energy efficiency, the highest average heating demand of ca. 220 kWh/m2/a, and the highest annual heating costs (Lang, 2007; Umweltbundesamt, 2018, 2018). After the 2nd WorldWar, housing demand was high and construction took place in a rather cheap and fast manner, characterized by inferior products and considerable sustainability losses (Austrian Energy Agency, 2011). Because of the small cross-sections of the outer walls, the buildings of this construction period rarely meet today's requirements for sound and heat insulation. In 2020, the energy performance of buildings directive obliges to build only „Nearly Zero Energy Buildings", having a maximum heating demand of 5 kWh/m2/a.

Excessive heating costs are a rural problem, while faulty housing conditions, or the inability to have a warm house, are city problems.

· High (37%) and low (37%) income quintile groups live predominantly in cities, while most mid-income quintile groups live in thinly populated areas of Austria (39%). Most people at-risk-of-poverty and social exclusion (40%) live in the city rather than in thinly populated areas.

9.5 Energy Poverty Intersections with Vulnerable Groups - EU-SILC Micro-Data Analysis

Inspired by Großmann and Kahlheber (2018), an intersectional lens will be employed to analyse vulnerable groups that have been identified in the literature. Table 14 below illustrates some of the key characteristics of energy poverty intersections with vulnerable households. The same four energy poverty indicators from the previous analysis (Table 13 above) are used for this analysis. Chi-square ($\chi 2$) tests of independence were utilised to evaluate whether the following characteristics are associated with a higher risk to be energy poor: single-parent households, pensioners, having children, being female, single women, being single and 65+ years or older, life events, such as a divorce or the sudden inability to work because of illness in the last 12 months.

Male vs. female

Throughout all energy poverty indicators, women are significantly more vulnerable to energy poverty than men are. The percentages differ by approximately 3-6% and are significant ($p < 0.001$).

Multi-person households vs. single- parent household

Single-parent households compared to multi-person household with one or more children have an increased risk to be energy poor (i, iii + iv). All energy poverty indicators (where analysis allowed) indicated significant results ($p < 0.01$).

Household without and without a pension

Pensioner households have significantly higher heating costs and are more likely affected by energy poverty calculated with Boardman's 10% rule (i). Considering, however, the subjective and combined energy poverty indicators, an opposite trend is observable: significantly more households without a pension report housing-related problems, difficulties to pay utility bills, or not having an adequately warm dwelling (iii + iv).

No children vs. presence of children

The subjective self-reported energy poverty indicator (iii) differs from Boardman's expenditure-based indicator (i) for children in the households: while excessive heating costs are more a problem of households without kids, arrears on utility bills, inadequately warmth at home, or housing faults emerge significantly more often in households with children (iii).

Single living women vs. single living men

Single living women experience significantly more often energy poverty than single living men on all indicators (i+ ii+ iii+ iv) ($p < 0.01$).

Single living younger than 65 years vs. single-living older than 65

Significantly more single elderly (65+ years) compared to singles younger than 65 years are affected by a high energy cost burden (22.2%) and energy poverty (8.9% vs. 5.0%) according to the Austrian benchmark indicator (i+ii). For the other indicators, there are no significant results encountered.

Female pensioners vs. male pensioners

On all energy poverty indicators, the $\chi 2$ test results indicate a clear association that female pensioners experience more often energy poverty: elderly women (65+ years) receiving a pension are more often affected by energy poverty than their reference group of elderly males with a pension ($p < 0.05$).

Experienced a sensitive life event(s) in the last 12 months vs. no life-changing events

Households who experienced a life event have more often arrears on utility bills, inadequately warm houses, or housing faults ($p < 0.01$). Also, the combined energy poverty indicator indicates an increased risk of experiencing energy poverty for households with a life event in the last 12 months ($p < 0.01$). Life events can have various implications that lead to higher energy poverty incidences, such as experiencing a sickness that leads to an increase demand of energy necessary for essential services or medical devices.

9.6 Conclusion

This chapter discussed the current developments of the key three indicators of energy poverty in the EU, Austria, and Vienna. The analysis has shown that the at-risk-of-poverty and the unemployment rate are higher in Vienna compared to Austria and the EU. In Austria, the real gross disposable income of households per capita did not increase in the same way as the EU average. In the trend, the EU and Austrian electricity and gas prices increased. On average, EU energy efficiency increased over the last two decades, and the improvements could catch up with the drivers that contributed to an increase in household energy consumption. Remarkably, retrofitting rates in Austria have collapsed since 2010 and are currently too low to make the building stock climate neutral by 2050 or 2040, as foreseen in Austria. Considering Austria's primary subjective energy poverty indicators, the Austrian rates are below the EU average. The low absolute energy expenditure (M/2) and high share of energy expenditure in income (2M) are similar in Austria and the EU. The chapter answered the research questions**,** *what is the extent of energy poverty in Austria and what population segments are energy poor* utilizing EU-SILC 2019 micro data. Results indicate that the extent of energy poverty in Austria differs heavily depending on the applied indicator, because each of the indicators focuses on a different aspect of energy poverty.

Considering the "objective" energy poverty indicator, 10.0% of the Austrian households pay over 10% of their household incomes for energy and are energy poor according to Boardman's 10% rule. 3.9% of Austrian households are indicated as energy poor according to the expenditure-based NECP benchmark. Composite indicators that account for the multidimensional nature of energy poverty have also been generated and applied, showing that 11.8% of households in Austria are subjectively energy poor, as they report inadequate warm homes, arrears on utility bills, or housing faults. Overall, 6.6% of the Austrian population experiences either too high energy costs or being at risk of poverty or one of the three subjective indicators.

This housing market structure and housing conditions analysis provided nuanced and valuable insights into general energy poverty incidences in Austria. The difference between expenditure-based and subjective indicators is striking and most apparent, especially between the rural and the urban divide, the renting vs. owing, and the floor area in m^2. The rental housing segment, and especially the private and social housing sector, has crystallised as a key policy area in need for policy measures, as the typical intersection of housing faults, low income and high heating costs are observed.

					Housing cost burden [1]	Heating costs [2]	Tenure status: Renting [3]	Multi-story apartment house [4]	Equivalised floor area [5]	Rental segments			Construction period 1945-1980 [7]	Degree of urbanization: Densely populated [8]
										Private rental	Limited-profit housing	Communal housing		
			in EUR	in %	in %	in %	in %	in %	in m²	in %	in %	in %	in %	in %
	mean				20.0	3.4	39.5	50.0	104.6	41.4	41.0	17.6	38.0	31.9
Poverty indicators	(a) Inequality per equivalised disposable income per year	Highest Quintile	> 38,336	20.0	9.9	1.6	27.1	44.2	120.3	47.2	42.6	10.2	29.6	37.3
		Higher Quintile	29,382 – 38,335	20.0	13.8	2.4	33.1	46.4	111.2	42.7	44.0	13.3	36.2	30.8
		Mid Quintile	23,290-29,381	20.0	16.9	3.0	39.4	47.8	105.0	36.1	47.6	16.3	39.9	27.6
		Lower Quintile	17,324-23,289	20.0	20.8	3.6	45.2	53.7	99.0	41.4	42.7	15.9	41.8	28.2
		Lowest Quintile	< 17,323	20.0	38.6	5.7	52.8	59.3	85.7	41.6	31.8	26.6	42.6	35.8
	(b) At risk of poverty [9]		15,437	14.6	43.7	6.5	53.4	60.3	83.2	44.1	30.9	24.9	42.6	37.3
	(c) At risk of poverty and social exclusion [10]		n.a.	17.4	40.8	6.0	56.1	61.9	82.1	43.3	30.4	26.3	42.8	39.7
Energy poverty indicators	(i) Expenditure-based: > 10% Heating costs [11]		n.a.	10.0	41.5	15.4	21.1	33.1	104.7	52.8	27.8	19.4	49.4	23.5
	(ii) NECP: AROPE + above-average energy costs			3.9	51.6	11.5	23.2	30.4	102.2	52.2	28.2	19.6	46.9	19.8
	(iii) Self-reported: arrears on utility bills or adequately warm or housing faults[13]		n.a.	11.8	25.1	3.7	55.1	58.9	93.7	36.8	30.6	32.6	37.1	41.6
Combined indicator	(b/i+ii) AROPE or >10% Heating Costs and arrears on utility bills or adequately warm or housing faults [14]		n.a.	6.6	37.2	5.8	67.7	67.7	74.9	35.2	25.55	39.4	40.5	50.0

Table 13 Prevalence of Housing Characteristics Among Generally Poor and Energy Poor Segments (Source: Statistics Austria, EU-SILC 2019).; N=5.983 households; row percentages displayed; * only limited valid as based on N<20.

1 Total housing costs include: gas, heating oil, electricity, coal, wood and district heating. Housing costs overburden is calculated as the ratio between the monthly total housing costs in € multiplied by 12 and the annual disposable income, with gross housing allowances deducted from both amounts. For further information see: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_statistics_on_income_and_living_conditions_(EU-SILC)_methodology_-_housing_conditions#Calculation_method

2 Annual heating costs excluding electricity in % of total annual consumption expenditures.

3 Tenure status: renting vs. owning and other contracts.

4 Multi-storey apartment house (more than 3 apartments) vs. detached house (one or two apartments).

5 Floor area weighted according the EU household-level scale.

6 Heating system using renewable energy vs. others (gas, heating oil, coal and district heating).

7 Year of construction of the dwelling: before 1945 vs.1945-1980 vs. 1981-2019.

8 Degree of urbanisation: densely populated area vs. intermediate area vs. thinly populated area.

9 Household with an equivalised disposable income (after social transfer) below the at-risk of poverty threshold, that is set at 60% of the national median equivalised disposable income after social transfers.

10 Household either at risk-of poverty, or severely materially deprived or living in a household with a very low work intensity. Severe material deprivation is defined as not being able to afford three out of nine basic necessities such as to pay the rent, mortgage or utility bills or to face unexpected expenses.

11 Household spending more than 10% of its disposable household income for energy services.

12 Households *considered energy poor if income is below the at-risk-of-poverty threshold and, at the same time, it has to cover above-average energy costs* (defined as expenses on energy (electricity and heating) that are above the median expenses*; in 2019 Austrian median expenses amount €1635 p.a.)*

13 Household agrees to “presence of a leaking roof, damp walls or rotten windows" or "the ability to pay to keep home adequately warm" or "arrears on utility bills (one, two or more payments delayed in the last 12 month)”.

14 Household either is at-risk-of poverty or expenditure for energy exceeds more than 10% of its total disposable income, and agrees to one of the three following questions: “presence of a leaking roof, damp walls or rotten windows" or "the ability to pay to keep home adequately warm" or "arrears on utility bills (one, two or more payments delayed in the last 12 month)”.

	Multi-person with kids	Single parent	Without pension	With pension	No kids	Kids	Male	Female	Single living men	Single living women	Single < 65 years	Single > 65+ years	Pension x male	Pension x female	No life event	Life event
(i) Expenditure-based: > 10% Heating costs [1]	3.4	9.4	7.74	12.9	10.5	4.3	6.8	12.45	11.7	18.6	12.1	22.2	13.7	19.6	n <20	
	Chi^2=17.0***		Chi^2=37.3***		Chi^2=43.9***		Chi^2=54.5***		Chi^2=18.9***		Chi^2=39.1***		Chi2=3.9*			
(ii) NECP: AROPE + above-average energy costs	n <20		3.3	4.1	4.0	1.4	2.8	4.9	5.0	7.6	5.0	8.9	3.8	7.8	n <20	
			Chi^2=2.4		Chi^2=20.1***		Chi^2=24.8***		Chi^2=5.9**		Chi^2=13.4***		Chi2=4.4**			
(iii) Self-reported: arrears on utility bills or adequately warm or housing faults [2]	11.5	26.0	12.2	8.5	10.4	14.0	9.5	13.3	10.5	12.8	12.2	11.3	6.5	11.1	10.8	15.2
	Chi^2=34.7***		Chi^2=17.0***		Chi^2=13.0***		Chi^2=21.5***		Chi^2=2.8**		Chi^2=0.4		Chi^2=11.7***		Chi^2=10.0**	
(iv) At risk of poverty or >10% Heating Costs & arrears on utility bills or adequately warm or housing faults [3]	3.2	23.57	6.3	4.7	7.0	8.6	4.7	11.2	7.8	11.7	13.6	10.1	n <20		8.4	5.6
	Chi^2=100.6***		Chi^2=4.3*		Chi^2=2.1		Chi^2=52.0***		Chi^2=6.5*		Chi^2=3.2				Chi^2=5.4**	

Table 14 Energy Poor Population Segment. Significant results are shaded grey (Source: Statistics Austria, EU-SILC 2019). N=5.983 households; row percentages displayed; Chi^2 = *p < .05; **p < .01; ***p < .001. For case numbers below 20, groups were not presented so that no results are shown. Life events include reasons that household income decreases because of a.) decreasing working hours/income, b.) job change, c.) inability to work due to illness, d.) job loss / unemployment / bankruptcy; e.) maternity / parental leave / child care; f.) retirement, g.) divorce, ending of a relationship, h.) elimination of social benefits. Energy poverty indicators: (i) Household spending more than 10% of its disposable household income for energy services. (ii) Households considered energy poor if income is below the at-risk-of-poverty threshold and, at the same time, it has to cover above-average energy costs (defined as expenses on energy (electricity and heating) that are above the median expenses; (iii) Household agrees to “presence of a leaking roof, damp walls or rotten windows" or "the ability to pay to keep home adequately warm" or "arrears on utility bills (one, two or more payments delayed in the last 12 month)”. (iv) Household either is at-risk-of poverty or expenditure for energy exceeds more than 10% of its total disposable income, and agrees to one of the three following questions: “presence of a leaking roof, damp walls or rotten windows" or "the ability to pay to keep home adequately warm" or "arrears on utility bills (one, two or more payments delayed in the last 12 month)”

In more detail, while the two expenditure-based indicators that include high heating costs point out that energy poverty is predominantly a rural problem, experienced in large detached homes, the housing cost burden is lower for energy poor households according to the subjective indicator, e.g. with housing faults. These results imply that presumably energy poor, who have on average lower total housing costs, may self-restrict on energy. The expenditure-based energy poverty indicators indicated that inhabitants of detached homes have higher risk to be energy poor in Austria, while contrary the subjective indicators showed that urban dwellers in multi-storey buildings constructed between 1945 and 1980 have the highest risk to be energy poor. A similar picture appears for renting and owning: while tenants are more prone to subjective energy poverty, households living in their own properties spend more of their income on heating and energy, and suffer more from "objective" energy poverty.

The conclusion can be drawn that using only the expenditure-based indicators would have shown a limited picture of energy poverty in Austria as major differences between objective and subjective indicator become clear. It, however, remains uncertain whether households who spend over 10% of their income on heating would feel energetically poor if asked in a questionnaire (Yip et al., 2020). Not everyone who is energy poor according to the subjective indicator spends at the same time also over 10% of the household's income on heating, as households can forcefully skimp on energy. Hence, the missing behavioural dimension can offer an answer to this alleged relationship.

While the positive relationship between inequalities, poverty and gender is well researched, it is not yet mainstreamed in quantitative energy poverty research. The concept of intersectionality has served as a theoretical background and it has been used for a household level analysis to evaluate what factors interact to form inequalities in relation to energy poverty. Furthermore, the analysis highlights the gendered nature of energy poverty in Austria. More women, particularly single parents and single living women receiving a pension, are identified as being energy poor. This emphasizes the need to include a gender perspective in energy poverty debates and to increase awareness among policymakers, advisors, and researchers.[207] The findings also indicate that pensioners and households that have experienced a life event in the last 12 months, such as a change in family composition or employment status, are more vulnerable to energy poverty. Overall, this section of the study underscores the complex and

207 A logistic regression analysis was performed with the relevant variables but it was decided not to present the table results in the thesis due to multicollinearity problems and small sample sizes for some variables of interest.

multifaceted nature of energy poverty in Austria, and the importance of considering different indicators and vulnerable household constellations in order to fully understand and address this issue. Figure 29 visualises the key results of the empirical analysis of predominant intersections and vulnerability axes of energy poverty in Austria.

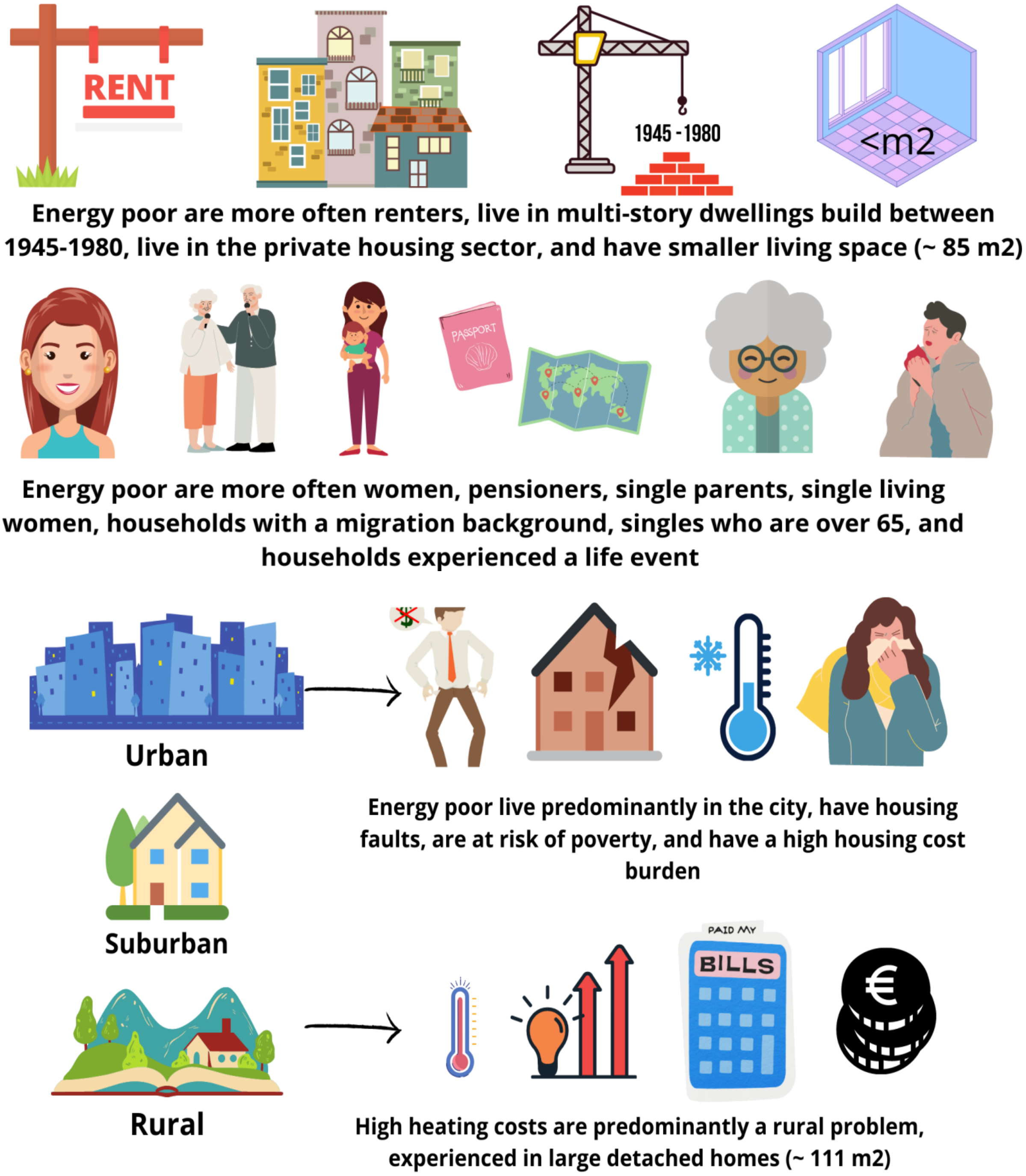


Figure 29 Typical Energy Poor Constellations in Austria (Source: Own Visualization asedon EU SILC 2019 calculations).

10. Quantitative Case Study Results – Energy Self-Restrictions in Social Housings in Vienna

This results chapter focuses on primary analysis of survey data on social housing tenants in Vienna. The previous chapter did not include the behavioural dimension of energy self-restrictions due to data limitations in the EU-SILC survey. Alongside an application of expenditure-based and consensual-based energy poverty indexes, this chapter approaches energy self-restrictions in an exploratory way by proposing a novel operationalization of hidden energy poverty using latent class analysis (LCA). The household socio-demographic and building characteristics of energy self-restricting behaviours will complete this analysis. Several cross-tabulations with typical income poverty and energy poverty indicators will reveal a crucial dimension in current energy poverty classifications that has been overlooked by current energy poverty research. This analysis exposes the necessity of considering energy self-restriction in order to avoid misidentification for future energy poverty rates and policy design.

The goal of this chapter is to combine energy poverty indicators with groups of households that use energy self-restricting behaviours to reveal energy inequalities in social housing in Vienna. Specifically, the aim is to further develop energy poverty metrics and to answer the research question "*do households use self-restricting energy strategies that would characterise them as hidden energy poor households?"* This analysis proposes an alternative understanding of hidden energy poverty that moves beyond expenditure-based approaches and thus allows the identification of energy poor households that are generally missed by existing energy poverty indicators. Specifically, it aims to capture households that, by adopting self-restricting energy behaviour and underconsumption, have low overall energy costs. Without their self-restricting behaviour, these households would be captured by typical expenditure-based energy poverty statistics, since their overall costs would be high. This chapter predominantly focuses on the not-retrofitted sample of the survey, and where necessary, a comparison with the retrofitted sample is drawn to understand major differences in housing costs developments, satisfaction with the apartment.

This quantitative results chapter proceeds as follows: sub-chapter *one* applies common energy poverty indicators to primary survey data of social housing residents in Vienna. Sub-chapter *two* proposes a new consensual hidden energy poverty indicator based on energy self-restriction behaviours. The alternative indicator is elicited by using LCA, which is a new method that was not yet been utilised for indicator development in previous energy poverty debates. Sub-chapter *three* identifies distinct self-restricting classes and shows that these groups only partially intersect with energy poverty and income poverty. Further predictors of energy self-restriction are inspected with LCA regression. Sub-chapter *four* ends with a summary of key results from the primary survey analysis and provides an answer to the research question.

10.1 Applying Energy Poverty Indicators to the Case Study

Three main drivers of energy poverty are considered in this chapter: the at-risk-of poverty rate, high energy prices, and inefficient dwellings. In 2019, the Austrian at-risk-of-poverty threshold for a single-person household was €1.286/month (Statistik Austria, 2021b).[208] According to EU-SILC micro-data, approxmately 15% of the Austrian population were at-risk of poverty. Constraining this EU-SILC analysis to households living in social housing in Vienna, the at-risk-of-poverty share is significantly larger and amounts 27%. Considering the primary survey data in social housing in Vienna for the retrofitted buildings, the share of 51% is substantially higher than in the EU-SILC survey. In the not-retrofitted buildings, approxmately 56% are at-risk-of-poverty. To summarise, more people in the not retrofitted social housing segment are at-risk-of-poverty than in the general Austrian population (see Table 15).

	Retrofitted Social Housing in Vienna	Not-Retrofitted Social Housing in Vienna	EU-SILC Social Housing in Vienna	EU-SILC Austria
At-Risk-of Poverty Shares (in %)	50.62%	55.87%	26.74%	14.61%
Total N	162	179	288	5.983

Table 15 At-Risk-of-Poverty Rate. Note: At-Risk-of-Poverty: Equivalised Disposable Income After Social Transfers Below 60% of the National Median, < €1.286 in 2019 (Source: Case Study Results and EU-SILC 2019(EU-SILC, 2019)).

Rental costs (including operating costs) have risen significantly over the past 12 years, including rental prices in social housing. According to Statistics Austria, domestic prices increased by 29% between 2008 and 2019 (see Figure 30). Considering the three main Austrian housing segments, housing costs developed to varying degrees. Figure 30 indicates that the social housing segment had the lowest median rental costs increase over the period 2008 - 2019, while the private rental segment had the highest rent increases. Hence, over the course of a decade, social housing associations and limited profit housing (and its underlying legal

208 People are considered being at-risk-of-poverty if their equivalised household income is below an at-risk-of-poverty threshold of 60% of the national median household income.

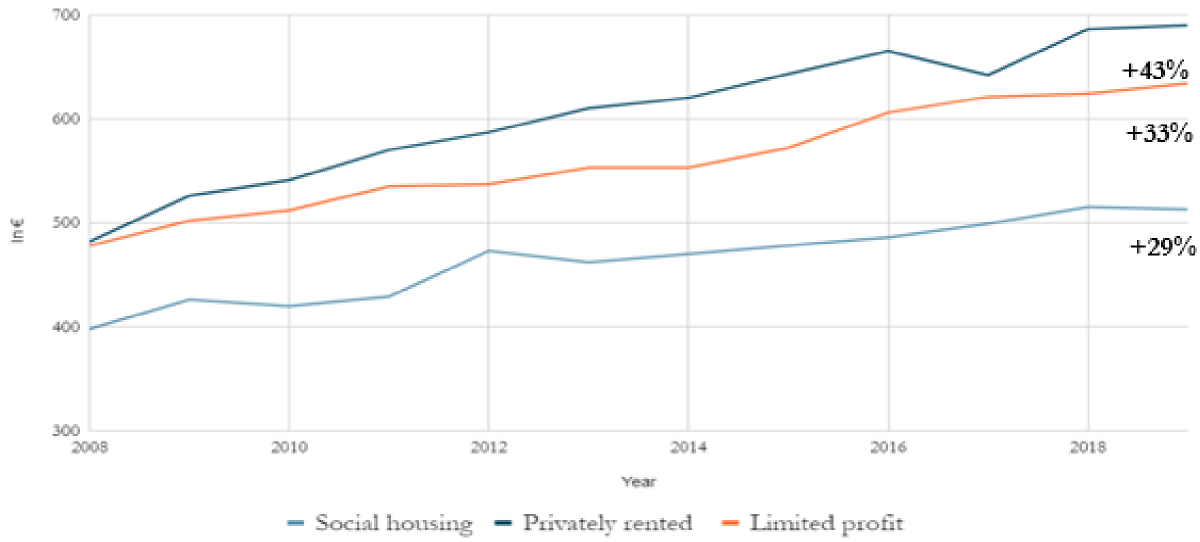


Figure 30 Development of Housing Costs in Main Three Housing Segment in Austria (Source: Statistik Austria, 2021c). Note: Housing Costs Refer to Rental Costs Including Energy Costs and Utilities and Interest Proportions According to EU- SILC.

structure) could secure lower rental prices compared to the private rental market in Austria. Considering the sensitivity to price changes, the following subjective indicator considers the development of general housing costs. The overall housing costs increased by approximately 80% of the surveyed households in not-retrofitted buildings and in only ~20% of the cases, heating, electricity, and rent costs stayed the same (Figure 31). Only a few respondents stated that their costs decreased. The majority (54%) stated that rent costs "increased a bit". Although rent in social housing in Vienna is subject to the regulated Tenancy Law and can only increase according to an annual valorisation, households indicated that the overall rent costs increased strongly (25.6%).[209]

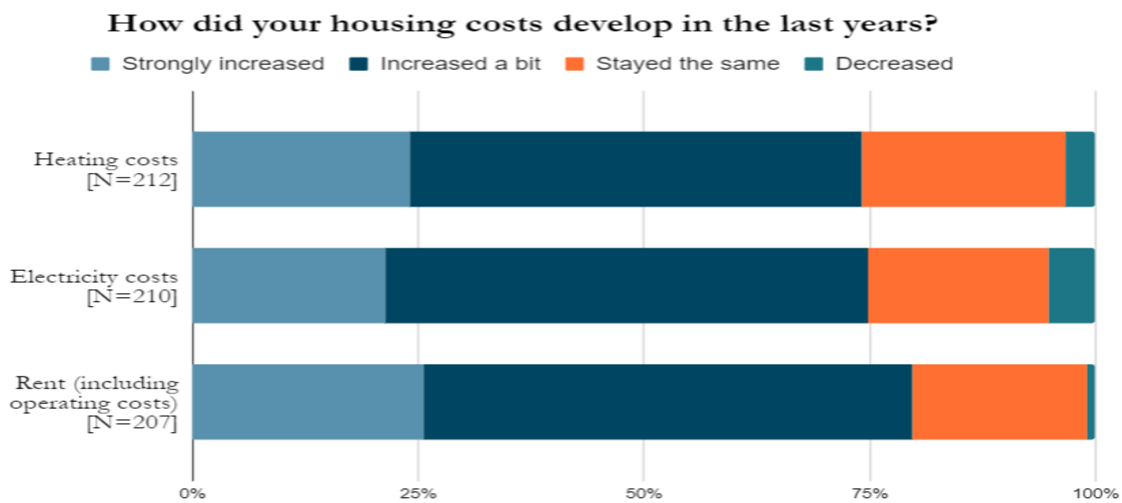


Figure 31 Development of Housing Costs in Not Retrofitted Social Housing Flats in Vienna (Source: Case Study Results)

209 A chi2 test was performed to analyse weather the subjective rent costs increased more for renters that moved in after 1994 and have a new rental contract under the reference value rent compared to households holding an old rental contract that is subject to the category rent, which

Table 16 compares heating, electricity and rental costs in (pre- and post) retrofitted and not-retrofitted social housing in Vienna, and Austria. Representative EU-SILC data and primary survey data are utilised for this analysis. The Austrian general population paid on average €71 per month for their heating expenses. The higher costs probably stem from the fact that all forms of living are included (owing a house resulting in larger m^2 to heat) in the analysis. When comparing the primary survey data in social housing in Vienna, heating costs are larger than the EU-SILC survey data.

€ per Month	Median Pre-Retrofit Social Housing in Vienna	Median Post-Retrofit Social Housing in Vienna	Median Not Retrofitted Social Housing in Vienna	Median EU-SILC Social Housing in Vienna	Median EU-SILC Austria
Heating Costs	70.9 [N: 118]	65.0 [N: 125]	65.5 [N:184]	50 [N: 254]	70.83 [N: 4219]
Electricity Costs	56.5 [N: 116]	51.0 [N: 123]	50 [N:188]	43 [N: 288]	60.00 [N: 5819]
Rent (incl. operating costs)	337.3 [N: 129]	360.0 [N: 133]	400 [N:199]	390 [N: 288]	515 [N: 2360]

Table 16 Median Heating, Electricity and Rent Costs in Austria and Vienna (Source: Case Study Results and EU-SILC 2019).

The median heating costs for households in the not-retrofitted sample were €66 per month, which is higher than the median of €50 per month for EU-SILC households in social housing. This difference may be attributed to the presence of housing faults in the not-retrofitted sample, which could result in higher heating costs. Comparing heating, electricity and rental costs before and after the retrofit in the primary survey data, two main results are apparent: we can presume that Wiener Wohnen targeted the energy inefficient housing accurately, since, on average, residents in the not-retrofitted sample had the highest heating costs (€70.9 per month) before a retrofit. After the retrofit, the median heating costs decreased by €6 per month on average, and electricity costs decreased by €5.5 per month on average. However, households reported a significant increase in rent, amounting to approximately €22 per month on average.

In comparison, the median rent costs after the retrofit were lower compared to the not-retrofitted sample by €40, and averaged €360 per month. The average rent costs in the not-retrofitted study sample were €400 per month. These findings suggest that, overall, residents pay more for rent in the not-retrofitted compared to the retrofitted social housing in Vienna. However, it is important to note that these rent costs are still lower compared to the average general Austrian

is typically lower. The test yielded an insignificant result, pointing to no difference in the subjective housing cost difference (chi2=2.65, p=0.26).

population due to rent caps for social housing.

Figure 32 captures whether the retrofit increased energy efficiency via decreased energy costs. Households expressed a decrease in heating costs that can be referred to as the increase in energy efficiency of the building. Considering the analyses from Table 16 and Figure 31, it is possible to conclude that energy costs decreased because of the retrofit: while the not-retrofitted sample indicated only a 3% decrease in heating expenses, 50% of the retrofitted sample reported a decline in heating cost. Following the same pattern as in Table 16, what stands out are the overall increases in rental costs in Figure 32. However, 18% of the retrofitted sample perceived a strong rent increase, while in the not-retrofitted sample this same figure rose to 26%.

10.1.1 Expenditure-Based Approach

Expenditure-based approaches typically employ heating and utility costs of households and the at-risk-of-poverty rate. The 10% rule of Boardman and the LIHC approach are approximations of the indicators as data availability does not permit the construction of original indicators as envisaged by Boardman (2013) and Hills (2012b). As large data requirements on housing characteristics are needed to estimate theoretical households' energy needs, an adjusted approach is utilised that is based on actual energy costs.[210]

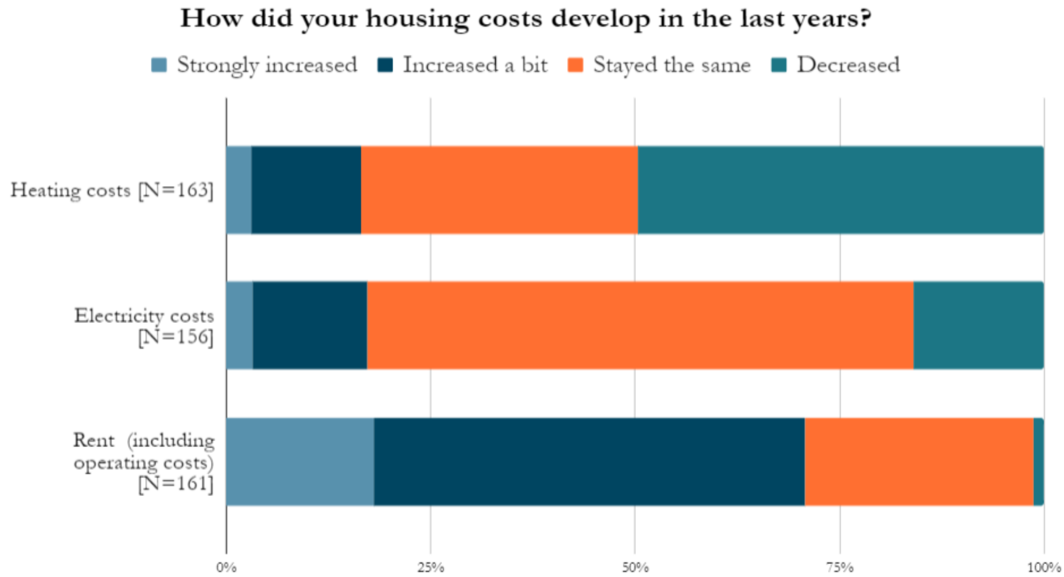


Figure 32 Development of Housing Costs in Retrofitted Flats in Vienna (Source: Case Study Results).

210 The required expenditure requires a lot of data to produce the indicator, and only a minority of EU Member States have the survey infrastructure to achieve this (Rademaekers et al., 2016a). Also, in this survey, it was impossible to include all necessary questions. That is why actual expenditure is utilized by cautioning the reader that this metric is not constructed as the original energy poverty indices. However, research papers outside of the UK regularly employ this kind of analysis (Antepara et al., 2020).

Boardman

A household is energy poor if $\frac{Fuel\ cost}{Household's\ income^{211}} > 0.1$

The share of energy poor, according to Boardman's indicator, is 30% in the not-retrofitted sample. However, because Boardman's indicator utilises actual energy costs, it cannot account for households who are forced to underconsume and skimp on energy to reduce their utility bills to affordable levels. These households also do not appear in the expenditure-based measures.

Low-Income High Costs

Households are energy poor under the LIHC indicator if two conditions are met: their incomes are low (below 60% of the equivalised national median poverty line) and their energy expenditure is high (above the equivalised national median).[212] The at-risk-of-poverty threshold in 2019 was €1.286 per month (annual €15.437) and the share of at-risk-of-poverty in the not retrofitted case study sample amounts 56%, which is above the national average of Vienna (Vienna 26%)(European Commission, 2019h). Compared to Boardman's indicator, the LIHC employs EU-SILC equivalised median energy costs, which amount €83 per month (annual €998, own calculations) in 2019. The share of energy poor considering the adjusted LIHC indicator in the not retrofitted case study sample of social housing residents in Vienna is 23.7% (see Table 17).

	Share of households in social housing in Vienna in %
At-risk-of poverty threshold	55.87 [N: 179]
Equivalised median energy costs thresholds	49.73 [N: 183]
Low-Income High Costs	23.72 [N: 156]

Table 17 Construction of LIHC Indicator (Source: Case Study Results).

10.1.2 Consensual-Based Approach

Consensual-based indicators add information about subjective and actual energy needs of households that expenditure-based indicators cannot take into account. One of the main subjective indicators to capture subjective energy poverty are housing faults. Consensual-based

211 Shares are based on own EU-SILC analysis using households weights. Income is the net income after tax with no deductions, includes household income from benefits, and takes account of council tax payments. Household income is not equivalised.

212 The original LIHC is based on energy needs rather than real consumption or energy expenditures.

indicators reflect personal perceptions and feelings of households, as they report building-related problems in the dwelling. Two consensual-based indicators are operationalized for this analysis.

The *first* indicator captures poor structural building characteristics that may result in excessive heating expenditures or increased feelings of cold due to dangerous levels of under-consumption. The *second* consensual-based indicator focuses on the ability to reach preferred temperatures at home. Note that, for a reliable energy poverty assessment, this analysis would ideally be complemented by a housing stock quality assessment that provides the energy performance of buildings, which is important to reflect energy poverty levels.[213] However, as the primary survey sampling strategy foresaw dividing the sample between retrofitted and not retrofitted buildings, it is possible to decrease bias that energy efficient buildings are included in the analysis of the not retrofitted sample.

Problems Experienced in Homes

Table 18 illustrates the responses (in percentages) to multiple questions about experiencing housing problems in not-retrofitted apartments. Most people in the not-retrofitted sample indicated having poorly insulated building envelope/ façade (56.5%), leaky windows (52.7%) or cold outer walls (46.3%). 22% of the households reported not having a regulatory heating system.[214] In order to crosscheck this result, Simons and Tielkes (2020) analysed data from Wiener Wohnen. They reported that most of the housing stock managed by Wiener Wohnen is classified as category A apartments (65.2%)[215]. 16.7% of the apartments are category B apartments without a central heating system and 17.9% are category C apartments without a bathroom and without a central heating system (Simons and Tielkes, 2020, p. 26). Category D (no running water and/or no toilet inside apartment) apartments make up less than 1%. In total, 34.4% of the residents of Wiener Wohnen do not have a central heating.[216] Hence, the estimated

213 Typically, the EU-SILC subjective indicator includes next to the two presented indicators also a third indicator that captures arrears on utility bills. This variable was, however, not included in the case study questionnaire.

214 The percentage values responses is the percentage of each response out of total responses from the given dataset. Thus, the percentage total amounts to 100. The ‘percent of cases’ value indicates the number of households that indicated experiencing the particular housing problem.

215 Category A: Minimum 30-m2 floor space, kitchen(ette), toilet, modern bathroom; central or single-storey heating system or equivalent fixed heating installation.

216 The expert from “Wiener Wohnen“ who is in charge of retrofitting activities explained that the exchange of the heating systems is an autonomous topic and does not fall under his duties in his department. “Heating system exchange does not affect the renovations. The apartments tend to be rearranged individually. If we can switch to district heating or similar, then we will do it. But it does not affect us that much in the renovation department" (I13).

numbers in the case study appear slightly overestimated; however this may be explained when considering that the sample is restricted to not-retrofitted households.

Consensual Approach to Energy Poverty Problems Experienced with Heating and Housing in Not Retrofitted Housing		
	Percent of Cases	**Total N of Responses**
Damp walls/ window frames or floor (mould)	21.90	210
Leaking roof	8.54	199
Cold outer walls	46.31	203
Cold floor	33.98	206
Leaky windows	52.66	207
Poorly insulated building envelope/ façade	56.46	209
Lacking regulatory for heating system	22.05	195
Other problems	10.20	49

Table 18 Reported Housing Faults in Not Retrofitted Dwellings in Vienna (Source: Case Study Results).

Based on the reported results in Table 19, 75% of households in the not-retrofitted sample mentioned having at least one or more housing problems. Austrian buildings constructed between 1945 to 1980 have overall the highest heating demand of ca. 220 kWh/m^2/a and the highest annual heating costs of (Lang, 2007; Umweltbundesamt, 2018), which points to the high demand for retrofitting activities in this social housing segment.

Housing Problems	**Frequency**	**Percent**
No reported housing problems	55	25.00
At least one reported housing fault	165	75.00
Total	220	100.00

Table 19 Housing Problems (Source: Case Study Results). Note: Household agrees to one of the seven following items: presence of 1. Damp walls, rotten windows or floor (mould), 2. leaking roof, 3. cold outer walls, 4. cold floor, 5. leaky windows, 6. poorly insulated building envelope, 7. absent heating regulation.

In the survey, an open-ended question allowed households to make general comments about the topic: d*o you have any information to share regarding the heating system or the state of the building?* In absolute terms, the most answers given were from the non retrofitted sample. Here, residents used the possibility to draw attention to the problematic housing conditions and the urgent need to improve insulation (Appendix E household's answers). Figure 33 illustrates a Word Cloud with most frequently mentioned words.

Figure 33 Word Cloud Responses to Open Question (Source: Case Study Results)

An important consensual energy poverty indicator is the subjective assessment of whether a household can achieve its preferred temperatures at home. Figure 34 presents an overview of reported answers to preferred temperatures if it is cold outside. Most households (56%) prefer 21°C – 22 °C. This indoor temperature constitutes also the WHO recommended temperature of 21°C (WHO, 1987). 20°C indoor temperature is typically considered as uncomfortable in central Europe (Frank, 2005). 23% of the households in the not-retrofitted sample prefer 23°C or more, which is above the recommended WHO temperatures.

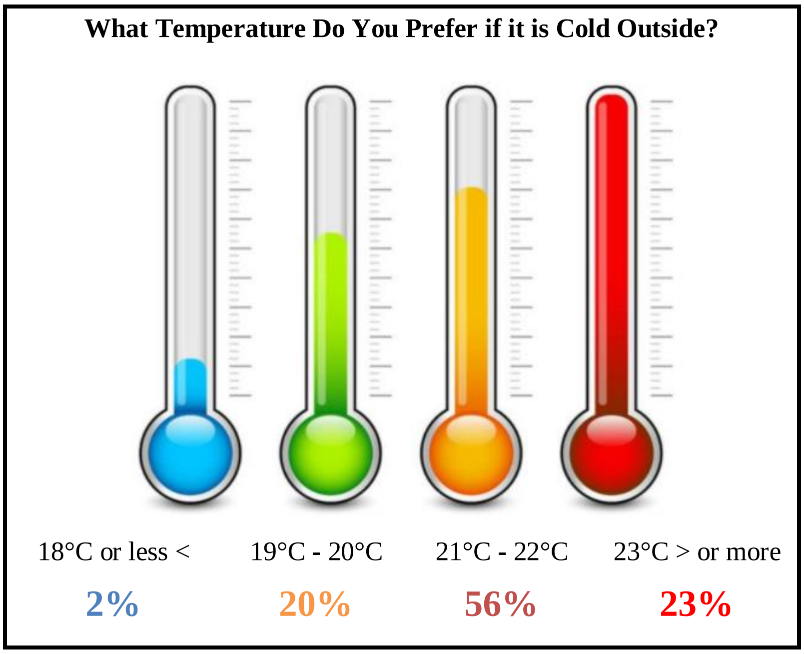


Figure 34 Temperature Preferences in Not Retrofitted Social Housings in Vienna; N= 217 (Source: Case Study Results)

A gap is present between the preferred and the ability to reach preferred temperatures: 18% of the case study households cannot reach their preferred temperatures at home (see Table 20). Comparing the subjective indicator from the EU-SILC analysis, where only a minority of 2.2% households reported to be unable to afford to keep the home adequately warm in 2019 in Austria, these results deviate strongly from the not retrofitted social housing sample. Although the EU-SILC indicator focuses on affordability issues, this indicator points to the general inability to reach comfort temperatures.

Can You Reach Your Preferred Temperature at Home?	Frequency	In %
Yes	175	81.78
No	39	18.22
Total	214	100.00

Table 20 Ability to Reach Preferred Temperature at Home in the Not Retrofitted Social Housing Sample (Source: Case Study Results).

Table 21 inspects a variety of expressed perspectives connected to the housing quality in not-retrofitted social housing. 12% of the sample expressed the intention to move out and 12% are not satisfied with their apartment. A large proportion of households reported disagreement with the statement that the apartment has comfortable temperatures (23.53%). A minority of 6% avoided the apartment because they feel too cold in their homes. 15% of the residents also mentioned that the apartment is too hot in summer. This question refers to the circumstance that energy poverty concerns not only cold homes but too hot apartments that cannot be cooled down.[217] To conclude, although overall housing satisfaction is high (88%), households also indicated the need for housing quality improvements due to too cold or too hot[218] indoor temperatures.

Agreement to the Statement	In %	Frequency
Because of problems in the apartment, I have the intention to move out.	11.94	24
I am often not in the apartment because it is too cold.	5.94	12
Sometimes it's too hot in the apartment.	15.08	30
The apartment has comfortable temperatures.	76.47	156
Overall, I am satisfied with my apartment.	87.79	187

Table 21 Subjective Indicators Concerned with Satisfaction in the Not Retrofitted Sample (Source: Case Study Results). Note: Percentages Indicate Agreement to the Statements. 4-point Likert Scale Was Recoded to Binary Agreement/Disagreement Variable.

A Spearman's rank-order correlation was performed to determine the relationship between various housing faults, being able to reach preferred temperatures at home, having the intention to move out because of housing problems, avoiding the apartment because it is too cold, and general dwelling satisfaction in not retrofitted buildings. Results are provided in Table 22.

Agreement to the Statements	V1	V2	V3	V4	V5
V1: Presence of housing faults	1.00				
V2: Inadequate warmth of apartment	0.23**	1.00			
V3: Problems in the apartment; intention to move out	0.33***	0.36***	1.00		
V4: Often not in the apartment because it is too cold	0.24***	0.43***	0.55***	1.00	
V5: Satisfaction with my apartment	-0.33***	-0.36***	-0.49***	-0.37***	1.00

Table 22 Spearman Correlation Results with Housing Faults (Source: Case Study Results). N: 193.

The effect sizes r_s range between 0.23 and 0.55 and express medium to large statistically significant associations (Funder and Ozer, 2019). There is a negative association between satisfaction with the apartment and variables indicating that if a household is satisfied with the flat, housing faults are less likely reported, or the household has the intention to move out or cannot reach its preferred temperatures at home. Housing faults, on the contrary, are positively associated with an inadequate warmth of the apartment, the avoidance of the apartment because of cold indoor temperatures, and associated problems and the intention to move out.

217 The item “The apartment it is sometimes too hot” was included after the pre-test as residents complained about the lack to cool down dwellings during hot waves in summer. Wiener Wohnen forbids air conditioning that need to be drilled as they affect the façade insulation.
218 The expert from the CARITAS stressed too hot weather events resulting in high electricity bills in the following way: “But we also often have cases where there is simply no awareness that electricity costs so much because it is sometimes cheaper in other countries. And that is why there is often no awareness that one should simply use the resource sparingly” (I6).

Reasons Not to Heat All Rooms

Households were asked to indicate their level of agreement to statements giving different motivations not to heat all rooms (see Figure 35). Differences between the retrofitted and not retrofitted sample are also inspected. Overall, most households indicated that their rooms have a pleasant room temperature and that the warmth distributes well to other rooms. The retrofitted sample demonstrates slightly higher levels of agreement, potentially due to the increased energy efficiency resulting from the retrofitting process. The samples differ with regard to cost-saving measures, as 69% of the non-retrofitted sample restrict energy usage for money-saving reasons compared to 55% in the retrofitted sample. In the retrofitted sample, around 60% of households report using energy for heating out of energy-saving considerations rather than economic factors. Roughly half of the sample does not heat all rooms due to habit, while energy and cost-saving reasons are more significant motivators for this behavior (range 45-49%). Structural issues are a reason for non-heating in 27% of non-retrofitted households, compared to only 15% in the retrofitted sample. These findings suggest that self-imposed energy restriction can lead to deprivation and add pressure to already materially deprived households.

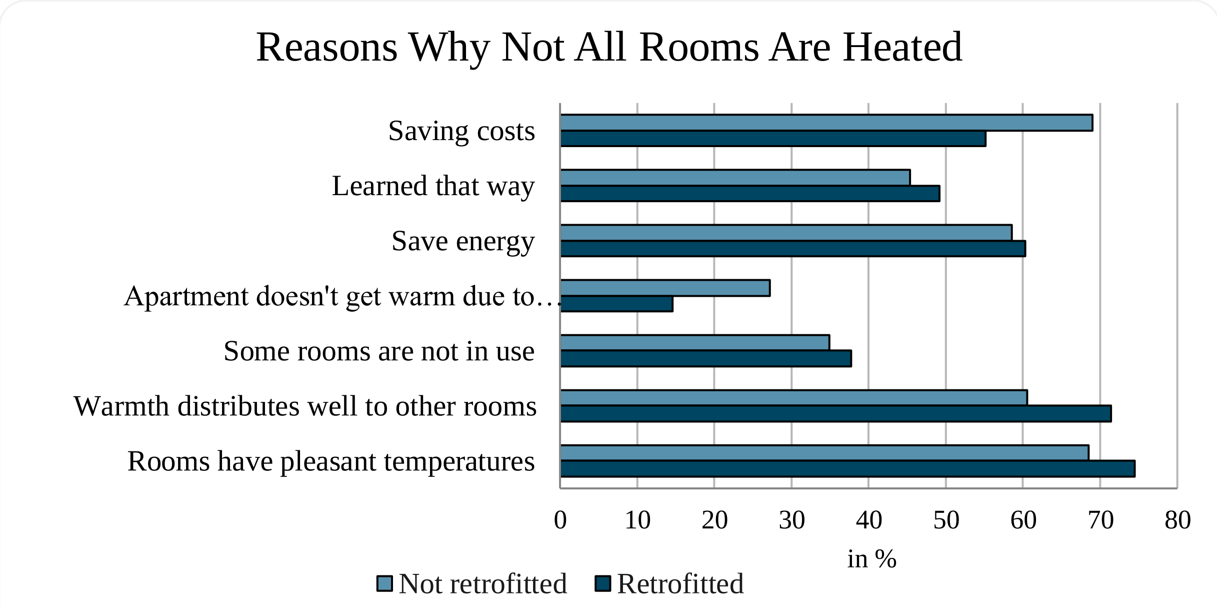


Figure 35 Reasons for Not Heating All Rooms (Source: Case Study Results)

In addition, a chi^2 test was performed for all items to understand whether there are statistically significant differences between the motivations of residents in retrofitted and not retrofitted social housing. A statistically significant result was found for cost saving motivations. Across all inspected variables, in the not retrofitted sample, this is the main motivation not to heat all rooms ($chi^2(1) = 5.8$, $p < .05$). A further significant difference between the retrofitted and not retrofitted sample is found for building related issues and the problem that the apartment doesn't get properly warm. More households report this problem in the not retrofitted than in the retrofitted sample ($chi^2(1) = 5.9$, $p < .05$). We have reasons to belive that the not retrofitted sample has lower energy efficiency so that residents are worried about their energy costs.

10.1.3 Housing Conditions After Retrofit

When asked about housing improvements after the retrofit, the majority of households reported significant progresses to home conditions. Figure 36 indicates that the insulation of the building envelope/ facade, leaky windows, cold outer walls, and leaking roof substantially enhanced after the retrofit: housing quality increased by 74%, 73%, 74%, 69%, and 64%, respectively. It is noteworthy that exactly the areas that have been objected to the most in the not retrofitted sample have been upgraded. It is also apparent that very few households reported that housing conditions got worst after the retrofit. The answers also indicate that the heating system did not improve substantially and remained its status quo. This stems from the fact that the heating system exchange is not part of the retrofitting process at Wiener Wohnen (see chapter 8.5). Cold floors have not improved substantially, as 21% report that they stayed poor as before the retrofit.

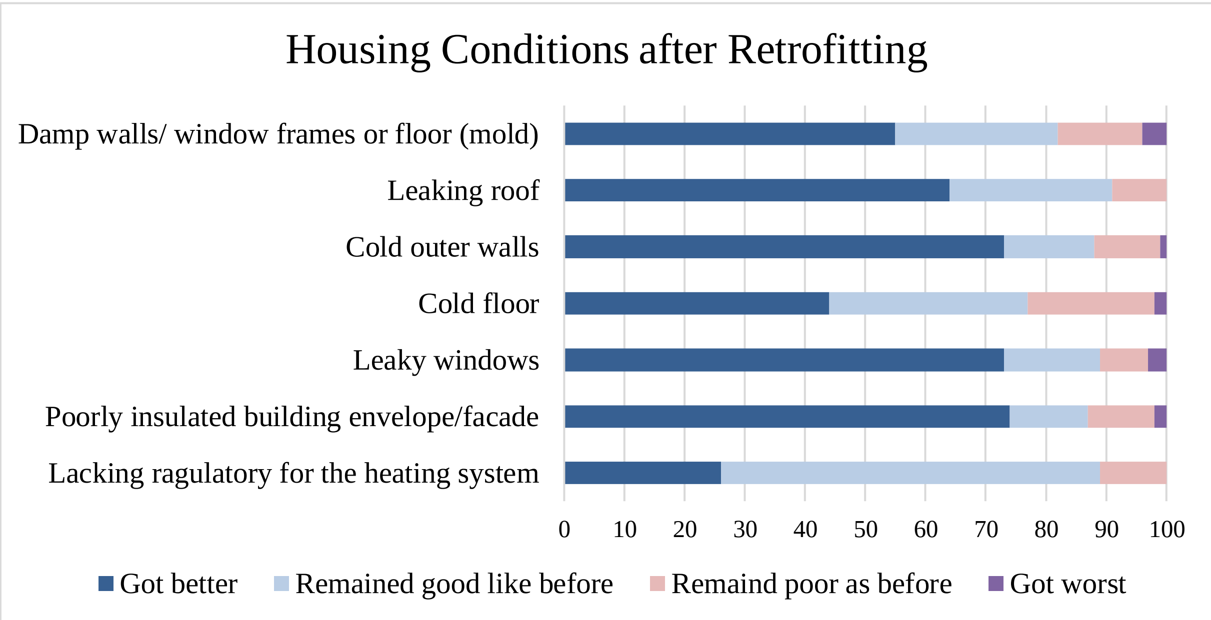


Figure 36 Building-Related Changes After the Retrofit (Source: Case Study Results)

Moving on to inspect further subjective indicators that summarise general satisfaction with the dwelling after the retrofit, we can conclude that 92% of the households in Viennese social housing are overall satisfied with their retrofitted dwellings and 77% perceived an improvement of their homes. 81% perceive more pleasant temperatures than before the retrofit, which points to temperature satisfaction after the retrofit. These results show that most households appreciate the outcome of the retrofit as indicated by the satisfaction with the apartment (see Table 23).

Agreement to the Statement	In %	Frequency
Due to retrofitting problems I have the intention to move out	7.98	13
Overall, I am satisfied with my retrofitted dwelling	92.18	165
My dwelling has improved since the retrofit	77.33	133
Since the retrofit, the apartment gets too hot	23.39	40
The temperatures in my apartment are more pleasant than before the renovation	80.70	138

Table 23 Dwelling Satisfaction in the Retrofitted Sample (Source: Case Study Results). Note: Agreement to the Statements on a 4 -point Likert Scale: Recoded to Binary Agreement/Disagreement.

This result is in line with other research on renovation programmes (Ambrose and McCarthy, 2019; Grey et al., 2017; Palm et al., 2020; Rau et al., 2020; Walshaw, 2011). Nevertheless, the downside is that 8% of the households have the intention to move out because of housing related problems. Recent energy poverty research directs not only to unpleasant perceived feelings of coldness, but also the inability of indoor cooling during hot waves (Thomson et al., 2019). In this study of retrofitted buildings, 23% of households reported their homes became too hot during the summer.

10.1.4 Examining Hidden Energy Poverty of Social Housing Residents

The Energy Poverty Advisory Hub defines hidden energy poverty as the share of the population whose absolute energy expenditure is below half the national median. The monthly energy expenditure threshold is €58.5 in 2019, as the EU-SILC 2019 median is €118 per month (see Table 24). In the case study sample, the average median energy expenses are €120 and are roughly in line with the EU-SILC median. In 2015, judged by the low absolute energy expenditure indicator M/2, 14.6% of all Europeans were hidden energy poor (EPOV, 2021b). Considering the EPOV indicator of hidden energy poverty, the case study sample of the not retrofitted houses deviates by 5% points from the EU-SILC shares. The hidden energy poor in the case study amounts 21% (equivalised) while the EU-SILC analysis in social housing and in the general population is approximately 15%. The difference is likely due to the bias in the traditional calculation of the hidden energy poverty index, as energy efficient houses are included in the analysis (Eisfeld and Seebauer, 2022).

	Case Study Social Housing in Vienna 2019	EU-SILC Social Housing in Vienna 2019	EU-SILC Austria 2019
Median Utility Costs (heating and electricity)	€120	€93	€118[219]
Hidden Energy Poverty Share	21.31%	15.63%	14.55%
Total N	183	288	5.836

Table 24 Hidden Energy Poverty Indicator. Median Utility Costs Have Been Equivalised (Source: Case Study Results).

10.2 Alternative Indicator for Measuring Hidden Energy Poverty

This sub-chapter proposes a novel entry point to approach hidden energy poverty for the not retrofitted subgroup of social housing residents in Vienna. In sub-chapter 2.9, it was highlighted that subjective and objective energy poverty indicators have flaws as no typically applied energy poverty indicator includes possible under-consumption behaviours. This chapter shall illustrate that excluding self-restrictions from the understanding of energy poverty implies overlooking households at risk and potentially incurring misidentification in policy strategies. Moreover, self-restricting on energy can undermine energy costs and expenditure-based indicators of energy poverty. Although several qualitative studies reported self-restriction strategies among households in the EU MS, the major challenge is its identification (Antepara et al., 2020). Florio and Teissier (2015) highlighted the challenge of identifying energy self-restrictions with lower than average real expenditure on energy and Palma et al. (2019) referred to possible underconsumption strategies in a case study on energy performance gaps. However, biases in the calculation of energy performance gaps occur due to theoretical (e.g. inaccuracy of occupant behaviour modelling, inputs and assumptions for buildings modelling, or climate data) and actual (e.g. execution of the work, non-optimal use by the occupants, measurement system limitations, malfunctioning equipment) deviation causes (Cozza et al., 2021).

To overcome the flaws of the expenditure focused hidden energy poverty indicators, an alternative way to capture hidden energy poverty is proposed. This indicator focuses on household's ways to avoid high energy costs. The proposed indicator focuses on thrifty energy strategies by including a behavioural dimension into the analysis. This alternative classification overcomes the drawbacks of existing income-based indicators and makes justice to the call to

219 Negative expenditure data with no observations was reported. While there are possible explanations for these negative income values (e.g. due to debt service exceeding annual income) or zero values for energy expenditure (e.g. if energy costs are included in the rent), it is not possible to trace back the origin of these anomalies. For the calculation of indicators, observations with negative values on either one or both of the two variables were deleted (Thema and Vondung, 2020).

employ multiple energy poverty indicators. It should, however, not be used as a stand-alone metric but in a conglomerate with the typically employed indexes.

Procedure

LCA allocates individuals into mutually exclusive and exhaustive subgroups, each subgroup comprising households similar to members of the same subgroup and dissimilar to households in other subgroups. Nine energy self-restricting behaviours were used initially for the LCA. Each item consists of statements to which the household indicates their level of agreement on a 4-point Likert scale (1-strongly disagrees; 4-strongly agree). Similar to previous applications of these LCA methods, items were dichotomised for the analysis to enhance convergence of the models and the interpretability of the findings. All indicator variables were (re-)coded with higher scores reflecting agreement on the item. Semantically reversed items were purposefully used in the survey to avoid acquiescence bias.

The expectation–maximization algorithm was used for the model estimation. According to common LCA procedure, if a priori hypothesis on the number of latent classes is not available (Masyn, 2013), the estimation with the number of latent classes is increased stepwise until the best-fitting model is identified. It is advised to gradually increase the number of classes one by one until the model fails to converge or the results no longer make sense. A one-class model serves as a baseline to obtain the endorsement probability (Nylund-Gibson and Choi, 2018).[220] A series of multiple models with an increasing number of classes to find the model that provided the best fit to the data was fitted. Variables that had low inter-class homogeneity and not a sufficient class separation were removed.

220 To ensure that the maximum likelihood solution was correctly identified, for the two- to five-class model estimation, 50 starting values and 100 iterations ensure initial random class assignments to avoid local maxima in determining likelihood parameters. Latent class models with logit indicators can fail to converge if the intercept hits + or -15 - that corresponds to a probability of nearly 1 or nearly 0.

10.2.1 Results of the Latent Class Analysis

Table 25 illustrates variables that were included in the LCA. The main descriptive statistics with means (M) and standard deviations (S.D.) are reported in the table. Of all nine self-restricting energy behaviours, most respondents reported: (i) *using the heater less often in transition periods* (M:3.2; SD: 0.85), (ii) *heating in everyday life and being conscious about it* (M:2.98; SD: 1.04), and (iii) *trying not to heat long (half a day) on high temperatures (over 23 °C)* (M:2.88; SD:1.04). Conversely, '*sitting next to the radiator to stay warm when it is cold outside'* was found to be among the least frequent behaviours among social housing residents (M:1.86; SD: 1.0). Few households reported '*turning off the heating when leaving the apartment'* (M: 1.98; SD: 1.12). Overall, results indicate high variability in the responses, which points to heterogeneity in the degree to which households employ energy self-restricting behaviours. Therefore, more than one class solution in the LCA was expected.

Item Wording	Mean	SD	N
1. Sitting next to radiator if cold to keep warm	1.86	1.01	199
2. Turning heater off when leaving the apartment	1.98	1.12	189
3. Not paying attention to costs when heating*	2.60	1.04	198
4. Pullover first before turning radiator on	2.46	1.18	194
5. Turn radiator on in the night if I am cold*	2.48	1.18	199
6. Closing doors between heated and not heated rooms	2.57	1.22	209
7. On cold days, I am heating longer (half a day) on high temperatures (over 23 degrees)*	2.88	1.05	189
8. I use the heating in my everyday life without thinking about it*	2.98	1.04	198
9. Heating as less as possible in transition periods	3.2	0.86	208

Table 25 Descriptive Statistics of Energy Self-Restriction Items
(Source: Case Study Results). Note: Items Indicated With * Have Been Semantically Reversed to Balance Out the Scale Direction. Original Response 4-Step Likert Scale From 1=Strongly Disagree to 4=Strongly Agree. For LCA, Scale Steps Were Recoded to 0/1 with 1 Indicating Endorsement of Energy Restrictions.

10.2.2 Subjective Hidden Energy Poverty Indicator with Latent Class Analysis

Table 26 presents model fit criteria for the LCA models. As models comprising six or more classes are empirically under-identified and do not converge, they are omitted from the table. If the baseline model with one class provides an adequate model fit to the data, it would indicate that no LCA is necessary to distinguish between different classes (Magidson and Vermunt, 2004). However, the two-class model has significantly better fit than the one-class model with lower values of AIC (1249) and BIC (1286), which indicates that LCA is appropriate. The two-class model has the lowest BIC as benchmark index (Nylund et al., 2007), and performs better or equal than the other models on the LL, AIC and SSABIC goodness-of-fit criteria. Inspecting the estimated latent class intercepts, none show abnormally high or low intercepts of values below or above 15 (see Appendix C Table 43). Hence, we have further reason to believe that the two-class model is “identified” and reasonable.

Number of Latent Classes	**LL**	**AIC**	**BIC**	**SSABIC**
1	-646	1302	1319	1303
2	**-614**	**1249**	**1286**	**1251**
3	-605	1244	1301	1247
4	-601	1249	1326	1253
5	-599	1252	1343	1257

Table 26 Model Fit Criteria of One- to Five-Class Models (Source: Case Study Results). Note: LL: Log-Likelihood; AIC: Akaike information criterion BIC: Bayesian information criterion; SSABIC: Sample-size Adjusted Bayesian Information Criterion; N=220.

Households’ average posterior probabilities provide information about how well the two-class model classifies households to their most likely class. Results indicate values above >.85, exceeding the >.7 threshold, and indicating well-separated classes, and low classification error (Nagin, 2005). Thus, the two-class model is selected as the best-fitting and most parsimonious solution.

<u>Interpretation help</u>: The assignment to the classes’ works in the following way: if for one household the estimated posterior probability is 75% and 35% for classes 1 and 2, respectively, this household would be assigned to class 1 based on higher probability. For item 3, for example, the estimated item probability of 0.81 means that 81% of the households in that class are likely to endorse that item and 19% of the respondents in that class are not likely to endorse that item. This item epitomises the first class because there is homogeneity in the responses to this item.

After identifying the best fitting model, posterior class probabilities are utilised to assign observed cases to the respective classes. The class probabilities are similar to factor loadings, as they provide the measurement structure that defines latent classes. Including all nine items in the first model estimations and inspecting the response patterns brought up surprising results: imprecise items have been identified based on class separation and homogeneity. The semantically reversed-coded survey items produced odd response patterns. This indicates that respondents had difficulties to answer the items. Multiple combinations with these items were estimated, but item probabilities yielded inadequate results. Therefore, they have been removed from the LCA analysis. From the nine items that have been included in the LCA, five items remained in the final model, as these items had a clear item separation.

Figure 37 facilitates comparison of the conditional response probabilities of the two classes. Each household is assigned to the respective class, where it has the higher estimated posterior probability. 56% of the sample are assigned to class 1, whereas 44% are assigned to class 2. Therefore, we can conclude that a substantial share of households engages in energy self-restriction activities.

Figure 37 Estimated Class Probabilities (left) and Conditional Responses (right) for Energy Self-Restriction for the Two Classes Resulting from LCA. (Source: Case Study Results). Note: The Y-Axis Represents the Item Response Probabilities for the Self-Restriction and Not Self-Restricting Class. The X-Axis Represents the Endorsement for each item; N=220.

Similarly to factor analysis, where the researcher names the estimated factors, in LCA the researcher also provides names to the classes based on the response patterns, and item probabilities. Table 27 shows conditional probabilities that households in class 1 and class 2 respond positively (agreement) to each item.[221] Class one members have overall a high probability of agreeing with positive statements and lowest probability of agreeing with negative statements (see Table 27). The marginal probabilities of agreeing with the statement are high for all questions, but particularly for putting a pullover first before turning on the heater (80%). This class can be called the "energy self-restricting" group. The second group is interpreted as follows: class 2 is larger than class 1 and considering the response patterns, households in this class less likely to act frugally. Class two members have low probabilities to endorse the items; or in other words, they have a low probability of responding positively to each item, as the probabilities are all lower than 0.5. Households in class two have high homogeneity because the response probabilities are less than ~0.35. Accordingly, this class can be labelled as the average 'neutral majority' class as the households are not apprehensive about heating practices at home.

221 Mean of the counterfactual conditional probabilities for each answer on each class.

Item Wording	Class 1 Self-Restricting	Class 2 Non Restricting
1. Heating that I am comfortable while paying attention to costs	0.62	0.29
2. Sitting close to the radiator to keep warm	0.56	0.03
3. Putting on a pullover instead of turning on the heating	0.81	0.26
4. Turning the heating off when leaving the flat	0.54	0.11
5. Closing doors between heated and not heated rooms	0.67	0.37
Class membership probability	**0.44**	**0.56**
Average posterior probability	**0.86**	

Table 27 Probability of Latent Class Membership (Source: Case Study Results). N=215.

At the item level, the results demonstrate satisfactory class homogeneity and class separation in the two-class models indicated by high endorsement (>0.5) within the self-restricting class, and low endorsement (<0.5) within the neutral majority class (see Figure 37 and Table 27). For all five items, the energy self-restricting class shows higher item endorsement rates than the neutral class.

Having determined the latent class model, associations between the two classes and other covariates of interest are examined. Covariates are included in LCA to answer typical questions such as “does the composition of the classes differ by socio-demographic characteristics” (Weller et al., 2020, p. 295)? Further analysis is carried out to understand which groups are most likely to be in the energy self-restricting group. Therefore, relevant socio-demographic and socio–economic variables enter the LCA as covariates in the latent class regression. The aim is to understand what explanatory variables are significant predictors of class membership.

10.2.3 Results of the Latent Class Analysis with Covariates

Often, it is useful to use descriptive statistics of socio-demographic- and economic segmentation patterns within the respective latent class in a simple bivariate cross-tabulation. One way would be simply to use the modal class assignment, then providing a cross-tabulation. However, this approach does not account for classification error, as the latent classes are unknown because they are estimated. Socio-demographic and structural building characteristics enter the LCA as covariates. With this approach, it is possible to account for the uncertainty of the predicted class membership in the regression model. Table 28 displays descriptive statistics that entered the LCA regression.

Covariates	Frequency	In %
1. Socio-Demographic Model		
Old (>65 years) women	58	26.73
Caring person or presence of sickness	28	15.00
Kids in household	41	18.64
Low income (<€1.400 per month)	179	37.99
Low education (compulsory and secondary school)	211	59.72
2. Structural Building Characteristics Model		
Inability to reach preferred temperatures at home	214	17.7
Presence of housing faults	219	75.00
Preferred higher temperatures at home > 23°C	217	22.3
Spending long hours at home (over 18 hours)	207	23.18
Year of construction before 1970	179	78.2
	Mean	
Number of heated rooms if cold outside	215	2.5
Household size	220	1.9

Table 28 Descriptive Statistics of Covariates Used in the Not Retrofitted Sample (Source: Case Study Results).

Table 29 presents the results of the LCA regression with class two (not self-restriction group) treated as the reference group. The coefficients from the multinomial logit regression output are the log odds of the probability of belonging to a given class compared with the probability of belonging to the reference class. Odds ratios were calculated manually by exponentiating the regression coefficients.[222] Gender, household size, rental contract before or after 1994, and the rent costs were excluded as insignificant predictors, also by comparing fit indices (BIC and AIC).

Energy Restricting Class	Coefficient and Std. Err.	Odds Ratios	95% Confidence Interval	P-value
Elderly (> 65+ years) x women	**-2.1*** (1.1)	0.12	-4.2 | -0.02	0.05
Sick	**1.88*** (0.96)	6.55	0.045 | 3.77	0.05
Children in household	**1.98*** (0.97)	7.24	0.87 | 3.88	0.04
Low income (<€1.400 per month)	**2.8**** (0.91)	16.44	0.96 | 4.6	0.01
Low education (compulsory and secondary school)	**-3.2***** (1.09)	0.39	-5.4 | -1.11	0.01
Constant	-0.67 (0.82)	-	-2.04 | 0.71	0.34

Table 29 Coefficients and Odds Ratios Results Being in the Self-Restricting Class (Source: Case Study Results). N = 148.

The log odds of being in the energy restricting class (compared with the reference class) is smaller for elderly women than for the rest of the sample (old and young men and younger women)($\beta = -2.1$; OR= .12; $p < .05$).[223] Severely ill households or households who take care of a person who has long-term illness are significantly more likely to be in the energy restricting class compared to the reference class ($\beta = 1.88$; OR = 6.55; $p < .05$). The presence of children significantly increases the odds by 7.24 times to be in the energy restriction class ($\beta = 1.98$;

222 Exponentiated β parameters are odds ratios, reflecting the increase in odds of class membership (relative to reference class) corresponding to a one-unit increase in the covariate.

223 Being a single parent was not included in the analysis due to insufficient sample size.

OR: 7.24; $p < .05$). Low household income increases significantly the odds by 16.44 of being in the energy restricting class compared to the neutral group ($\beta = 2.8$; OR = 16.44; $p < .01$). Having a compulsory or secondary school degree decreases the likelihood of being in the energy self-restricting class by 61% compared to having a higher degree ($\beta = -3.2$; OR = .39; $p < .01$).

Interpretation help: While it would not make sense to include age as an indicator of the latent class, as the latent class does not cause being old or young. However, it may influence responses to survey questions. For instance, household's age, being a woman or receiving a pension may affect certain response patterns. If, for example, it is hypothesised that older females are more likely to be in a specific class, is makes sense to consider age and gender as predictors of the latent class. In this way, age and gender do not influence any of the indicators directly. They are just predictors of which latent class you end up in.

Energy Self-Restricting Class	**Coef. and Std. Err.**	**Odds Ratios**	**95% Confidence Interval**	**P-Value**
Inability to reach preferred temperatures at home	**2.4*** (1.06)	11.02	0.33 | 4.4	0.02
Presence of housing faults	**3.1*** (1.55)	23.57	0.12 | 6.2	0.04
Preferred higher temperatures at home >23°C	1.72 (1.00)	5.58	-0.24 | 3.67	0.08
Spending long hours at home (> 18 hours)	-0.98 (1.00)	0.38	-2.95 | 1.00	0.33
Year of construction before 1970	5.95 (3.45)	383.75	-0.81 | 12.71	0.08
Number of heated rooms if cold outside	-0.80 (0.43)	0.45	-1.64 | 0.04	0.06
Household size	1.11 (0.60)	3.03	- 0.06 | 2.27	0.06
Constant	**-10.2*** (4.90)		-19,81 | -0.60	

Table 30 Estimated Coefficients and Odds Ratios of Being in the Energy Self-Restriction Class and Structural Building Characteristics Covariates (Source: Case Study Results). N=148.

Turning now to structural building characteristics presented in Table 30, households that cannot reach their preferred temperatures at home significantly more often are found in the energy restriction group ($\beta = 2.4$; OR = 11.02; $p < .05$). The presence of housing faults (e.g. cold floors, presence of mould) is a significant covariate for being in the energy restricting group ($\beta = 3.1$; OR = 23.57; $p < .05$). If the number of heated rooms increases, households less likely belong to the energy restriction group. This covariate, however, is just above the level of significance ($\beta = -0.80$; OR = 0.45; $p < .10$). With increasing number of people in the households, the more likely they belong to the energy restriction class. Also, this coefficient is not significantly different from zero ($\beta = 1.11$; OR = 3.03; $p < .10$). Spending long hours at home (>18 hours), the construction year of the building and high preferred temperatures at home are not significantly different from zero. The analysis identified two distinct behavioural patterns of possibilities for households to underconsume energy. This patterning helps to link an array of factors such as low income, low education, being severely ill, housing faults and the inability to reach preferred temperatures at home.

The next sub-section captures the limitations of typically employed energy poverty and income poverty indicators. The aim is to unveil false negatives that incorrectly allocate energy poor households who self-restrict to the non-energy poor group.

10.3 Intersections of Energy Self-Restrictions with Income Poverty and Energy Poverty

The two identified latent classes are intersected with established classifications of income poverty and energy poverty. Table 31 summarises the four combinations: the top left (a.) and bottom right (d.) quadrant indicates correct identifications, either by recognising self-restricting households as income or energy poor, or by considering not self-restricting households as not income or energy poor. The bottom left quadrant (c.) indicates the possible blind spot of current classifications and illustrates the share of households at risk of recognition injustice (shaded grey in Table).

	Self- Restricting	Not Self-Restricting
Energy Poor	*a.) Correctly identified (recognised by policy)* Disadvantaged households who are captured by current definitions. These households self-restrict their energy use to remedy their situation, but this does not suffice to lift them out of energy poverty.	*b.) Energy needs not curtailed (potential target group)* Disadvantaged households who are captured by current definitions and who might benefit from retrofitting subsidies and counselling how to decrease energy consumption, dependent on their specific energy needs and vulnerabilities.
Not Energy Poor	*c.) Blind spot (lack of identification)* Self-restricting households, who are overlooked in current definitions. Self-restricting may keep some of these households barely over the energy poverty threshold.	*d.) Correctly identified (aid to save energy)* Households who do not have any problem with heating expenses and with maintaining comfortable indoor temperatures.

Table 31 Intersection of Energy Poverty Self-Restricting Energy Behaviour (Source: Case Study Results).

These households do not appear as income poor or energy poor in the typically employed energy poverty statistics, but may be deprived because they self-restrict their heating needs potentially below their comfort level. The top right quadrant (b.) contains households who are income or energy poor but do not engage in energy self-restrictions. Group (b.) may have several reasons for their behaviour: they can still afford normal comfort levels; they have high energy needs (e.g. families with small children, old aged), they skimp on other basic services (heat or eat) or they do not (yet) consider the curbing of heating demand as a strategy to alleviate their situation. Depending on their specific needs and vulnerabilities, households in group b. might profit from targeted counselling on energy saving practices and retrofitting activities.

Table 32 applies this 2x2 matrix to seven different definitions of income and energy poverty. In most cases, the differences between the four quadrants are statistically significant at p< .05 according to Fisher's exact test. A substantial share of households that are captured by current poverty classifications apply self-restricting energy behaviours (quadrant a.). Despite their active effort to engage in thrifty behaviours and sufficiency strategies, self-restriction does not help lift these households' out of poverty.

Poverty Indicator	Categories	Self-Restricting	Not Self-Restricting	Fisher's Exact Test
Income poverty: Total income	Lowest quartile	50.9	49.1	p=.03
	Higher quartiles	33.8	66.1	
Income poverty: At risk of poverty	At risk	54.0	46.0	p=.006
	Not at risk	32.9	67.1	
Energy poverty: >10% energy costs	Energy poor	59.6	40.4	p=.001
	Not energy poor	40.4	59.6	
Energy poverty: 2M	Energy poor	34.6	65.4	p=.812
	Not energy poor	33.2	66.8	
Energy poverty: Cannot keep adequately warm	Energy poor	69.2	30.8	p=.001
	Not energy poor	36.0	64.0	
Energy poverty: Housing deprivation	Energy poor	47.3	52.7	p=.02
	Not energy poor	27.8	72.2	
Low-income high costs	Energy poor	48.6	51.4	p=.43
	Not energy poor	45.4	54.6	

Table 32 Intersection of Energy Self-Restriction, Income Poverty and Energy Poverty (cross-tabulation). (Source: Case Study Results). Note: Blind Spot Quadrant c. Shaded Grey. Table provides valid row wise percent and two-sided p levels in Fisher's Exact Test. Total income: Non-equivalised household income in the lowest quartile of the national income distribution, < €1,965 in 2019 (EU-SILC, 2019). At risk of poverty: Equivalised disposable income after social transfers below 60% of the national median, < €1,286 Euro in 2019 (EU-SILC, 2019). 2M: Equivalised energy expenditure (electricity and heat) is more than twice the national median of energy expenditures, €166.3 in 2019. >10% energy costs: Household spending more than 10% of its non-equivalised household income for energy services. Cannot keep adequately warm: Household agrees to the item: "cannot afford to keep home adequately warm". Housing deprivation: Household agrees to one of the seven following items: presence of 1. damp walls, rotten windows or floor (mould), 2. leaking roof, 3. cold outer walls, 4. cold floor, 5. leaky windows, 6. poorly insulated building envelope, 7. absent heating regulation.

Presumably, this group includes the households most severely affected by energy poverty, and it captures the multidimensional nature of energy poverty by focusing on unmet basic needs and deprivation. The cross-tabulation draws attention to a significant blind spot in current poverty classifications: across various poverty definitions, 30-40% of those not considered income poor or energy poor actually engage in self-restriction behaviours (quadrant c.). These households self-restrain their energy consumption below their comfort level to avoid excessive energy costs. Some of these households cut down on heating for other reasons than financial constraints.

The share of households that is income or energy poor and do not self-restrain (quadrant b.) ranges from 30 to 65%. This group might benefit from energy and financial counselling or nudges to lower energy consumption, exchange of energy inefficient devices, or, as is emphasised throughout the energy poverty literature, energy efficiency upgrades of their housing. However, energy-saving interventions should not conflict with the household's energy needs or vulnerabilities. Quadrant d. includes the largest group in both samples that neither is classified as energy poor, income poor nor employs self-restriction behaviours. Note that the study sample comprises predominantly deprived and low-income households[224], therefore, the counter categories (i.e. higher quartiles, not at risk, not energy poor) refer to the remainder of the study sample, not the general Austrian population.[225]

10.4 Conclusion

This chapter applied various energy poverty indicators to the case study of social housing residents in Vienna. Cost developments related to tenancy have been examined for retrofitted and not-retrofitted households. Households in the retrofitted buildings paid on average more for heating and electricity before the retrofit and less after the retrofit. Simultaneously, these households living in retrofitted flats reported a strong rent increase. However, in comparison, residents in the non- retrofitted sample reported, on average, higher rental costs than the retrofitted sample did. Applying Boardman's and LIHC expenditure-based indicator to the primary survey data, 30% and 24% of households are energy poor, respectively. Considering the consensual energy poverty indicator, 75% reported having at least one housing problem and 18% of the non- retrofitted households stated they cannot reach preferred comfort temperatures. Results suggest high housing satisfaction in the retrofitted (92%) and non- retrofitted apartments (88%). However, a substantive proportion living in the non- retrofitted flats reported unpleasant indoor temperatures (24%), signalling necessary structural building-related improvements. The hidden energy poverty indicator shows larger incidences in the not-retrofitted social housing, compared to EU-SILC incidences in the Austrian population.

This chapter also explored the potential of using self-restricting energy behaviour as an additional indicator of hidden energy poverty to counterbalance the pitfalls of expenditure-

224 The sample is characterized by a large proportion of low-income households: the equivalised median household income in the study amounts to €1133 per month, while in the Austrian population it was €2213 per month in 2019.

225 In order to neutralise potential objections of over-assuming the lines that households engage in these behaviours and limit their energy usage below comfort levels on order to keep costs down, Appendix C shows further validation reasons for self-restrictions.

based indices. Moreover, it aimed to understand how hidden energy poverty indicators might complement each other to give a more comprehensive picture of the *status quo* in energy poverty incidence. The most meaningful result of this chapter was obtained by applying the LCA, which indicated that 44% of the households used energy self-restriction behaviours. The cross-tabulation indicated that these hidden energy poor households are often incorrectly captured as non-energy poor. Therefore, the research question "*do households use self-restricting energy strategies that would characterise them as hidden energy poor households*" was answered.

The 'false negatives' that emerge from current energy poverty rates have a detrimental impact on policy, since many energy poor individuals are erroneously classified as non-energy poor. Including covariates in the LCA allowed to capture which households are more at risk of being 'hidden energy poor', in other words, of adopting energy self-restricting behaviours. Households who cannot reach comfort temperatures, and with housing faults, as well as those suffering from illness, on low incomes or with children at home have increased odds of being in this energy self-restricting class.

11. Quantitative Case Study Results – Multidimensional Energy Poverty Indicator

Given that many energy poor are misclassified as not affected by energy poverty, this chapter creates multidimensional energy poverty indicators (MEPI) using Alkire-Foster method. The proposed three indices apply to the case study of not-retrofitted social housing residents. The combined MEPI can account simultaneously for expenditure-based and consensual-based dimensions of energy poverty. The strength of the index lies in the consideration of at least two forms of energy deprivations and the behavioral dimension, which has yet not been applied to the Austrian setting or other contexts. Hidden energy poverty is, therefore, operationalized through energy self-restrictions and included in the MEPI generation. Although this primary survey data focuses on social housing residents in Vienna, the findings may also have broader implications for how energy poverty is studied in Austria and, more broadly, in the EU.

This chapter has three main objectives. The first is to develop a comprehensive measurement of multidimensional energy poverty by combining three measurements that capture different facets of deprivation. The second objective is to assess the extent of multidimensional energy poverty among social housing residents in Vienna and investigate its determinants. Finally, the chapter aims to contribute to the discussion of the socioeconomic and building-related factors that influence multidimensional energy poverty.

Sub-chapter *one* introduces the construction of the three MEPI's and presents the energy poverty rates for the primary survey data. Findings of odds ratio results of key determinants of social-demographic and building-related characteristics of energy poverty will be presented. The concluding sub-chapter *two* summarises the results of the analysis.

11.1 Multidimensional Energy Poverty in Not Retrofitted Social Housings in Vienna

Several authors have called for multidimensional indicators to measure energy poverty. Heeding to this call, three MEPI are created using Alkire-Foster method (Alkire et al., 2015). This method allows the identification of energy poverty by considering several dimensions where people experience deprivation. Based on the identified classes from the LCA, self-restriction behaviour is accounted for in the consensual-based MEPI. The final MEPI combines the consensual-based and expenditure-based energy poverty dimensions (Heshmati, 2019; Nussbaumer et al., 2012; Okushima, 2017; Olang et al., 2018).

In a first step, before constructing the consensual-based MEPI, Spearman's correlations were utilised to ascertain whether there is a statistically significant relationship between consensual (subjective) energy poverty dimensions (inability to reach preferred temperatures at home, presence of at least one reported housing fault and presence of self-restricting behaviour). Table 33 indicates that the correlation results were all significantly different from zero and ranged between .17 and .26, suggesting weak to moderate associations (Cohen et al., 2002). They also indicate that, while the chosen dimensions are interrelated and convey complementary information, they capture different aspects of subjective energy poverty. It is deemed acceptable to combine these three aspects into one indicator.

	V1	**V2**	**V3**
V1: Inability to reach comfortable temperatures	1		
V2: Presence of housing faults	.24***	1	
V3: Self-restricting energy behaviour	.26***	.17*	1

Table 33 Spearman Correlation Results for the Combined Subjective Energy Poverty Indicator (Source: Case Study Results).

The *first* subjective energy poverty index is constructed based on the three indicators presented in Table 33. All three indicators are assigned an equal weight because it is assumed that each measure is an important part of energy poverty. Following Sokolowski et al. (2020), it is argued that energy poverty deprivation in only one dimension many not indicate energy poverty as it may result from other circumstances or measurement error. Therefore, a more conservative and constrained indicator is chosen. The dual cut-off method outlined by Alkire et al. (2015) and Alkire and Apablaza (2016) shall indicate subjective energy poverty if a household is deprived in at least two of the three dimensions. A household experiencing deprivation in only one of the dimensions is not considered energy poor.[226] Based on the three binary indicators, the cut-off is 0.66 as all three dimensions are equally weighted and two dimensions must be present to be classified as energy poor (2 x 0.33). Combining these conditions on the not retrofitted sample in social housing in Vienna, 40.4% of households are considered subjectively energy poor.[227]

The *second* MEPI is generated based on the expenditure energy poverty variables (equal weighting): a household is identified to be energy poor if it has low income and high energy

226 For detailed information on how to implement this methodology in STATA please see Pacifico and Poege F. (2017). Note that households with missing values are excluded from the estimation sample.

227 Please note that the subjective indicator did not contain the variable "inability to pay utility bills". Ideally, this indicator would include arrears on utility bills, as typically employed in the EU-SILC questionnaire.

costs (LIHC)[228] or it spends more than twice the median for actual energy expenditures (2M).[229] According to this expenditure- based MEPI, 28.2% of social housing residents in Vienna are energy poor.

A *third* and final indicator constitutes a combination of the two expenditure-based indicators and three subjective energy poverty indicators. It indicates energy poverty if households are deprived on at least two of these five indicators (the cut-off is .4 as each dimension has an equal weight of .2). The results show that half of the sample would be considered multidimensional energy poor (51.3%). Figure 38 summarises the descriptive statistics for the multidimensional energy poverty indicators.

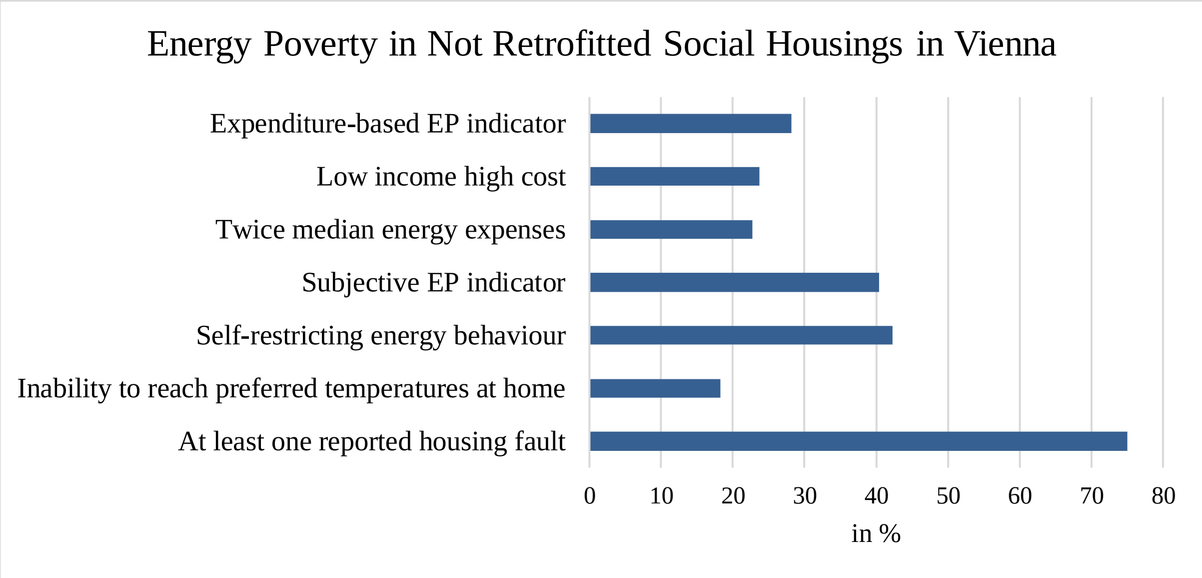


Figure 38 Energy Poverty Indicators. Inability to Reach Preferred Temperatures (Source: Case Study Results). N = 214; Presence of Housing Faults N = 219; Energy Rrestricting Ggroup N = 220; Twice Median Energy Consumption N = 183; Low-income High Cost N = 156; Subjective EP N = 213; Expenditure-Based EP N = 156; Composite EP Indicator; N= 154

11.1.1 Multidimensional Consensual-Based Energy Poverty

Once composite energy poverty indicators have been developed, socio-demographic and structural building characteristics are determined. The analysis is based on odds-ratio calculations. Table 34 summarises the results of the analysis.

228 Low income, high costs (LIHC): a household is classified as energy-poor if it fulfils two criteria simultaneously: high actual energy expenditure and a low income.

229 High share of actual energy expenditure in income (twice of the equivalised median): a household is classified as energy-poor if its percentage of population/ households whose share of (equivalised) energy expenditure in (equivalised) disposable income is above twice the national median share of energy in income. This analysis is based on EU-SILC estimations (reference year 2019). Household energy expenditure is the sum of spending on electricity and heat. Annual equivalised Austrian median energy costs (electricity and heating) were €998. Hence, twice the monthly median energy expenditures threshold was €166 (own calculations based on EU-SILC).

Socio-demographics: results indicate that households at risk of poverty (OR: 3.27, $p < .001$) or where the head of the household is not in work or receives unemployment benefits (OR: 2.34, $p < .05$) are more likely to be energy poor. Having children increases the risk of being energy poor in social housings (OR: 2.88, $p < .01$). Households with low educational attainments (OR: .49), where the head of the household is older than 65 (OR: .26) or a woman older than 65 (OR: .37) are significantly more likely **not** to be energy poor on the subjective indicator ($p < .05$). This is a surprising result, as the hypothesis based on the literature review suggested the opposite to be true. Prior studies have shown that women, old aged women or households that experienced a critical life event in the last 12 months are more likely to experience energy poverty (Healy and Clinch, 2004; Fizaine and Kahouli, 2019). These results were not significantly different from zero and the hypotheses cannot be accepted for the subjective energy poverty indicator ($p > .05$).

Structural building characteristics: disagreement with the statement “I’m not heating all rooms because some rooms have a pleasant room temperature anyway” (OR: 3.94, $p < .001$) increases the odds of being energy poor on the subjective energy poverty index. Also, not heating all rooms because the apartment does not get warm due to structural reasons increases significantly the odds of being subjectively energy poor (OR: 5.51, $p < .001$). If the household moved in the social housing after 1994 (rental contract signed after 1994 leading to higher rental costs), the odds of being energy poor on the subjective indicator increases (OR: 2.8, $p < .01$) compared to households that live longer in the dwelling. Living on the top floor significantly increases the odds of being energy poor (OR: 2.01, $p < .01$). However living on the first floor (suggesting that households may have colder floors) does not have a significant effect of the likelihood of being energy poor. Living in an older building that was built between 1931 and 1960 (higher probability that it features bad energy ratings) increases the odds of being energy poor on the subjective indicator (OR: 2.23, $p < .05$). Other hypothesised variables, such as the square meter surface area of the dwelling, higher preferred temperatures (> 23°C), being at home for longer hours overall (> 18 hours), or numbers of rooms are not significantly different from zero. The heating system does not have a significant effect on the emergence of energy poverty rates, also using an alternative heating system to gas or district heating, such as an electric heater, has not an increasing effect to be energy poor.

11.1.2 Multidimensional Expenditure-Based Energy Poverty

Socio-demographics: results indicate that women (OR: 3.10, $p < .01$), households receiving unemployment benefits, means-tested guaranteed minimum income or housing allowances (OR: 2.5, $p < .05$), households that experienced a critical life event in the last 12 months (OR: 3.61, $p < .001$), households at-risk-of-poverty (OR: 7.58, $p < .001$), households with low educational attainment (OR: 2.78, $p < .05$), single headed households, and women aged over 65 (OR: 2.51, $p < .05$) have higher odds of experiencing energy poverty. Compared to the subjective energy poverty indicator, insignificant results are found for older households compared to households that are younger than 65, and having children at home ($p > .5$).

Structural building characteristics: similar to the consensual–based energy poverty indicator, the older the year of construction of the building, the higher the odds of being energy poor (OR: 4.37; $p < .1$). No other structural building characteristic differs significantly from zero. Hence, when comparing the expenditure-based indicator with those determined based on the subjective indicator, the results indicate strong differences mainly regarding socio-demographics.

11.1.3 Combined Multidimensional Energy Poverty Indicator

Socio-demographics: critical life events (OR: 4.60, $p < .001$), and the at-risk-of-poverty (OR: 5.87, $p < .001$) increase the odds of being energy poor. Household members over 65 years have a *decreasing* odd of being energy poor (OR: .50, $p < .05$). Single households and receiving unemployment benefits are close to the significance line to be energy poor.

Structural building characteristics: living on the top floor (OR: 2.32, $p < .05$), in an old building build before 1960 (OR: 5.35, $p <.01$), and if households moved in the dwelling after 1994 (OR: 3.35, $p < .01$) significantly increase the odds of being energy poor. Also, households that responded that they do not heat all rooms because the apartment does not get warm because of structural reasons (OR: 3.57, $p < .01$), and the disagreement to the statement that not all rooms are heated because they have a pleasant temperature increases the odds of being energy poor. While square meters and number of rooms were not significant in the other two indicators, here a larger apartment size (OR: .96; $p < .001$) and an increasing number of rooms (OR: .62, $p < .01$) significantly decreases the odds of being energy poor.

	Consensual-based energy poverty		Expenditure-based energy poverty		Composite energy poverty indicator	
	Odds ratios	95% CI	Odds ratios	95% CI	Odds ratios	95% CI
Socio-demographics						
Old aged >65	.26***	[.14 – .48]	1.17	[.58 – 2.38]	**.50***	**[.26 - .96]**
Sex = Female	1.11	[.63 – 1.99]	**3.10****	**[1.32 –7.30]**	1.36	[.70 – 2.66]
Children between 0-17 years	22*	[1.11 – 4.41]	.41	[.13 – 1.26]	1.36	[.58 – 3.19]
Unemployment benefits or means-tested minimum income or housing allowances	**2.34***	**[1.18 – 4.65]**	**2.5***	**[1.10 – 5.81]**	**2.32***	[.98 – 5.52]
Critical life events	1. 73	[.88 – 3.40]	**3.61*****	**[1.65 – 7.92]**	**4.60*****	**[1.94 – 10.93]**
At risk of poverty	**3.27*****	**[1.73 – 6.21]**	**7.58*****	**[3.11 – 18.49]**	**5.87*****	**[2.93 – 11.77]**
Low education (compulsory and secondary school)	**.49***	**[.27 – .86]**	**2.78***	**[1.24 – 6.22]**	.544	[.28 – 1.06]
Old aged >65 women	**.37****	**[.18 – .74]**	**2.51***	**[1.18 – 5.32]**	.80	[.39 – 1.64]
Single household	1.14	[.66- 1.96]	**2.5***	**[1.22 – 5.16]**	1.79	[.95 – 3.40]
Structural building characteristics						
Not heating all rooms because some rooms have a pleasant room temperature anyways*	**3.94*****	**[1.95 –8.00]**	1.91	[.78 – 4.71]	**4.51*****	**[1.87 – 10.86]**
Not heating all rooms because the apartment doesn't get warm due to structural reasons	**5.51*****	**[2.38 – 12.77]**	1. 17	[.64 – 4.61]	**3.57****	**[1.36 -9.38]**
Preferred higher temperatures at home > 23°C	1.26	[.65 – 2.43]	1.86	[.83 – 4.16]	1.42	[.66 -3.11]
Longer than 18 hours per day at home	.74	[.38– 1.42]	1.17	[.53 – 2.56]	.84	[.40 – 1.73]
Square meters	.99	[.97 – 1.00]	.98	[.96 –1.01]	**.96*****	**[.94 - .98]**
Number of rooms	.68	[.59 – 1.08]	.89	[.62 – 1.26]	**.62****	**[.43 - .89]**
Year of construction						
1931 - 1960	**2.23***	**[.98 – 5.07]**	**4.37****	**[1.18 – 16.08]**	**5.35****	**[1.98 – 14.48]**
1961 – 1970	1.30	[.52 – 3.21]	2.52	[.62 – 10.15]	2.35	[.82 – 6.74]
1971 – 1990 (reference category)						
Moved in after 1994	**3.50*****	**[1.92 – 6.46]**	1.32	[.63 – 2.75]	**3.35****	**[1.70 – 6.64]**
Heating system						
District heating (reference category)						
Gas	1.20	[.63 – 2.27]	.99	[.44 – 2.21]	1.66	[.80 – 3.44]
Other (e.g. electric heating)	1.03	[.48 – 2.19]	1.22	[.48 – 3.12]	1.54	[.64 – 3.70]
Floor level						
First floor	1.10	[.51 – 2.40]	1.73	[.67– 4.42]	1.71	[.69 – 4.22]
Middle level (ref.)	-	-	-	-	-	-
Top floor	**2.01***	**[.96 – 4.25]**	1.23	[.50 – 3.04]	**2.32***	**[.98 -5.50]**

Table 34 Multidimensional Energy Poverty Indicators. (Source: Case Study Results). Odds Ratios Note: * Item was semantically reversed; critical life event in the past 12 month subsumes birth of a child, severe sickness, death of a households member, divorce, caring responsibilities.

11.2 Conclusion

The findings from the quantitative research indicate that energy poverty exhibits variations and does not follow a uniform pattern. he survey results underscore the challenge of identifying and defining typical energy-poor households in social housing. The subjective energy poverty measure yielded a notable finding that many households experience housing faults, underscoring the need for housing renovation and retrofitting programs. The determinants of energy poverty vary across different MEPI, emphasizing the importance of addressing the limitations of relying solely on one approach to measure energy poverty. This chapter presented the analysis of the relationship between a range of socio-demographic and building-related variables and the multiple dimensions of energy poverty at the household level. The findings offer compelling evidence that social-demographic and building-related factors play a significant role in determining the levels of household energy poverty in non-retrofitted social housing in Vienna. The odds ratios from different indicators revealed a high prevalence of energy poverty among income-poor households and those at risk of poverty. Having experienced a critical life event also had an influence on being energy poor. Remarkably, and in contrast to consolidated research, older people experienced less energy poverty and gender was only significant when considering the expenditure-based indicator. This result differs from the EU-SILC analysis in this thesis. Studies show that there is a substantial mismatch between the results of expenditure-based indicators of energy poverty with those based on subjective self-declared indicators (Healy, 2003a; Hills, 2012a; Kempson et al., 2004). Therefore, policies that seek to ease energy poverty should be multidimensional, comprehensive, and consider energy poverty differences across subgroups. This conclusion aligns with the argument proposed by Fizaine and Kahouli (2019), who argue that the choice of indicator impacts the identification of the target population.

Finally, it can be concluded that there are high levels of energy poverty in not-retrofitted social housing in Vienna, which oscillate between 28.2% and 51.3%. For future research, it is advised to include energy restrictions as an additional dimension related to energy efficiency in respective public statistics and surveys to better understand and trace energy poverty over time. The objective of this research was twofold: to introduce a novel approach to measure energy poverty and to enhance the conventional energy poverty indicators by utilizing the Alkire-Foster method. This approach is more restrictive than the typical composite indicators because as it requires a minimum of two deprivation dimensions to be met.

12. Testing the Paths to Explain Energy Behaviours for Social Housing Residents in Vienna

This chapter summarises the results of the structural equation models (SEM) to explain household energy behaviours in the social housing context. Within this data analysis process, it is the aim to examine the different relationships in the model to determine whether the constructs are significantly and directionally related, as predicted by theoretical hypotheses. The primary survey data of not-retrofitted and retrofitted buildings will be utilised for this analysis. Each of the structural models illustrates the relationships between latent variables based on the hypotheses derived from the extended TPB presented in chapter 3. Next to the main energy poverty drivers outlined in the previous analysis, this chapter aims to understand the main psychological determinants of energy restriction behaviours. This endeavour, however, bears a trade-off, as explaining energy behaviour is complex and likely driven by multiple causal factors. Hence, the models presented in this chapter cannot fully include realistic and application-oriented models that depict interdependencies between the influencing factors. The proposed integrated theoretical framework of the research is grounded on the theory of planned behaviour ("TPB") by extending it with additional constructs, i.e. habits, housings faults. Following the two-step approach provided by Anderson and Gerbing (1988), Confirmatory Factor Analysis ("CFA") and SEM was employed, with model fit assessed utilising fit indices as suggested by Hair et al. (2014) and Marsh et al. (2004). The main objectives of this chapter are:

- to estimate a structural model that provides an understanding of energy behaviours
- to identify the predictors of energy restriction behaviours and rebound behaviours
- to examine the relationships between psychological determinants and energy restriction behaviour, and rebound behaviours.

The sub-research question asked about the relevant psychological factors which determine how dwellers in social housing in Vienna behave in terms of their energy use. Therefore, the question *do attitudes, social norms, perceived behavioural control, housing faults and habits influence energy restriction behaviours* shall be answered.
After estimating the measurement model (CFA) in a first step, the chapter presents the SEM results of the not retrofitted sample (structural model 2 + 3) following the estimation results of the retrofitted sample (structural model 4 +5). This involves specifying the structural model that

identifies the paths between the various latent constructs. Throughout the sub-chapters, the fit indices are evaluated, followed by a discussion of the results of the path coefficients. The chapter ends by presenting and discussing the main results of the analysis.

12.1 Results of the Confirmatory Factor Analysis

CFA results for the retrofitted and not-retrofitted social housing residents indicate how well the observed items represent hypothesised latent constructs. Only the base measurement model containing all items that were asked in the retrofitted and non- retrofitted survey is presented in this sub-chapter. CFA estimation results for the other measurement models can be found in Appendix D.[230] Items with low factor loadings (< .40) were excluded from the analysis. According to Hair et al. (2014), a standardised factor loading should be .40, ideally .70 or higher, providing strong evidence of convergent validity. In this study, all the items were found to be significant (all t values at p = .01 level), and had significant factor loadings -most of them greater than .50- confirming the convergent validity of the measurement models. The visualisations include results of the model fit and standardised regression weights to allow for direct comparison across parameters.[231] General model fit (supporting the structure of the factor model and thus the basis of any validity issues) reflects the quality of the assignment of items to factors. Some of the latent constructs did not reach the conventional cut-off value of Cronbachs $\alpha = .80$, and therefore the reliability will be further investigated with CFA as part of the structural equation modelling analysis. According to Said et al. (2011), this approach has been found to give more reliable and valid results than Cronbach's alpha.

When applying the goodness-of-fit indices, the measurement model was found to be parsimonious (see Figure 39). For the joint sample, containing the latent constructs attitudes, subjective norms, external and internal perceived behavioural control and intentions (five constructs), the following model indices have been obtained: the chi-square goodness-of-fit test result was not significant, $\chi^2(67) = 105.25$, $p < .002$. This suggests that the model is an acceptable fit to the data. The SB-RMSEA = .05 signalled an acceptable fit and the pclose = .21 was not significant, indicating that RMSEA is not greater than .05. The incremental fit indices (SB-CFI = .94 and SB- TLI = .91) were greater than the recommended value of .90 and

230 Appendix D shows full SEM path results and descriptive statistics of the observed items used in the SEM models.

231 The graphical output with standardized factor loadings is more common and was chosen to visualize results. Throughout the chapter, item loadings and coefficient results of the latent variables are not included to simplify the presentation. Please see Appendix D.

indicated a well-fitting model. Similarly, the SRMR was .06, which is less than .10, suggesting a good fitting model. The overall goodness-of-fit is $R^2 = 99.3\%$. These findings suggest that the model fit is acceptable and meets all key fit criteria. The proposed measurement model fits the observed data because all goodness-of-fit measures fall within, or are better than, the recommended acceptable threshold levels.

Figure 39 illustrates the CFA for the basic measurement model with standardised factor loadings. The following latent independent factors attitudes, social norms, and internal and external perceived behavioural control are examined. High factor loadings confirm that the indicators are strongly related to their associated factor. The z-values for all factor loadings of the items were significant ($p< .01$), except for the latent construct social norms (.45) (Hair et al., 2014). As the measurement model of the CFA provides a good fit to the data, it is deemed

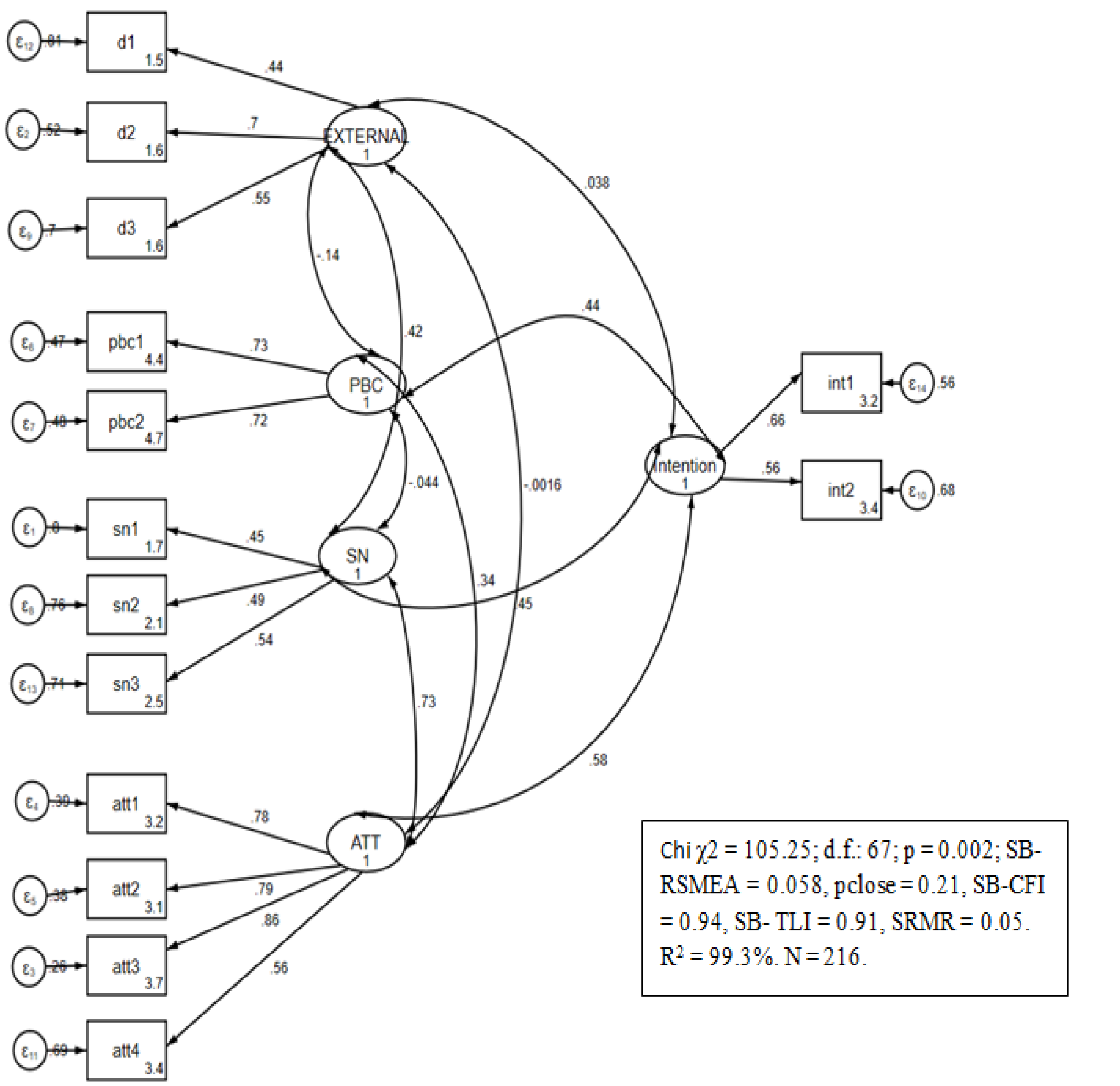


Figure 39 Basic Measurement Model Based on Confirmatory Factor Analysis with Standardized Factor Loadings for the Joint Sample (Source: Case Study Results).

appropriate to continue with the structural models to test the hypothesised paths and explain the proposed integrated model of energy restriction behaviour.

12.1.1 Structural Model to Predict Pro-Environmental Intentions

Structural model 1 is presented in Figure 40. The data fit was adequate: Chi-χ^2 indicated a significant difference between the predicted and observed data. The coefficient of determination (CD) was .99, which was close to 1 (> .9). The CD can be understood as the proportion of variation in the set of indicators that is explained by the latent variable. In this model, it indicated a perfect fit. The SB-RMSEA was .05, which is in the range of acceptability (less than .08), and the pclose test indicated a close fit to the data (.21) because it is not statistically significant. The SRMR is 0.06, which is less than .10, suggesting a good fitting model. The CFI and TLI incremental fit criteria are all significantly above the recommended thresholds of > .9 as suggested by Hair et al. (2014). Hence, we have reason to believe that the baseline model fits the data of the study. Having considered all the model level fit measures, this suggests that the overall model fits well, meaning that the relationships among variables specified in the path model captures the patterns in the data well.

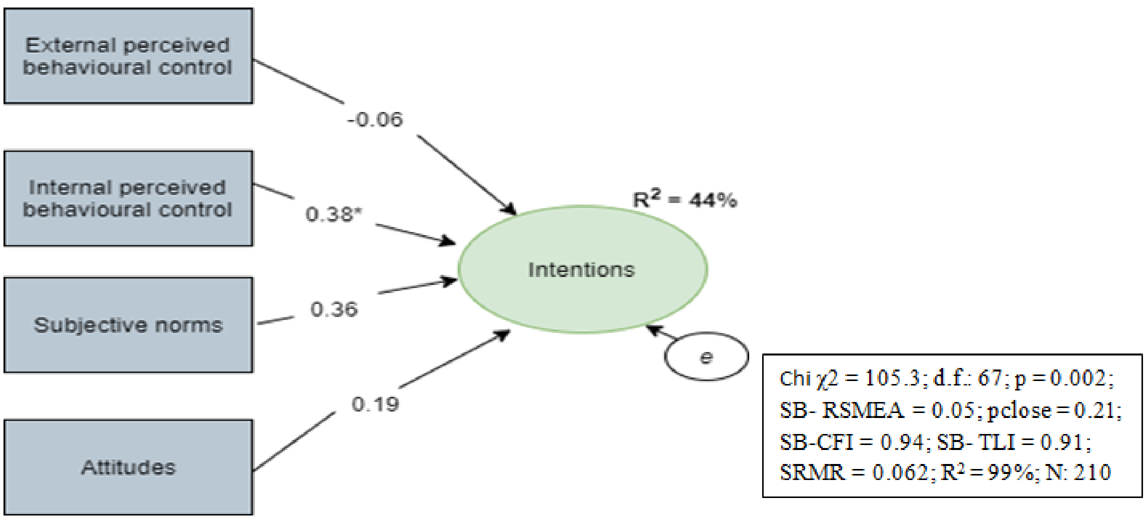


Figure 40 Structural Model 1. Base Model for the Overall Sample (Source: Case Study Results).

The proposed base model for the overall sample has five latent variables. The tested dependent latent variable was the intention for energy efficient use of energy at home (structural model 1). Overall, it explained 44% of the variation in intentions (see Figure 40). However, only the exogenous variable of internal PBC had a positive and significant effect ($\beta = .38$, $p < .05$) on the endogenous variable pro-environmental intentions. Attitudes ($\beta = .19$, p = n.s.) and subjective norms (β = .36, p = n.s.) did not have a significant effect on intentions, and external PBC had a small negative and insignificant effect on intentions (β = -.06, p = n.s.). This suggests that external PBC has a direct effect on energy behaviour, but not on intentions. The latent construct subjective norm is not always a reliable predictor of the intention to perform certain behaviours because peer pressure or influence of family and friends are not at all times relevant to the behaviour in question. This may be the case for energy efficient heating behaviour. For social housing resident in Vienna, it can be assumed that friends and family do not have a strong influence on energy related intentions. This is in line with results of the meta-analysis by Armitage and Conner (2001), who found that the construct of subjective norms is frequently reported to be a weak predictor of intentions. As these results refer to the whole sample, there might be differences between the two samples.

12.1.2 Structural Model 2 - Not Retrofitted Sample

This paragraph presents the SEM results for the not-retrofitted sample of social housing residents (see Figure 41). The tested endogenous latent variable was energy self-restriction behaviour. The structural model -incorporating all 20 items- fits the data reasonably well. While the absolute fit indices all lie within the acceptable value range (SB-RMSEA = .06; SRMR = .08; pclose = .16), the incremental fit indices produced mixed results (SB-CFI = .90; SB-TLI = .88) as the SB-TLI lies under the acceptable range of > .90. It was close to the fit index, but it did not reach the ideal values. Hence, the SB-TLI failed to meet the a priori fit criteria.

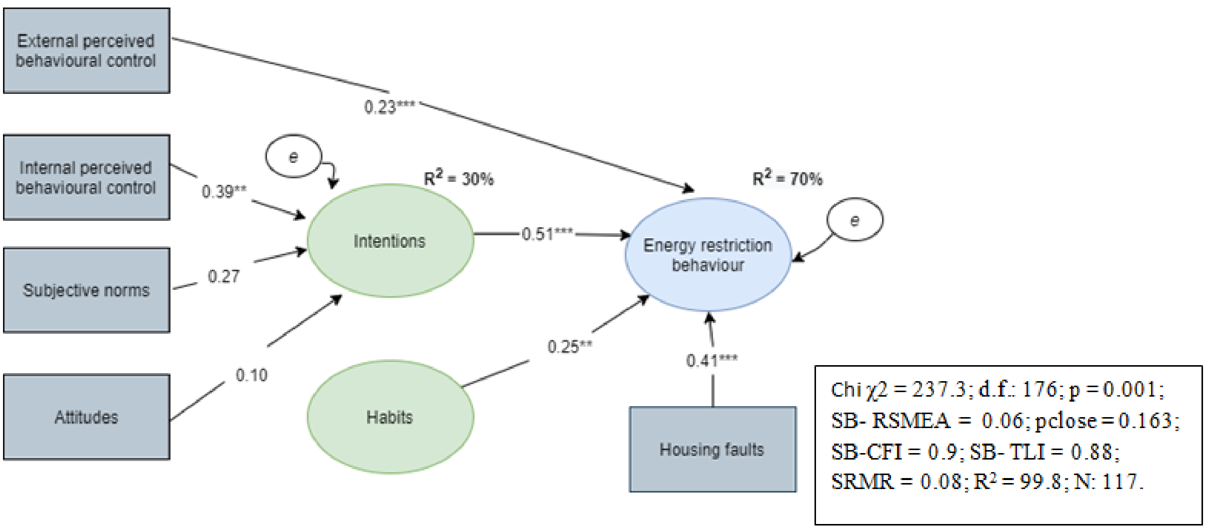


Figure 41 Structural Model 2. Base Model for the Not Retrofitted Sample. Asterisk Indicate Significance At 95% Confidence Level. The Numbers Over the Endogenous Variables Are the Squared Multiple Correlations, which Are the R^2's in Regression Analysis (Source: Case Study Results).

Inspecting the paths coefficients, the estimates reveal the following results: attitudes (β = .10, n.s.) and subjective norms (β = .27, n.s.) did not have a significant effect on intentions. Internal PBC (β = .39, $p < .01$) had a significant and positive effect on environmental intentions. As hypothesized, positive environmental intentions had a direct positive effect on energy restriction behaviour (β = .51; $p < .001$). They explain 30% of the variation of energy restriction behaviour. Habits (β = .25; $p < .01$) and external PBC (β = .23; $p < .001$) had a positive, unique direct and significant effect on energy restriction behaviour. There is a significant positive indirect effect of internal PBC (γ= .24; $p < .05$) on energy restriction behaviour. The indirect paths from subjective norms (γ= .26; $p < .26$), and attitudes (γ = .06; $p < .64$) to energy behaviour mediated through intentions were not significant. The presence of housing faults is positively associated with energy restriction behaviours (β = .41, $p < .001$). The latent construct of positive energy saving intentions accounts for 63% of the variance in energy restriction behaviour. Overall, 70% of the variation of energy restriction behaviours are explained by the structural model 2.

12.1.3 Structural Model 3 - Not Retrofitted Sample

Structural model two above yielded mixed model fit results. To improve the model fit, non-significant paths were eliminated, and alternative paths were added based on the modification fit indices and the CFA results. The path from attitudes towards intentions was not significantly different from zero in structural model 2, suggesting that this factor may not be a determinant of intentions to restrict energy use. Therefore, a path was introduced to the latent construct habits, as it is theoretically sound and the correlation based on the CFA was strong, significant and positive (r = .66; $p < .001$, see Appendix D shaded). This structural model 3 tested the (in-)direct effect of attitudes mediated through habits on energy restriction behaviours. The structural paths are visualised in Figure 42. Chi-χ^2 test was statistically significant (p-value < .05), the RMSEA was low at .05, and the pclose probability was above the .05 threshold. If the p-close value is greater than .05 (i.e., not statistically significant), it can be concluded that the fit of the model is "close". As the RMSEA value was less than the 0.08 cut-off and the p-value is above the .05 cut-off, this indicates a well-fitting model. The incremental fit indices were all acceptable and above the > .9 threshold (SB-CFI = .9; SB- TLI = .9). The standardised root mean squared residual (SRMR = .09) was at the cut-off of point .10, indicating an acceptable fit. All goodness-of-fit indicators strongly meet the ex-ante requirements, implying that the fit of the structural equation model is acceptable. Hence, based on the analysis of the aforementioned statistics of model fit, the empirical data adequately fits the conceptual model.

Upon examination of the modification indexes, an error covariation between er#att3 and er#att4[232] was applied. The introduction of this relationship reduced the chi-square value of the model, and model fit statistics indicated a good fit to the data. Figure 42 indicates that six latent independent constructs have a significant effect on the endogenous variable energy restriction behaviour. This suggests that pro-environmental attitudes, internal and external PBC, energy habits, subjective norms, and positive environmental intentions are the key explanatory factors that predict energy restriction behaviour. Housing faults are also significant and positively associated with energy restriction behaviours ($\beta = .41$; $p < .001$). The model accounts for 54% of variance of the outcome variable *restricting energy behaviours*. By examining the goodness-of-fit statistics to evaluate how much of the variance of each endogenous variable is being explained by the model, we see habits explaining 52% of the variance in the latent variable and positive environmental intentions explaining 31% of the variance in the endogenous latent construct.

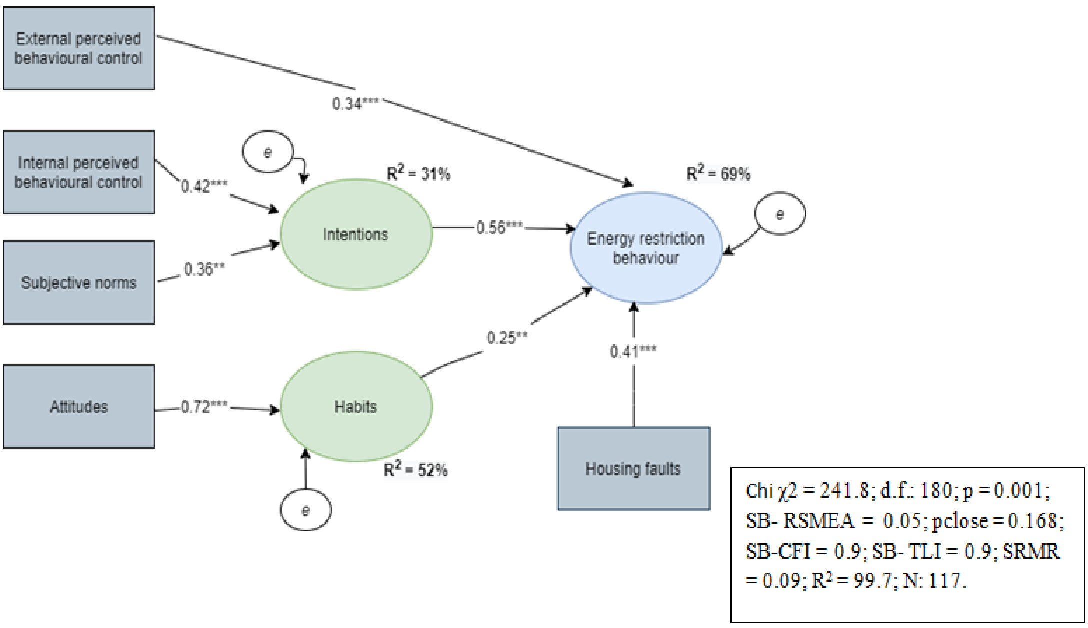


Figure 42 Structural Model 3. Results of the Structural Equation Model for the Not Retrofitted Model. SB-ML Standardized Estimation Results (Source: Case Study Results). Asterisk Indicates Significance at 95% Confidence Level. The Numbers Over the Endogenous Variables Are the Squared Multiple Correlations, which Are the R^2's in Regression Analysis.

232 "Att3: I think it is important to use less energy and recourses for heating" and "Att4: I have the ability and the knowledge of heating energy-efficient"

Intentions were specified to be preceded by internal PBC, and subjective norms. External PBC, which considers whether energy use and heating rooms can be controlled by the households, affects energy restricting behaviours: having low controllability to reach preferred temperatures at home is positively and significantly correlated with energy restriction behaviours ($\beta = .34$; $p < .001$). Therefore, the fewer households have control over their heating and temperature at home, the more they use energy restricting behaviours. Following TPB theoretical framework, the indirect path from external PBC through intentions to energy behaviour was also tested, but not found significant. It was, therefore, eliminated from the model and not presented. The direct significant path from external PBC to energy behaviour, however, remained significant and positive.

Instead of multiple regression analysis steps, SEM has the advantage to estimate simultaneously mediation effects. Therefore, a popular use of SEM is the examination of the process by which an independent latent construct is thought to affect an endogenous latent construct through a mediator. Different from the original TPB framework, habits are influenced by positive environmental attitudes ($\beta = .72$; $p < .001$), which is the strongest parameter estimate in the model. The indirect effect from attitudes to energy restriction behaviour mediated through habits was positive and statistically significant ($\gamma = .19$; $p <.05$). Therefore, this result suggests that if energy restriction behavior is subsequently repeated in stable contexts at home, strong attitudes might promote habit formation. Inspecting the indirect paths, internal PBC ($\gamma = .26$; $p < .01$), and subjective norms had a positive and significant effect on energy behaviour ($\gamma = .38$; $p < .05$).[233]

12.1.4 Structural Models – The Retrofitted Sample

This sub-chapter focuses on the retrofitted sample. Hereby, two SEM models are presented: structural model 4 estimated pro-environmental behavioural changes of households that are living in retrofitted social housing, and structural model 5 estimated drivers of a rebound effect based on the TPB as outlined in chapter 3. The initial models included attitudes, social norms, intentions, internal and external PBC as exogenous latent constructs, and energy restriction behaviour, and the rebound effect as endogenous latent constructs. However, both models were

233 A further model was analysed that contained household income. A higher household income had a negative and statistically significant effect on energy restriction behaviours but habits were not statistically significant anymore. However, the model fit was not acceptable. Consequently, this model is not presented here.

not converging. As the latent construct "external PBC" contained many missing values (above 25%; see Appendix D Table 45), it was excluded from these estimations because sample size partially fell under 100 observations. Moreover, in structural model 4 and 5, the variable att4 "*I have the ability and the knowledge of heating energy-efficient*" had a low factor loading (.35) in the CFA and was excluded from model analysis and structural model estimations.

The two endogenous latent constructs "energy restriction behaviour" and "rebound behaviour" and its constituent variables are briefly summarised in Table 35. Most of the households in the retrofitted sample try not to heat during the transition period (82.5%), and half of this sample turns off the heater when they leave the apartment since the retrofit or do not heat long on high temperatures any more. Fewer people changed their behaviour towards a less environmentally friendly direction: 20% of the retrofitted sample turn on the heater instead of putting a pullover on in the first place. Moreover, since the retrofit, 21% turn on the heating without focusing on the costs they are paying. Even fewer people in the sample (12%) use the heater in the night more often if they are cold compared to the time before the retrofit. In comparison, more people are conscious of their energy behaviour and try not to overheat the apartment in the retrofitted sample.

Latent Constructs	Items	Agreement in %	N
Energy Restriction Behaviour	In transition periods, I try to use the heating as less as possible.	82.5	188
	Since the retrofit, I turn off the heating if I leave the apartment.	50.3	169
	Since the retrofit, I do not heat long (half a day) on high temperatures (over 23 degrees) any more.	50.3	167
Rebound Effect	Before the retrofit, I put on a pullover if I was cold. Now I just turn on the heating.	20.0	171
	Since the retrofit, if I am cold I turn on the heating more often in the night.	12.4	170
	Since the retrofit, I heat without paying attention to the costs.	21.2	171

Table 35 Descriptive Statistics of the Two Endogenous Latent Constructs: Energy Restriction Behaviour and Rebound Behaviour (Source: Case Study Results). For an easier interpretation the items have been recoded to binary (0= disagreement to the statement and 1= agreement to the statement).

12.1.5 Structural Model 4 - Retrofitted Sample

The traditional TPB model for the retrofitted sample on the endogenous latent construct energy restriction behaviour indicated a good fit to the data: Chi-$\chi 2$ = 63.7; d.f. = 58; pclose = .28; SB-RMSEA = .03; CFI = .98; TLI = .97; SRMR = .06; R^2 =98.8%. All fit indices were in the acceptable range. In the model specification, no measurement error covariation was included.

Following the TPB theoretical framework, results indicated positive significant effects ($p < .01$) of environmentally friendly attitudes ($\beta = .57$), subjective norms ($\beta = .45$) and positive environmental intentions ($\beta = .84$) on energy restricting behaviour. Internal PBC had a positive effect but boarders on statistical significance ($\beta = .28$; $p < .06$). Inspecting the indirect effects, subjective norms ($\gamma = .38$; $p < .01$), PBC ($\gamma = .23$; $p < .05$) and positive environmental attitudes were positive and statistically significant. The latent construct attitudes had the strongest indirect effect on energy restriction behaviour ($\gamma = .48$; $p < .001$). 86% of the variance of energy-saving intentions were explained by the antecedents internal PBC, attitudes and subjective norms; among all latent constructs, attitudes had the strongest effect on positive environmental intentions (see Figure 43).[234]

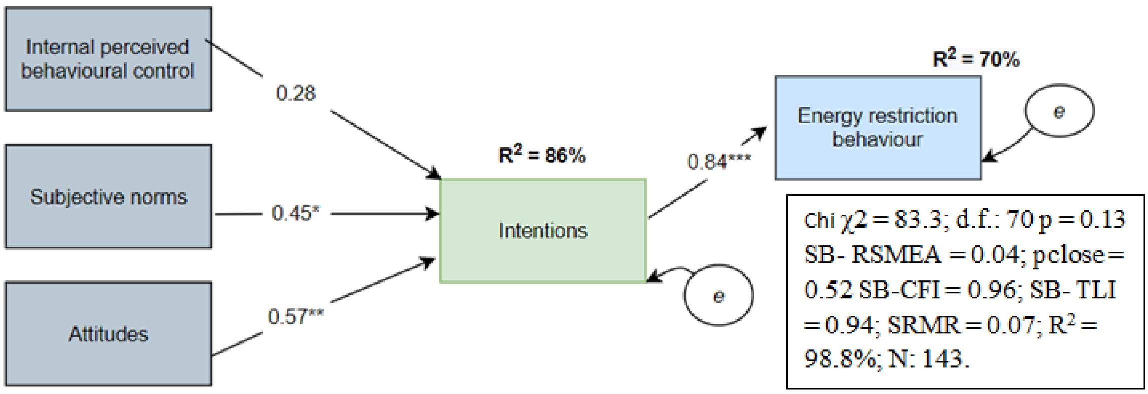


Figure 43 Structural model 4. Results of the Structural Equation Model for the Retrofitted Model. SB-ML Standardized Estimation Results (Source: Case Study Results). Asterisk Indicates Significance at 95% Confidence Level. The Numbers Over the Endogenous Variables Are the Squared Multiple Correlations, Which Are the R^2's in Regression Analysis.

12.1.6 Structural Model 5 - Retrofitted Sample

This paragraph discusses two structural models, the initial, and the modified final structural model 5 that includes paths of the three exogenous latent constructs of positive energy-saving intentions, pro-environmental attitudes, subjective norms, and internal PBC. The tested endogenous latent construct was the rebound effect (using more energy/heater after the retrofit). The initial model 5 did not meet the goodness-of-fit criteria (see Figure 44). Therefore, only results of the final structural model 5 are discussed in this sub-chapter.[235]

234 Several additional potentially influencing factors (rent increase) entered the SEM model, but convergence was not achieved as sample size was too low.

235 The initial and the final models comparisons based on the BIC and AIC and goodness-of-fit indices are presented in Table 36.

Model fit statistics obtained from survey results indicate that SB-RMSEA is .05, which means a close fit to the data. Pclose provides the p-value of the null hypothesis that the estimate is below .05. Results indicate a value of .21. This result is not approaching significance. We can therefore not reject the null hypothesis. The SRMR is .08 and demonstrates an acceptable fit to the data. The comparative fit index and the Tucker–Lewis index is high (CFI = 0.93, TLI = .90), respectively, given their .90 cut-offs. All key goodness-of-fit indicators display a good fit of the model, as indicated by exceeding the respective acceptance levels. Positive energy-saving intentions have a negative and significant effect on rebound behaviour ($\beta = -.94$; $p < .001$), meaning that energy-saving intentions have a lowering effect on rebound behaviours after a retrofit. Energy-saving intentions explain 70% of the variation of rebound behaviours in the model.

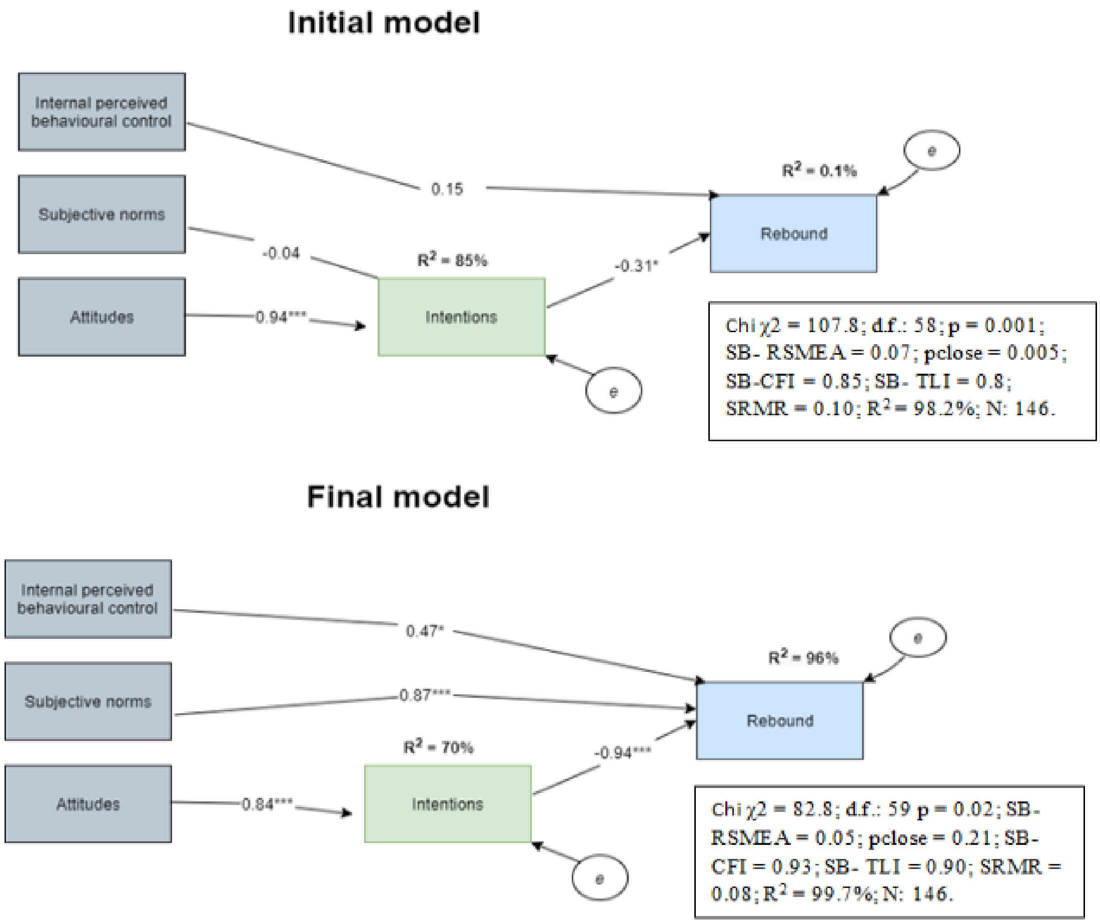


Figure 44 Structural Model 5. SB-ML Standardized Estimation Results (Source: Case Study Results). Asterisk Indicates Significance at 95% Confidence Level. The Numbers Over the Endogenous Variables Are the Squared Multiple Correlations, Which Are the R^2's in Regression Analysis.

Energy efficient attitudes ($\beta = .84$; $p < .001$) have a positive and significant effect on energy-saving intentions. The indirect effect from attitudes to rebound behaviour mediated through intentions is significant and negative (not indicated here; $\gamma = -.79$; $p < .001$). Internal PBC has a positive and statistically significant effect on rebound behaviour after a retrofit ($\beta = .87$; $p < .001$). Hence, increasing the controllability of the temperature and radiator at home increases rebound behaviour. A surprising result is that subjective norms were significantly and positively associated with rebound behaviours. This finding goes against the conventional understanding that social pressure to conserve energy would result in lower levels of energy use. Further research would be needed to determine the exact mechanisms behind this relationship (e.g. moral license or entitlement to use more energy if they perceive that others around them are also doing so).

Table 36 compares the initial to the final model based on BIC and AIC and the fit indexes. Overall, the final model 5 demonstrated a better model fit based on lower BIC and AIC values. Overall, the results do not support the TPB as a robust framework in describing rebound behaviours in retrofitted social housings. Future research needs to consider other exogenous constructs that can theoretically influence a behavioural rebound after a retrofit.

	Initial Model	**Final Model**
$\chi 2$(d.f.); p-values	107.8 (d.f.=58); p > 0.001	82.8 (d.f.=59) p = 0.02
Pclose	0.005	0.21
SB-RMSEA	0.08	0.05
SRMR	0.10	0.08
SB-CFI	0.85	0.93
SB-TLI	0.80	0.90
R2	0.98	0.99
BIC	4988	4954
AIC	4851	4820

Table 36 Model Comparison of Initial and Final Structural Model 5 (Source: Case Study Results).

12.2 Conclusion

Energy behaviours are important factors in understanding energy poverty and improve the situation of vulnerable households. This chapter aimed to provide further insight into the psychological, habitual and contextual factors that relate to energy restriction behaviours and rebound effects among not retrofitted and retrofitted social housing residents in Vienna. Only few studies have empirically extended the TPB by adding studied variables and could conduct a study in retrofitted and not retrofitted buildings.

In summary, Table 37 presents the results of the main hypotheses of this study setting: H_1 and $H_{4,}$ H_{10} are rejected, while the other hypotheses are supported. In an integrated approach, the TPB was extended by the constructs habits and housings faults. It found that, in line with the hypothesised relationships, intentions and habits are key factors explaining energy restriction behaviour. Moreover, housing faults are an important key factor associated with energy restriction behaviours. The current research provides some indication that positive environmental attitudes do not have a positive and significant influence on energy-saving intentions in this social housing context. Rather, the study indicates an significant association between pro-environmental attitudes, and energy restricting behaviour, which is mediated through habits. Overall, habits had a strong impact on energy restricting behaviours. Households who are unable to control their heating system or/and indoor temperatures show higher levels of energy restriction behaviours.

Hypotheses	**Research Hypothesis for the Not Retrofitted Sample**	**Results**
H_1	Positive attitudes towards the energy efficient energy use have a positive effect on intentions to save energy.	Rejected
H_2	Positive social norms have a positive effect on energy saving intentions.	Accepted
H_3	Internal perceived behavioural control (self-efficacy) have a positive effect on the intention to save energy.	Accepted
H_4	External perceived behavioural control contribute to positive intentions to save energy.	Rejected
H_5	External perceived behavioural control have a positive effect on energy restriction behaviour.	Accepted
H_6	Habits have a direct positive effect on energy restriction behaviour, which are stronger than intentions.	Accepted
H_7	Housing faults has a positive direct effect on energy restriction behaviour.	Accepted
	Research Hypothesis for the Retrofitted Sample	
H_8	Positive attitudes towards the efficient energy use have a positive effect on intentions to save energy.	Accepted
H_9	Social norms have a positive effect on energy saving intentions.	Accepted
H_{10}	Internal perceived behavioural control has a positive effect on the intentions to save energy.	Rejected
H_{11}	Intentions to save energy have a positive effect on energy restriction behaviour.	Accepted
H_{12}	Intentions to save energy have a negative effect on rebound behaviour.	Accepted

Table 37 Results of Hypothesis Tests Based on SEM Results.

The study results highlight the need for further examination of psychological, building, and energy poverty factors contributing to energy consumption patterns. While the sample size is sufficient, findings should be cautiously interpreted and cannot be broadly generalized to the entire Austrian population. More recently, the COVID-19 pandemic has created ‘window of opportunities’ for transitioning toward sustainable practices in health, transportation, and energy consumption, both individually and structurally (Auener et al., 2020; Schmidt et al., 2021). Individually, lockdowns have changed people’s behavioural context and external cues that influence consumption patterns. They have offered possibilities of breaking old habits, lead to a re-evaluation of sustainable lifestyles, and the establishment of new habits (Bodenheimer and Leidenberger, 2020; Thomas et al., 2016). Structurally, the crisis can also be considered a policy window for new reforms. External factors such as the war in Ukraine and increased energy prices resulting from reliance on Russian gas also impacted energy use in Austria and throughout Europe. These circumstances influence the energy-related choices of households. Overall, this research contributed to energy poverty literature and illustrated the value of an integrated approach by showing the importance of including housing faults and habits in explaining energy restriction behaviours.

13. Discussion

In this chapter, the key findings of the research will be presented and analysed in relation to the research questions, providing insights into the households experiencing energy poverty in Austria, the reasons behind it, and the effectiveness of current policies aimed at reducing energy poverty. The research questions addressed in this study are:

(R1): Which household types experience energy poverty in Austria?

(R2): What are the reasons behind energy poverty in Austria?

(R3): Are current policies in Austria successful in reducing energy poverty?

The chapter will also place the results in the larger academic context, discussing the contribution of this research to the field of energy poverty, and comparing and contrasting the findings with previous studies. The overarching goal of this thesis was to evaluate energy poverty in the EU, Austria, and Vienna, develop a new approach to measuring energy poverty, and analyse climate and housing policy from a multilevel governance perspective. For this endeavour, this research used a concurrent mixed methods design approach, including expert interviews, document analysis, latent class analysis, and structural equation modelling. Thereby, this PhD thesis moved from the general to the specific: it transitioned from an international literature review to the context of Austria and Vienna and the analysis of EU-SILC micro-data and a sample of 412 respondents in not retrofitted and retrofitted social housings in Vienna. It provided a multilevel governance analysis of climate, housing and energy poverty policies in the EU and moved on to investigating the energy poverty and climate policy framework in Austria and Vienna.

This chapter is organised into four parts. The *first* part discusses the quantitative results of the thesis (analysis of EU-SILC and primary survey data in social housing in Vienna) and answers research question one and research question two. Chapter *one* provides an interpretation and synthesis of the energy poverty research results in a wider research context and shows support for applying the proposed behavioural restriction questions to measure hidden energy poverty in quantitative surveys. The *second* part of this chapter combines this self-restricting concept to psychological research literature of the theory of planned behaviour and the habits approach. Structural equation models applied to the proposed integrated model and specify the necessity of applying the concept of habits to explain energy restriction behaviour. The *third* part of this chapter discusses the policy analysis results by moving from the *general* EU climate policy framework and its comprehensive set of energy poverty policies to the *specific* by providing an answer to research question three whether current policies sufficiently tackle energy poor households in Austria. The *fourth* part of this chapter concludes with a discussion of the limitations of the study. Possible areas of future research and policy recommendations are raised in the corresponding paragraphs.

13.1 Discussion of the EU-SILC Analysis Results in Austria

The need for a common definition of energy poverty has been stressed by researchers due to its urgency and the lack of coherence in definitions across the EU (Thomson et al., 2017a). Various national definitions exist, making it difficult to identify energy poor households and harmonise across the EU. Typically, energy poverty is measured using expenditure-based or consensual-based indicators, or a combination of both, but the use of single indicators has been criticised and the limitations of binary metrics have been outlined. This thesis argued that energy poverty is a complex concept with multiple causes, which requires a multidimensional approach that considers both expenditure and consensual dimensions.

However, trade-offs between indicators must be carefully weighted, especially which dimensions to include in the analysis (Halkos and Gkampoura, 2021; Pelz et al., 2018; Sareen et al., 2020; Thomson et al., 2017a). The subjective energy poverty indicator has received criticism for being overly dependent on individual perceptions, but the lack of a harmonised definition opens the door to new approaches (Healy and Clinch, 2002; Hills, 2012a; Thomson et al., 2017a).

This thesis aims to address the limitations of expenditure-based approaches by suggesting an alternative consensual-based approach that captures energy-self restrictions. The following paragraphs present the main findings and address the first research question, which focuses on explaining energy poverty and identifying those who are energy poor in Austria, using different energy poverty definitions applied to the EU-SILC micro database from the year 2019.

The subsequent paragraph is contextualized within this discussion, as it highlights the main limitations of the current (unofficial) energy poverty definition in Austria, and synthesizes the key results of this dissertation, making a significant contribution to the field of energy poverty definitions in Austria and the European Union.

The Austrian Notion of Energy Poverty and its Flaws

Although energy poverty intersects with income poverty, it cannot be equated with it. Energy poverty is its own form of poverty, caused by a lack of capital investment in finance retrofits to improve energy efficiency (Bordman in Liddell, 2012). The expenditure-based definition used in Austria's National Energy and Climate Plan ("NECP") considers households with low income and high energy costs, but it doesn't consider other important influencing factors, like the condition of the building. It does not differentiate conceptually between income poverty and energy poverty. It refers to the simultaneous condition of households being at-risk-of-poverty *and* having above average energy costs. Therefore, this indicator considers energy poverty as a symptom of general poverty, which translates into the policy conclusion that increasing household income can also mitigate energy poverty. Both aspects intersect empirically, but they do not necessarily overlap and are even distinct from each other. Both the Austrian energy regulator and the benchmark indicator utilised in the NECP disregard *structural causes*, namely the energy efficiency of the building stock, as well as high energy prices. These indicators also neglect arrears on utility bills, inability to maintain comfort temperatures, or an inefficient heating system. However, these dimensions are typical features agreed upon in the scientific literature that are typically employed in energy poverty research. In this thesis, it was argued that despite households' efforts to reduce energy expenditures, their consumption still may lead to high energy expenses because of poorer energy efficiency in their home. As a result, a fundamental limitation is that the currently employed Austrian indicator focuses on too high energy costs but ignores too low energy consumption (hidden energy poor by self-restricting on energy).

The NECP indicator has a 140% energy cost threshold without a clear reason for its choice. This threshold, however, must undergo a critical discussion, as there has been no detailed empirical investigation of household consumption behaviour in Austria and no justification for the 140% threshold, which is derived from the at-risk-of poverty rate. No other EU wide energy poverty indicator employs such an energy costs threshold. More common are above the median share or twice the national median share. Using the quote from Lanjouw (2001, p. 14) where he explains that

> *"[t]he fact that households have different consumption patterns when their composition differs is interpreted to reflect the different needs of persons of different ages and gender, and equivalence scales are then developed which summarize those needs."*

Energy poverty measurement includes normative assumptions and some level of subjectivity. No indicator is truly objective and all are open to debate and interpretation. To effectively measure energy poverty, indicators need to be flexible, identify vulnerable households, have support from science, policy, and the public, and encourage public discussion to raise awareness. It must be agreed with Sareen et al. (2020, p. 14) who stressed that "no measurement is perfect".

Applying the current expenditure-based Austrian benchmark indicator on EU-SILC 2019 micro data, predominantly rural homeowners living in large dwellings (in m^2) in detached houses are identified as energy poor (see chapter 10.7). However, the Austrian energy regulator argues that existing measures to protect customers, and particularly energy poor households, are available and sufficient:

> *"[…] that the existing measures to protect customers, and especially the energy poor, are entirely fulfilling their purpose overall […]. The results show that energy poverty is very little widespread in Austria, especially in international comparison (own translation from German) (E-Control, 2020, p. 130)."*

This shows that the current method of measuring energy poverty in Austria is limited and results in under-representing the problem. This lack of comprehensive measurement results in limited policy adjustments to address energy poverty. A major caveat of the current Austrian indicator is that it suppresses the necessity of identifying housing segments with high incidences of housing faults (subjective/consensual energy poverty). Also, Austria's benchmark indicator compresses the group of energy poor to those who are also considered income-poor.

It also points out that increasing household income is not enough to solve energy poverty, as there are other structural barriers, such as the design of subsidy schemes, that make it difficult for households to access energy-efficient investments as they predominantly targeting mid- to high income home owners (Seebauer et al., 2019). The policy implication of this quote traces back to insufficient federal state action regarding energy poverty mitigation. This assessment is also shared by the assist project partners (Assist2gether, p. 22), who indicated that

> *"there are a number of Member States for whom energy poverty not does appear to be an issue and is certainly not considered as outside of their existing welfare system, this is particularly the case in the Scandinavian countries and Austria."*

A secondary data analysis using EU-SILC (2019) data was performed to answer the first research question: *what types of households are likely to experience energy poverty in Austria*. For this expenditure-based, as well as consensual-based indicators were utilised. Due to the outlined weaknesses of an inadequate definition, this thesis provided 1.) a segmented analysis of energy poverty in Austria and 2.) a definition that matches the criteria agreed upon in scientific literature.

Taking Boardman's 10% expenditure-based indicator, 10% the Austrian population is energy poor. The indicator showed that vulnerable households are those with lower incomes, living in detached houses, with a large living space, in the rural part of Austria. Considering the benchmark indicator used in the NECP, 3.9% of the Austrian population is energy poor. According to this indicator, most energy poor live in thinly populated areas in Austria and are more often homeowners.

A clear distinction between consensual and expenditure-based energy poverty indicators was found: based on the expenditure-based indicator, more energy poor households live in their own property outside the city. These households are strongly affected by high energy costs. This finding is in line with those found in the EU, which showed that in thinly populated areas, households more often experience high energy expenditures (2M indicator) compared to densely populated areas (Bouzarovski and Thomson, 2020).

Regarding the *subjective/consensual indicator* of energy poverty, three dimensions[236] have been merged to one index for a joint evaluation, as suggested by, e.g. Halkos and Gkampoura (2021). This index shows that 11.8% of the Austrian population experiencing one of the challenges indicating energy poverty. A decomposition by housing market structures and socio-demographics revealed that energy poverty is a city problem occurring predominantly amongst tenants in multi-storey apartments. Also, results indicate that housing problems are more common in cities and particularly in buildings constructed between 1945 and 1980 that feature low energy efficiency (Lang, 2007; Umweltbundesamt, 2018).

This investigation revealed regional differences between expenditure-based and consensual-based measures, highlighting the spatial complexity of defining and assessing energy poverty in Austria. The consensual and expenditure-based indicators were used to construct a composite indicator to capture the multidimensionality of energy poverty, following suggestions of various researchers (e.g. Berry et al., 2016; Fabbri, 2015; Fizaine and Kahouli, 2019). Figure 45 summarises the major quantitative results of the indicators utilised in this EU-SILC analysis and the three created composite indicators based on the case study survey.[237] According to the

236 Leaking roof, damp, or rot, inability to afford to keep home adequately warm, and arrears on utility bills.

237 For a detailed explanation how the indicators have been generated, please see chapter 12.

composite indicator, 6.6% of Austrians are energy poor. Tenants living in social housing and privately rented multi-storey apartments build in the city between 1945 and 1980 are more likely to be energy poor. These results are in accord with research by Bollino and Botti (2017), who employ EU-SILC data and an energy poverty multidimensional index in the EU.

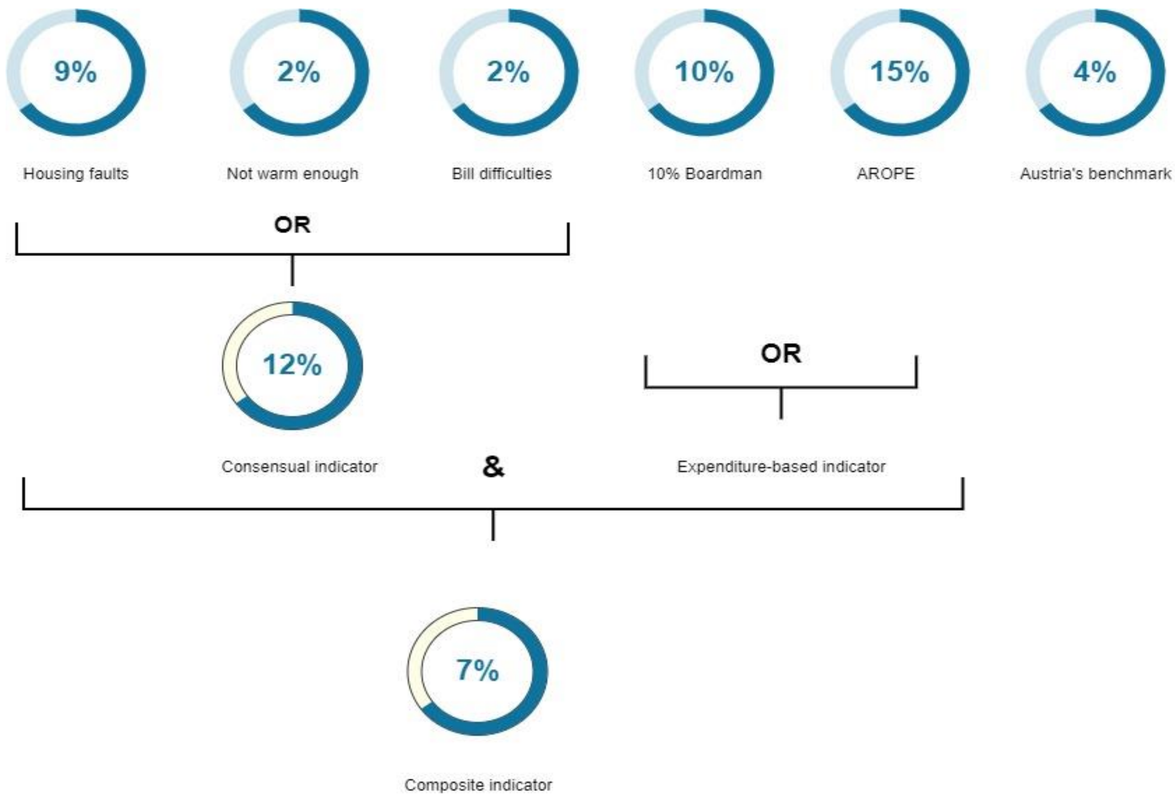


Figure 45 Energy Poverty Indicator Results (Source: Based on EU-SILC 2019). Note: the consensual indicator is created based on either the presence of housing faults, not achieving comfort temperatures at home, or bill difficulties. The expenditure-based indicator comprises households either being energy poor according to Boardman's 10% rule or the at-risk-of poverty indicator. The overall composite indicator combines either the consensual and expenditure-based indicator to account for energy poverty in Austria.

By disaggregating socio-demographics, this thesis also contributes to a better understanding of the intersectional dimensions of energy poverty in Austria. The *first* important result is that energy poverty in Austria is deeply gendered. Single living women, single-parent households (typically more single mothers in Austria), and elderly female pensioners are more often energy poor. These results are in line with those of other EU countries (Clancy et al., 2017; Feenstra and Clancy, 2020; Robinson, 2019; Sánchez-Guevara Sánchez et al., 2020). However, current Austrian climate and energy policies are gender neutral, as well as existing policies aiming at elevating vulnerable consumers, which are too generic and do not reflect gendered differences. Regarding statistical identification of the relationship between gender and energy poverty, it is important to include the individual as a unit of analysis, additionally to the household as a unit of analysis.

Second, elderly and pensioners (including single living pensioners) typically spend more of their available income on energy and are affected by a high energy cost burden. This result is consistent with other studies (Drescher and Janzen, 2021; Sokołowski et al., 2019; van Hoof et al., 2017). However, this only applies to the expenditure-based measurement, and not to the combined or consensual indicator.

Palmer et al. (2008), Price et al. (2012), Legendre and Ricci (2015), Fizaine and Kahouli (2019), and more recently Deller et al. (2021) found different energy poor segments and only partial overlap between energy poverty indicators. Some households that are energy poor based on one metric are not necessarily energy poor based on another. This observation is corroborated in Austria. Considering only the expenditure-based indicator shows only one side of the coin. Therefore, to answer the ***second*** research question, *how can we explain energy poverty in Austria using EU-SILC data*, a combination of consensual/subjective and expenditure-based metrics is best suited for a comprehensive assessment of the nature of energy poverty.

To summarise, results illustrate that specific household energy needs and practices compounded by factors such as tenure type, income, age, and gender are key drivers of energy poverty and need to be included in future analysis. The EU-SILC study results have added knowledge to explain the nature of energy poverty in Austria by demonstrating how different energy poverty rates vary between the present benchmark and the combined or consensual energy poverty indicator that is typically considered in research and other EU countries. Moreover, the results of the EU-SILC decomposition by housing market structure, socioeconomic status and demographics point to the necessity for an intersectional analysis, as suggested by Großmann and Kahlheber (2018) or Middlemiss (2020).

Energy Poverty Rates in Austria Put into European Context

Putting Austria into the EU perspective, on several metrics, it certainly outperforms the EU averages, such as the inability to keep home adequately warm (EU 7.0%; AT: 1.8%), or arrears on utility bills (EU 6.1%; AT: 2.4%) (Eurostat, 2021a, 2021c). However, on the two primary expenditure-based EPOV indicators, Austria’s incidences are on par with the EU average: 16.0% of Austrian households spend a high share of their income on energy (EU 16.0%). Regarding the low absolute energy expenditure, for 15.0% of the Austrian households, energy expenditure is lower than the average population, which directs to hidden energy poverty (EU 14.6%)(EPOV, 2021b). Deprived households with low incomes and lower-than-average energy expenditures may indicate that households are forced to limit their energy consumption. At the same time, excessive energy bills caused by inefficient building fabric can also restrict a household's budget for other fundamental necessities, leading to severe trade-offs, as households must -in a worst-case scenario- choose between e.g. heating or eating (Brunner et al., 2017).

The Missing Aspect in the Hidden Energy Poverty Indicators

So far, critical discussion of the established expenditure-based indices of energy poverty utilised in policymaking has concentrated on economic, social, and political fragmentations (Middlemiss, 2017), however, the behavioural aspects through self-restriction practices have not yet gained momentum. In line with the argument, weaknesses of various hidden energy poverty indicators have been outlined. Moreover, low energy expenditure in the hidden energy poverty indicators can stem from various circumstances that are not covered by the low absolute energy expenditure leading to biases. The strongest drawback concerns the circumstance that it does not reflect behavioural dimensions. Therefore, the sub-research question *of whether households use self-restricting energy strategies that make them invisible to the energy poverty indicators* was raised.

Research Contributions to the Hidden Energy Poverty Indicator

During the interviews, several experts offered support for the assumption that households in multidimensional deprivations engage in energy self-restriction behaviours to keep their energy expenses low. Underconsumption and energy self-restricting strategies were found also in qualitatively oriented EU-wide studies (Anderson et al., 2010b; Chard and Walker, 2016; Harrington et al., 2005), as well as in Austria (Brunner et al., 2017; Brunner et al., 2012; Christanell et al., 2014). However, in quantitative surveys they are sparingly mentioned and under researched (Betto et al., 2020; Karpinska and Śmiech, 2020; Papada and Kaliampakos, 2020). Consequently, a novel measurement was proposed: energy self-restrictions as an additional consensual-based proxy for hidden energy poverty next to the expenditure-based hidden energy poverty indicator.

It was the aim to further develop energy poverty metrics and analyse self-restricting behaviours using an innovative person-centred method to elicit distinct groups with primary survey data. For this aim, not retrofitted social housings in Vienna have been purposefully chosen, inter alia, because of the higher probability of capturing households with lower incomes and energy inefficient building stock. Moreover, focusing on social housing in Austria is justified, as EU-

SILC results indicated higher rates of energy poverty in this particular housing segment in Austria.

A Latent Class Analysis ("LCA") was employed that identified two distinct groups of households: a self-restricting and a non- restricting group. These research results show that energy self-restrictions are prominent strategies among 44% of not retrofitted social housing residents. The main covariates influencing self-restrictions are the inability to reach preferred temperatures at home, housing faults, low income, the presence of children, and having a severely sick household member. Previous research results showed that chronically ill or households with a member (e.g. children with asthma) who is severely sick, have to make critical trade-offs between assessing their family's needs against the resources available to them (Liddell and Guiney, 2015; Tod et al., 2016). In this line, Snell et al. (2015) have shown that alongside space heating, households with a long-term illness may require energy-intensive medical equipment. This must remind us that the amount that households spend on energy to achieve the same levels of comfort varies and presumably self-restriction behaviours may be applied in those households.

The results indicated that elderly (65+ years) and households with low education are less likely to apply self-restriction behaviours. Previous research results in other contexts, such as, by Chard and Walker (2016), Willand and Horne (2018), or Porto Valente et al. (2021) illustrated that elderly use coping strategies to keep their energy costs low. This study was, however, unable to indicate significant associations in the Viennese social housing setting.

One of the major findings to emerge from this research is that when the estimated latent classes are cross tabulated with typical energy poverty indicators, a blindspot was unveiled: across various poverty definitions, of those not considered income poor or energy poor, more than a third (approximately 30 - 40%) engage in self-restricting energy behaviours. These households are not recognised in energy poverty statistics or eligibility criteria of welfare and housing policies as they typically focus on above average energy consumption, arrears on utility bills or unemployment benefits (see policy paragraph in this chapter). Therefore, the sub-research question '*do households use self-restricting energy strategies that make them hidden energy poor'* can be answered with a yes. With this contribution to research, an original perspective on hidden energy poverty is proposed, which is derived from how residents actively cope with their precarious situation. This result illustrates that excluding self-restriction behaviours from the understanding of energy poverty implies overlooking households at risk to be energy poor, which results in an error of exclusion.

The Multidimensional Energy Poverty Index Applied to Primary Data

This newly proposed hidden energy poverty indicator should not be used as a stand- alone indicator for an overall assessment. Therefore, the identified self-restricting groups of the LCA were utilised to construct a multidimensional energy poverty index ("MEPI") comprising both expenditure and consensual indicators (see chapter 12). The Alkire Foster method (2011) allowed to account for multidimensionality by setting minima for expenditure and consensual indicators (Sokołowski et al., 2020). Following proposals from pertinent literature, a minimum of two deprivations were accounted for energy poverty (Abbas et al., 2020; Nussbaumer et al., 2012): 1. presence of housing faults, or 2. inability to reach comfort levels, or 3. identified consensual hidden energy poverty self-restriction, or 4. low-income high-energy costs or 5. spending twice the median (2M) for energy.

The constructed index reveals that over a half of the interviewed households are energy poor based on the presence of at least two deprivations. The most important results are that low income, being at-risk-of-poverty, having experienced a critical life event in the last year (e.g. loss of employment) are key determinants increasing the risk of being energy poor in not retrofitted social housing in Vienna. Moreover, buildings constructed between 1931- and 1960, living on the top floor, if the household moved in the flat after 1994 (new rental contracts), and not heating all rooms because the apartment doesn't get warm due to structural reasons increase the odds to be energy poor.

While results from the EU-SILC analysis found gender as a key determinant, this finding was not supported by this primary data. Regarding age, this study in social housings in Vienna could not show that elderly have an increasing likelihood of being energy poor, as opposed to previous research results (Burholt and Windle, 2006; Buzar, 2007b; Day and Hitchings, 2011; O'neill et al., 2006; Willand and Horne, 2018). However, Bollino an Botti (2017) utilised EU-SILC data, created a MEPI, and similarly, the authors could not find a significant effect for old age. As the Alkire Foster method is flexible and can be tailored to specific contexts because of its variable cut-offs and weights, we can conclude that the results provide a more complete and complex evaluation of energy poverty in Austria.

Problems of Transferability Due to Cultural Idiosyncrasies

Nussbaumer et al. (2012) emphasised that some energy poverty proxy indicators may not always be applicable in a certain contexts due to variances in cultural norms or climatic conditions (Zhang et al., 2017), between regions with different energy efficiency standards and availability of central heating in the housing stock, even between residents with different thermal sensitivity and temperature tolerance. In another country or regional context, the self-restriction questions addressed in this survey may be regarded as a cultural norm, as described for instance by interviewees in Portugal, who accept thermal discomfort and consider feeling cold as normal (Horta et al., 2019). In fact, Heidernstrøm et al. (2013) found different energy cultures and comfort practices in Norway and Denmark and referred to various ways of how we relate and what kind of expectations we have towards energy. In Austria, the self-restriction questions relate to deprivation as suggested by previous qualitative work in Vienna (Brunner et al., 2012) and are supported by expert interviews. How households use energy and notions of normality depends on existing lifestyles (Shove, 2003) and established cultural norms (McKague et al., 2018), as also Bradshaw and Hutton (Bradshaw and Hutton, 1983, p. 27) elaborated:

> *"Individuals, families and groups in the population can be said to be in fuel poverty when they lack the resources to obtain the reasonably warm and well lit homes which are customary, or at least widely encouraged or approved in the societies to which they belong."*

More prominently, the worldwide COVID-19 outbreak reveals that this pandemic is not simply a health and economic catastrophe, but it created, aggravated and revealed existing vulnerabilities because people were forced to stay longer at home during lockdown restrictions, resulting in higher energy bills for heating and electricity (Mastropietro et al., 2020). This adds another layer of pressure to vulnerable households, as in 2021, gas and electricity prices skyrocketed in Austria and other European countries (Eurostat, 2022a)(Azeez, 2021). Certain groups in society are burdened more than others, and self-imposed energy restriction behaviours may have eased some vulnerable households to mitigate the economic effects of the pandemic on their household budgets. While the pandemic has considerably deepened the existing inequalities, it may have also led numerous people experiencing energy poverty for the first time.

Contribution to Energy Saving Theory

Literature on the key determinants that influence energy behaviours of low-income households and/or social housing residents is scarce (Boomsma et al., 2019, 2019; Chen et al., 2017). In accordance with Galvin and Sunikka-Blank's (2016) recommendations, a behavioural approach that integrated the theory of planned behaviour ("TPB") was developed for this thesis. This approach aimed to identify the psychological factors that influence energy use behaviors among deprived households, including attitudes, perceived (external andinternal) behavioral control, social norms, and intentions, as outlined by Ajzen (1991)). To address the sub-research question regarding the energy use behaviors of residents in social housing in Vienna, it was suggested that a focus on stable home environments where strong energy habits persist is necessary. This is particularly relevant given the tendency to neglect habits in energy-saving behavior research (Canova and Manganelli, 2020). Therefore, an integrated approach was proposed that combined the TPB with the habits approach and considered housing faults, as suggested by Verplanken and Aarts (Verplanken and Aarts, 1999). Using structural equation modelling ("SEM"), the relationships between energy self-restriction behaviours of residents in not retrofitted social housings in Vienna, and the predictors external and internal perceived behavioural control, subjective norms, attitudes, intentions, habits and housing faults were tested.

The results showed that subjective norms and internal PBC had a positive and significant mediating effect through positive environmental intentions on energy self- restriction behaviours. Perceiving to have control over the heater and the indoor temperature increases environmental intentions and energy restriction behaviour. This result is supported by similar studies (Kaiser et al., 2005; Tanner, 1999; Thøgersen and Grønhøj, 2010). Moreover, external perceived behavioural control, which corresponds to the building-related context, had a direct positive effect on energy restrictions: not heating the rooms because the radiator is not working, or because the apartment does not get warm due to structural reasons increases energy-restriction behaviours. Similarly, Boomsma et al. (2019) found that housing faults increase heating related energy saving behaviours, but perceived behavioural control did not.

Previous studies showed a positive effect of environmental attitudes on environmental saving intentions and behaviours (Abrahamse and Steg, 2011; Boomsma et al., 2019; Chen et al., 2017; Gadenne et al., 2011). However, these research results point to an insignificant attitude-intention-behaviour relationship. Moreover, the SEM model fit was acceptable but low (Barr et al., 2005; Sapci and Considine, 2014). Several scholars studying the attitude-behaviour gap argue that it may emerge as a result of a lack of capability and established habits (Barr et al., 2005; Maréchal, 2010; Verplanken and Faes, 1999). Linder et al. (2021), for instance, point out that habits are an under-explored research agenda in sustainability science and calls to analyse behaviours through a habit lens. Primary data results support this assumption that much of household behaviour is habitual (Abrahamse et al., 2005; Barr et al., 2005; Gadenne et al., 2011). Furthermore, unlike the well-studied path from attitudes to intentions, in this research, environmental attitudes had a strong positive effect through habits on energy self-restriction behaviours.[238] Klöckner (2013) found in his meta-analysis that intentions are the strongest predictor of behaviour followed by habits. These research results differ from the meta-analysis results, as habits were the strongest predictor in the model.

These results provide theoretical and practical contributions to energy poverty literature. Theoretically, it contributed in several ways: *first,* the current study used the TPB to study the factors that drive energy restriction behaviour and intentions to lower energy consumption. To the best of the researcher's knowledge, this study is the first of its nature that has extended the TPB original model to explain the factors behind energy restriction behaviour in not retrofitted social housing. *Second,* this study has unfolded some interesting results, especially pertaining to the antecedents of the TPB, e.g. insignificant relationships of attitude and intentions. *Third,* research results for this group of not retrofitted social housing residents revealed that energy self-restriction behaviours are less related to positive environmental intentions or social norms than learned habits, external PBC and housing faults, corroborating findings from previous research (Maréchal, 2009; van den Broek et al., 2019). In this vein, Elsharkawy and Rutherford (2018) demonstrated that 43.5% of social housing residents did not change their heating patterns after a retrofit and they attributed this result to anchored habits. Bal et al. (2021) explained for the case of social housing residents where a retrofit was planned that tenants felt hesitant about their capacity to learn new habits and have expressed their need for a clear guidance on optimal reductions in energy use. Peters and Dütschke (2016) addressed how the adoption of energy efficiency technology might trigger behavioural changes, but the authors suggested that both directions are conceivable, either increasing or decreasing intensities of rebound effects. According to their qualitative data, rebound effects are more prevalent for transport and lighting

238 A note of caution is in order here, since low income had a statistically significant increasing effect on energy restriction behaviours. While all other factors remained significant, habits became not significant, indicating that income takes precedence over ingrained habits. An explanation for this might be that low income pressures households to change long-lasting habits and to self-restrict on energy. However, the overall model fit was not acceptable. This is an important issue for further research.

behaviour, while heating behaviours are more stable and habitual, suggesting that they are difficult to break.

Persisting energy habits pose a barrier to change behaviour, however, retrofits may also be ‘moments of change’ to establish new habits. Therefore, from a practical point of view, this research finding illustrates that energy-related habits should be addressed in energy efficiency interventions, as described by, for instance, Kurz et al. (2015). Also, Gooding and Gul (2017) suggested to consider environmental attitudes and habits while planning home improvements to increase energy efficiency measures.

In summary, to answer the sub-research question which factors determine *how dwellers in social housing in Vienna behave in terms of their energy use, the* results of the SEM in the not retrofitted sample indicate that habits, poor buildings conditions and positive environmental intentions are main drivers of energy self-restriction behaviours. Moreover, the model accounts for a large amount of variance in energy restriction behaviour: the latent construct habits accounted for 52% and intentions for 30% of variance in energy restriction behaviour, respectively. Therefore, the study results imply that persisting habits overrule people's intentions to restrict energy use. In conclusion, this approach contributes significantly to our understanding of energy poverty and behavioral theory by highlighting the importance of energy self-restriction behaviors and identifying the key factors that drive these behaviors.

Retrofits and Possible Implications on Energy Related Behaviour

Life course changes (e.g. moving to a new home or COVID-19 lockdown restrictions) give momentum to change long-lasting habits (Verplanken and Wood, 2006; Walker et al., 2015). It was argued that a retrofit constitutes a ‘window of opportunity’ to change energy-related habits as environmental cues are disrupted (Oreszczyn et al., 2006). From another point of view, Boomsma et al. (2019) reasoned that the *take back effect* (using the heater/energy more) might be even stronger in social housing as tenants typically have lower incomes than the general population and use more often energy self-restriction behaviours *before* a retrofit. After a retrofit, households are more likely to catch up to consumption levels they could previously not afford, because deprived households are more likely to use the benefits of increased efficiency to raise their comfort levels rather than reduce consumption (Berger and Höltl, 2019). Therefore, next to not retrofitted social housing, this thesis analysed behaviours of social housings residents in Vienna, which underwent a retrofit in the last five years.

Various studies on building efficiency measures have neglected the impact of occupant behaviours, so that saving potentials were overestimated due to potential pre-bound effects (Belaïd et al., 2018; Berger and Höltl, 2019; Brøgger et al., 2018; Teli et al., 2016). Given these two arguments and following some concluding thoughts by Peters and Dütschke (2016), two opposing SEM models were proposed using the theoretical constructs (internal PBC, social norms, attitudes, intentions) of the TPB:

1.) social housing residents strive not to overheat/ after the retrofit[239], or
2.) social housing residents 'take back' their energy/ temperature they have been cutting in the past (Calderón and Beltrán, 2018; Stafford et al., 2011).

Descriptive statistics indicated that energy restriction behaviours after a retrofit are more common among social housing residents compared to rebound behaviours. The SEM model yielded the following results: positive environmental attitudes and subjective norms mediated through positive environmental intentions have a significant and positive effect on energy restriction behaviours. Heat-reducing intentions significantly increase energy restriction behaviours.

Over 50% households in the retrofitted social housings make use of energy restricting behaviour although one driver -energy inefficiency- of energy poverty is levelled out. Restriction behaviours may also stem from other various aspects that were not tested in this study: high energy prices, increased rents, their low incomes or ingrained habits. In his analysis on rebound effects in Austria, Seebauer (2018), for instance, offers the explanation that frugal households still prefer to put on a pullover first before turning on the heating, even if households have more means to afford higher temperatures after a retrofit. Results in this thesis indicate that approximately 50% of social housing residents living in retrofitted homes do not heat all rooms because they learned it that way, also suggesting persisting frugal habits. Further research should investigate these potential drivers.

Rebound Effects after a Retrofit?

Referring to the outlined argument in the previous paragraph, the other SEM model focused on the rebound effect, and aimed at explaining its main determinants in retrofitted social housings,

239 There may be several options for this behaviour: becoming aware of energy saving topics, overall housing costs may have increased and force residents to skimp on energy.

using psychological drivers based on the TPB.[240] This research provides a valuable contribution to the understanding of the relationship between environmentally friendly attitudes and heating related saving intentions and rebound behaviours: data indicates that environmentally friendly attitudes have a significant and positive effect on heating related saving intentions, and that positive environmental intentions effectively reduce rebound behaviours. Additionally, high internal perceived behavioural control over the radiator leads to a significant increase in rebound behaviours. Surprisingly, social norms have a direct, positive and significant effect on rebound behaviours. The results can bring out a level of uncertainty as the more a household believes they are expected from family and friends to heat their apartment in an environmentally friendly manner, the higher the likelihood for rebound behaviours. Seebauer (2018) found comparable findings for building insulation and behavioural rebound effects. Peters and Dütschke (2016) warned that subjective norms can be reduced after an improvement in energy efficiency. A explanation for this result is that households may feel less social pressure to behave environmentally friendly stemming from moral licensing: it means that past positive environmental behaviours increase the likelihood to show less environmental behaviour (Mullen and Monin, 2016; Thøgersen and Crompton, 2009).

In summary, this study takes a significant first step in expanding and enriching the discussion of the determinants of rebound behavior and energy self-restriction behavior following refurbishment. This is achieved by introducing and exploring a psychological framework that provides valuable insights into these behaviors.

Housing Costs after Retrofits

When comparing the housing costs before and after the retrofit, these research results illustrated that median heating and electricity costs decreased while rent costs increased after the retrofit (67% agreement). In an overall calculation, the total housing costs levelled out energy costs savings from the retrofit, and when comparing housing expenses, housing costs were overall larger than before the retrofit. The high self-restricting rates indicate some households may restrict energy because they may have done this in the past, or because they established new coping behaviours due to increased total housing costs.

240 The relationships between internal PBC, subjective norms, positive environmental attitudes, positive environmental intentions, and rebound behaviours were assessed.

Similar explanations where found in Switzerland, where energy consumption decreased after the retrofit from 253 kWh/m^2/a to 73 kWh/m^2/a, however, rental costs increased and led to an additional burden on tenants (Kägi et al., 2014). Research shows that especially vulnerable tenants saved on basic needs to compensate for increased rental costs (e.g. eating, areas of leisure, and heating practices) (Suppa et al., 2019). Also in the Netherlands, social housing residents were concerned and feared increased costs after the retrofit (Bal et al., 2021). In Germany, Wolff and Weber (2018) found increased rent costs after a retrofit in social housings that exceeded the overall low energy consumption.

However, it is important to note that the study design of this thesis does not allow for concluding causality, and it cannot be determined whether the retrofit itself caused behavioral changes. Nonetheless, it is plausible to assume that increased housing costs due to the retrofit may trigger energy restriction behaviours. Further research is needed to investigate this association by considering frugality and increased housing costs in the analysis of rebound effects and energy self-restriction behaviours.[241] This assumption is not far-fetched as other research directs to so called ‘renovictions’, which are forced displacements, gentrification tendencies after retrofits because tenants are unable to afford increased rental prices (Baeten et al., 2017; Bouzarovski et al., 2018 Großmann et al. Großmann et al., 2014 and Berger and Höltl Berger and Höltl, 2019).

Comfort Temperature - the Elephant in the Room?

When addressing hidden energy poverty as self-imposed energy restriction, a key elephant-in-the-room remains: what constitutes a normal comfort level, and how much does it have to be undercut to qualify as deprivation? Thresholds for *normal* indoor temperatures are often set at uniform values, such as 18–21°C (World Health Organization., 1987). Cozza (2021) and Flourentzou et al. (2019) propose 21.5 °C as the ‘optimal’ indoor temperature for which they report no significant complaints about cold or discomfort by occupants. Indeed, similar comfort temperatures were reported in this study setting, in which most tenants preferred 21–22°C degrees during the heating season. However, this question cannot be addressed in absolute terms.

241 In this study, a variable was created that was based on the difference between overall before and after housing costs, and it was included in both models in the retrofitted sample. However, convergence issues were encountered and models could not be analysed.

Determining appropriate indoor temperatures is challenging as there is no consensus on human energy requirements or basic energy needs thresholds (in kWh) as this involves value judgements and is subjective (Bhanot and Jha, 2012; Pachauri, 2011). Considering an ageing population in the EU, policy design requires a critical discussion about 'minimum comfort temperatures". For instance, elderly demand higher indoor temperatures to reach comfort levels due to changes in thermoregulation (sedentary or ill people are less able to generate their own heat) and longer time spend at home (Blatteis, 2012; Day and Hitchings, 2011; Dear and McMichael, 2011).

In order to calculate the at-risk-of-poverty rate, equivalence scales are a gold standard. For instance, children in the household are counted with the factor 0.3. For energy consumption/ expenses, there is disagreement on how to introduce equivalence scales as benchmarks.

Would an approach make sense that applies equivalence scales not only according to household size but also to the age of the household to avoid underestimation of energy poor and to address household's heterogeneity and energy needs?

For example, on the one hand, room heating does not have to be generated more for each additional person. On the other hand, more people also require more living space, and therefore, more energy to heat the flat. Comparing equivalised energy consumption/ expenses with actual expenses could provide - next to energy self-restriction questions - a solid basis for energy poverty estimations. In future investigations, equivalised energy consumption/ expenses based on age besides household size could be developed.

Interim Summary of Quantitative Research Results

This study has contributed new insights to the existing literature on energy poverty by addressing the first research question of *how to explain energy poverty in Austria*. While the current benchmark indicator in Austria relies primarily on estimating energy poverty using a one-dimensional measure based on expenditure, this thesis has analyzed and conceptualized energy poverty as a multidimensional concept and utilized several indicators, including expenditure, consensual, and behavioral-based dimensions. To address the sub-research question regarding energy self-restriction strategies by households that may be hidden energy poor, the findings of this research revealed a substantial share of households that exhibit energy self-restricting behaviors despite not being identified as income or energy poor. This study represents the first application of the LCA method in hidden energy poverty research to analyze the prevalence of energy rationing in a vulnerable population segment that is typically difficult to reach by means of public surveys. The second research question of this study aimed to identify the types of households that are vulnerable to energy poverty in Austria by examining various dimensions. By decomposing the data using EU-SILC, the study found that expenditure-based indicators used for national estimates tend to overlook crucial factors, such as building fabric and behavioral patterns, which can undermine the accuracy of the estimates. Most energy poor households are renters in multi-storey dwellings build between 1945 and 1980 in the city, women, single parents, and elderly women.

In addition, this study made a significant contribution to the energy poverty discourse by enhancing the TPB through the inclusion of housing faults, external PBC, and ingrained habits. More specifically, the sub-research question of identifying the factors that can explain how dwellers in social housing in Vienna behave energetically was answered. The models proposed in this study explained a high proportion of variance in energy restriction behaviour and rebound behaviours, respectively. We can therefore conclude that the modified TPB model can predict sufficiently energy restriction behaviours of households in social housing in Vienna.

13.2 Discussion of Climate Policies from a Multilevel Governance Perspective

The policy analysis of this thesis utilised a multilevel governance perspective to answer the third research question: *what policies exist to decrease energy poverty and to what extent are current policies able to tackle energy poverty in Austria*? This chapter presents the key findings and discusses h*ow the design of the Austrian housing policies shape energy poverty*. Moreover, it will shed light on how existing laws and programs target energy poor households in Austria.

The amended Clean Energy For All Europeans Package sets out new rules to update the European energy policy framework and the transition from fossil fuels to cleaner (renewable) energy in order to comply with the Paris Agreement commitments (European Commission, 2019a). It comprises a set of eight legislative acts (Directives and Regulations) and a significantly enlarged energy poverty policy framework. While the Effort Sharing Regulation for the 2021-2030 period sets legally binding GHG reduction targets individually to each MS, the Energy Efficiency target only contains the requirement for MS to set their own 'indicative' (useful guidance) national contributions. Indicative targets are not subject to infringement procedures since their attainment is not linked to a legal obligation; it also does not break down the target into individual national targets for each MS (Monti and Martinez Romera, 2020).

The Renewable Energy Directive II has undergone significant changes in its legal framework. Unlike the previous Directive, which had legally binding national targets and the possibility of infringement proceedings, the current legislation has a collectively binding EU-wide obligation. The new rules for non-compliance and the use of benchmarks for determining national contributions are seen as a setback, as they only result in voluntary payments to the Financing Mechanism in cases of non-compliance. The targets for energy efficiency and renewable energy sources have fewer coercive measures and rely more on the member states' willingness to comply (Vandendriessche et al., 2017).

The EU framework makes it possible to monitor and compare the climate performance of member states, allowing for the application of the "blaming and shaming" principle (Kryk and Guzowska, 2021).

Austria's failure to meet its 2020 climate targets for GHG emissions, energy efficiency, and retrofitting, can be attributed, in part, to the country's fragmented and conflicting climate policy design, resulting in the country lagging behind other EU nations in this regard. According to interviewed experts and the latest report of the Austrian Court of Auditors (2021a), the fragmented competencies between federal government and federal states in matters of climate protection make the implementation of effective measures difficult. Divergent interests between federal ministries and the nine federal states vetoed the introduction of measures for climate protection at the federal level. Although the budget responsibility lies with the relevant ministries and federal states, the experts emphasised the hesitant role of the Austrian Federal Ministry of Finance and the additional coordination efforts between the federal levels.[242] Moreover, subsidies for fossil fuels have not dropped over the last decade, and they even increased in Austria (European Commission, 2020b).[243]

242 The Austrian Court of Auditors has criticized the country for not meeting its 2030 and 2050 climate targets. Based on current measures, Austria is expected to only reduce GHG emissions by 21% in 2030 instead of the target of 36%, and 55% in 2050 instead of 100% (Austrian Court of Auditors, 2021b)

243 The EC requests Austria to create a document, which identifies incentives and subsidies classified as counterproductive to energy and climate targets and it should contain a plan how they should gradually be removed by 2030 (European Commission, 2020g).

Main EU Climate Targets		
	2020 targets	**2030 targets**
Greenhouse Gas Emissions (compared to 1990 levels)	20% binding for member states	55% binding for member states (Fit for 55)
Share of Energy Consumption From Renewable Sources	20% binding for member states	40% Binding at the EU level only (collectively) for heating and cooling (annual binding increases of 1.1% point at national level). For buildings 49% renewable energy.
Energy Efficiency Improve by	20% indicative for member states	39% and 36% energy efficiency targets for primary and final energy consumption. Indicative national contributions at the EU level
Renovation Rate	2%	2%
Poverty Reduction	20 million people	15 million (5 million children, compared to 2019)
Energy Poverty Reduction	Not outlined	Not outlined

Table 38 Overview of Main EU Climate Targets (Source: European Commission, 2021c, 2020f).

Considering energy poverty, the third EU Energy Package mainstreamed energy poverty to protect vulnerable consumers in the energy market. The following Winter Package (Clean Energy For All Europeans) assigned energy poverty a more prominent role compared to its predecessor by addressing the root causes and it obligated MS to define and assess energy poverty. Overall, the legal framework with its eight Directives and Regulations extends the EU energy framework. However, it does not sufficiently pave the way for a fundamental transformation. The 2030 framework and its climate commitments do not align with the goals of the Paris Agreement (Gibson-Wood and Wakefield, 2013; Kulovesi and Oberthür, 2020).

The EU Social Climate Fund Regulation critically assessed energy poverty challenges and proposed "*to address the social and distributional impacts on the most vulnerable arising from the emissions trading for the two new sectors of buildings and road transport*" (European Commission, 2021j, p. 2). More specifically, it is aimed at ensuring fair burden-sharing across society and helping citizens finance investments in energy efficiency, new heating, and cooling systems, and cleaner transport because of the price increases due to the new carbon pricing. The proposal contains a long-term view on energy poverty as it stresses that *"while social tariffs or direct income support can provide immediate relief to households facing energy poverty, only targeted structural measures, in particular energy renovations, can provide lasting solutions*" (European Commission, 2021j, p. 15). In their endeavours to fight energy poverty, some MS focus predominantly on short-term income-related support, while other MS provide aid to improve energy efficiency of the building fabric or foster the use of renewable energy sources that has a long-term effect. Austria falls into the group of countries, which predominantly provide short-term income-support for energy poor households.

To summarise, the EU has a strong commitment to combat energy poverty and it introduced the issue in several legal documents. Despite this effort, did not present a common energy poverty definition, nor did it set legally binding measures or specific targets for reducing energy poverty, as it referred to the subsidiarity principle, allowing Member States to set their own policies. Therefore, definitions not only differ between the EU Member States, also the ways in which energy poverty is addressed in policy design (Creutzfeldt et al., 2020; Ugarte et al., 2016). Specifically, several pitfalls were detected in the policy analysis:

1.) While the EC urges reducing energy poverty, EU Regulations and Directives set guidelines only for vulnerable consumers, i.e. general consumers at-risk-of-poverty. This is because EC's competency concerns vulnerable consumer in regulated energy markets and not households in energy poverty across all energy systems. The concepts of energy poverty and vulnerable consumers are linked, however they are distinct (Dobbins et al., 2019). The concept 'vulnerable consumers' targets only electricity and gas consumers based on legislative requirements of the EU (Directives on common rules for the internal market for electricity and gas (2019/944/EU) (2019/692/EU)). These measures are usually short-term, and often provide aid for acute access issues to energy services (Pye et al., 2015b).

2.) For many MS, energy poverty is a blurry concept without a clear definition and Member States set their own criteria individually to identify 'vulnerable' households (Kyprianou et al., 2019; Sareen et al., 2020).

3.) The principle of subsidiarity affects the way countries address energy poverty, leading to differing national approaches based on political culture. The concept of 'vulnerable consumers' directs to a group of consumers, such as recipients of social welfare. The UK defines vulnerable consumers as elderly households, households having a disability or long-term illness, and families with young children, while Austria does not make such distinctions (Boardman, 2013). Based on research in this thesis, it is recommended that Austria also adopt such distinctions, as households with certain socio-economic or demographic features are more prone to experiencing energy poverty. This policy analysis result aligns with Sareen et al. (2020, p. 32) who summarise that

> *"[t]hese criteria vary by country and have little to do with the headline indicators used to monitor the incidence of energy poverty for statistical purposes, such as the ones proposed by the EU Energy Poverty Observatory (EPOV)".*

In Austria, vulnerable consumers, who are identified through social welfare systems or Ombudsman services provided by energy companies, are typically households that have arrears on utility bills. Support is provided to the general population through these systems, and vulnerable consumers are primarily classified based on their low-income status (Austrian Court of Auditors, 2020). Consequently, vulnerable consumers in Austria are primarily classified based on their low-income status. In Northern and Western European member states, with low rates of "expenditure-based" energy poverty typically use poverty-related measures, like social welfare, to address energy poverty. This approach avoids the need for inter-sectorial coordination to combat energy poverty (Bouzarovski et al., 2021).

A policy review conducted by Berger (2011) for an Austrian Federal State ten years ago noted that among experts, energy poverty was not seen as an independent issue separate from income poverty. However, in recent years, energy poverty has gained increased attention in Austria from various institutions, including energy utilities, NGOs, and research projects. This heightened focus can be attributed to the proposed definition of energy poverty by E-Control in 2013, the prominent work by the NELA project (Christanell et al., 2014), and efforts by the European Union to raise public awareness and anchor energy poverty in the legal structure of the energy framework. Nevertheless, in light of the policy analysis, it is necessary to conclude unequivocally that federal level instruments dedicated specifically to energy poor households are inadequate, since they do not sufficiently target energy poor households.

At the national level, Austria lacks a systematic approach to energy poverty, resulting in a lack of recognition and policy framework for the issue. The findings of the study suggest that the central government views energy poverty as a problem of income poverty, which is addressed through social welfare policy rather than as an inter-sectorial issue of energy, climate or housing policy, making the needs of those experiencing energy poverty invisible (Bouzarovski et al., 2012; Seebauer et al., 2019). Building energy efficiency is not included in the calculation of the energy poverty rate in Austria. Hence, there is room for improvement as innovative measures or quantitative targets regarding the reduction of the share of the population living in energy poverty were not outlined in the Austrian NECP (Federal Ministry for Sustainability and Tourism, 2019).

This is similar to the situation in Germany or the Netherlands, which are also latecomers in energy poverty mitigation (Feenstra et al., 2021; Strünck, 2017). Feenstra et al. (2021, p. 1) determined that in the Netherlands "[t]here is, as yet, no national policy, and the national government has been reluctant to articulate energy poverty as distinct from poverty in general". The Austrian Court of Auditors (2020) arrived at essentially similar conclusions that typical measures are concerned with increasing household income. The problem with income-related measures is that they are not targeted and broadly defined, so households affected by energy poverty only receive limited benefits.

While the Austrian Federal Government shows rather little dedicated energy poverty initiative on the national level, there are various approaches and projects on the federal states level and municipal level, which drive the agenda. The Austrian energy poor are predominantly recognised through municipal administrations, the Caritas, a humanitarian NGO, and large energy utilities, which are key players in fighting energy poverty in Austria.

The policy analysis evaluated that the involved stakeholders cooperate and constitute a well-organised nodal governance network in Austria (Creutzfeldt et al., 2020). The Caritas or Ombudsman's offices do not understand energy poverty in isolation from other difficult life situations that households are often confronted with. With this perspective, the institutions adhere to Großmann and Kahlheber's (2018) intersectional and multiple deprivation understanding of energy poverty. Therefore, close cooperation and networking activities between multiple institutions (social counselling, debt counselling, and housing office) are expedient to improve the life situation of deprived households. Nevertheless, although necessary, their strategy does not go beyond providing aid in acute situations through energy counselling, raising environmental awareness, and the exchange of inefficient devices.

Retrofitting subsidies are assigned to climate policy resort, and socio-political goals are not attuned to it (Seebauer et al., 2019). It has been suggested that to tackle effectively both climate and social issues, cooperation and coordination between relevant sectors, and horizontal and vertical climate policy integration is crucial (Adelle and Russel, 2013). As an example, the UK has established a committee on Fuel Poverty (non-departmental public body) to facilitate coordination across key organizations, which could serve as a best practice example in Austria (Committee on Fuel Poverty, 2021; Robinson, 2018).

Creating a centralized contact point (e.g. One-Stop-Shop in Vienna) that provides energy (poverty) counceling, counselling on subsidies for heating costs and assistance with investments in energy-efficient measures, would streamline the administrative process and enhance access to funding (please see e7 (2023)). This approach would offer cohesive support to those in need. Unmistakably, contacts with local decision-makers, other stakeholders/ multipliers and local social initiatives are necessary because their localised knowledge is fundamental for implementing innovative measures (Fahmy et al., 2011; Walker et al., 2014; Walker et al., 2012).

Information campaigns and advisory services with a focus on energy saving tips are widespread energy poverty instruments, also in Austria through e.g. the ‘klimaaktiv program’ (Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology, 2021b). In the analysis, it was argued and found that environmental awareness measures do not automatically change behaviour due to long-lasting habits that need to be broken down first (attitudes-intention-behaviour gap). Interviewed experts referred to a high - and already existing - level of environmental knowledge and energy saving awareness among vulnerable groups. In line with the quantitative results of this research and the detected high proportion of households who self-restrict on energy, it can also be questioned whether raising energy awareness is a fruitful approach to lower energy poverty.

The Green Electricity Relief and the Energy Efficiency Act

The Green Electricity Relief is outlined as a dedicated energy poverty instrument in the Austrian NECP that relieves low-income households of additional costs of green electricity production (Federal Ministry for Sustainability and Tourism, 2019). The Green Electricity Relief targets only households with low income and does not effectively reach those experiencing energy poverty, as it has the same requirements as exemption from broadcasting fees, which is managed by the GIS (Gebühren Info Service GmbH).[244] An evaluation of the program and its intended beneficiaries is necessary.

244 In 2022, the renewable subsidy will not be collected due to high energy prices. The ordinance came into force on 01.01.2022.

The policy review found that the energy efficiency programs of energy utility companies in Austria under the Energy Efficiency Act have not been effective in addressing energy poverty among low-income households (Austrian Court of Auditors, 2020).[245] The current measures under the Energy Efficiency Act are considered to be insufficient in terms of both the level of support and stringency to effectively address energy poverty among low-income households. To address this, a comprehensive strategy/ roadmap is needed that allows for investment in energy efficiency measures, and dedicated sanctionable targets for energy-poor households should be considered in either the Energy Efficiency Directive or the Austrian Energy Efficiency Act.

Phase out of Oil-fired Heating Systems

A socially compatible phase-out of oil-fired heating systems was outlined in Austria's Governmental Program to avoid cases of social hardship (Federal Chancellery, 2020). Income and energy poor households are at risk to fall further behind the energy transition, as mid- and high-income households may be the first adopters of low carbon heating and electricity technology (Sunderland et al., 2020).

While gas heating systems are banned in new buildings by 2025 at the latest, and oil boilers are already prohibited by law in Austria, the replacement of oil and gas heating systems in existing buildings will be expedited through available subsidies.[246] To help address energy poverty among renters, it is important to offer financial incentives for retrofitting rental properties. Renters face challenges, as disputes over "contracting tariffs" often arise in the rental housing market, particularly in multi-storey buildings. Renters have difficulty making changes to heating systems because the property owner must approve them. This presents a significant challenge in Austria, where 43% of people rent their homes (Statistik Austria, 2019). The Austrian Governmental Program does not address the legal barriers to switch to renewable heating, especially in multi-storey properties (Federal Ministry of Finance, 2021). From July 2022, subsidies for the replacement of fossil heating systems and a comprehensive thermal renovation were increased and they will be tax deductible if they meet the criteria for funding.[247] The non-subsidised rest of the costs is deductible over ten years. Households with low incomes

245 It is transposed from Article 7(7) of the EU Energy Efficiency Directive.

246 1.65 million households in Austria are affected by the phase-out of approximately 600.000 oil-fired heating systems (Matzinger and Herzele, 2020).

247 "Phase out of oil-fired heating systems" or "Federal Renovation Check".

are subsidised up to 100 percent for the new heating (Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, 2022).[248] The effectiveness and adoption of this measure are yet to be determined, but it is considered a potential stepping-stone in addressing energy poverty. However, this funding is limited to single-family, two-family, and terraced houses owned and occupied by the applicant as their primary residence. Therefore, the funding does not target multi-apartment buildings and tenants.

How the Design of the Austrian Housing Policies Shape Energy Poverty

Energy poverty in relation to housing policy has been inadequately explored, and it has been suggested that housing policies, including housing subsidies, as well as the rental housing sector and regulations governing maintenance work in the Tenancy Law, have a significant impact on the nature of energy poverty in Austria. Embedded within a complex multilevel governance structure, Austria is characterized by a high share of rental housing, where distinctive legal competences between the federal and federal states levels are evident. Austrian Tenancy Law, the Limited Profit Housing Act, and the rent setting system are federal level responsibilities, while the building-centred housing subsidies (object- and subject side) are typically the concern of the federal states. However, retrofitting subsidies are a concern at both the federal level (Renovation Check) and the federal states level (housing subsidy). This multilevel governance framework puts an additional complexity into the housing policy design in Austria as climate policy objectives are insufficiently considered in the existing Tenancy Law.

In the EU, energy poverty is highest among households living in rented apartment buildings and lowest among households living in detached and semi-detached properties (Bouzarovski and Thomson, 2020) as research results show, for instance, for Spain (Aristondo and Onaindia, 2018; Romero et al., 2018), France (Imbert et al., 2016), and Austria (Seebauer et al., 2019). According to the EU-SILC data analysis, energy-poor households predominantly live in the private rental segment built between 1945 and 1980. This housing segment is characterized by high rents, low rental protection, and the lowest energy efficiency among the building segments in Austria.[249] As landlords are not required to establish reserve funds (only a fictional reserve

248 Clean heating for all: The full 100 % subsidy can be applied for by households whose joint income does not exceed €1.454 net for a single-person household. A 75 % subsidy is available to single-person households whose combined income does not exceed €1,694 net. The subsidy is accompanied by energy counselling. The subsidy is financed by the federal government and implemented jointly with the federal states.

249 Tenants avoid requesting repair measures, reporting housing faults or retrofits from their landlords, as they fear disturbances, rent increases or – in the worst-case scenario – a cancellation of the rental contract. Moreover, time-limited rental contracts in Austria (three-year contracts) increased an put and additional vulnerability level onto tenants.

fund) for private rental properties, the Tenancy Law allows them to raise rents after a retrofit (for the next ten years) (after § 18 procedure) but only if the costs are not covered by the rental income for the next ten years. This short duration typically results in sudden high rent increases.

In the limited profit housing segment, where mid- to high-income households typically reside, heating and rent costs are lower and the energy efficiency of the building stock is higher (see chapter 9). However, entry conditions in the form of down payments impede energy poor from entering this housing segment.

"Climate change and decarbonization concerns should be given significant consideration in any future changes to residential law. It is suggested to improve tenants' rights and reduce the use of fixed-term rental contracts in private rentals. The repayment period for retrofitting costs could potentially be increased to align with the lifespan of the measures installed and reduce the burden of housing costs, but this would require updates to the Tenancy Law.

Housing Subsidies - for Whom?

The Austrian government offers several energy efficiency subsidies and grants for homeowners that include supporting both the energy efficient construction of new homes and the renovation of existing properties. Despite the incentives in place, the retrofitting rate in Austria has remained stagnant at 1% per annum for several years, significantly below the envisioned 2% target. Thus, the Austrian system of housing subsidies for retrofitting activities has not resulted in increased retrofitting rates, which would need to triple ideally to achieve EU climate targets (BPIE, 2020b). "In summary, there is a lack of energy efficiency subsidies (targeting renovation measures) for low-income or energy-poor tenants, as subsidies are skewed towards mid to high-income homeowners with adequate capital and rural building owners, rather than urban apartment dwellers (Schleich, 2019).

The Tenant/ Landlord Dilemma

The tenant-landlord dilemma is often discussed as a barrier to renovation measures. This widely accepted but incorrect interpretation of this concept is that landlords make the energy efficiency investment, while tenants reap the benefits of the renovation measures through reduced utility bills. However, in Austria, Germany, and other European countries, expenses are often shifted to tenants. For instance, in Germany there is the possibility for owners to allocate 11% of the total sum of the retrofitting costs to the tenant each year, as long as the tenant is informed at least three months before the start of the work (§ 559 BGB).

In Austria, housing law prescribes the maintenance obligations for homeowners; on the other hand, there are obligations towards tenants to tolerate increased costs in connection with maintenance and improvement work. On a wider note, in the Austrian policy debate, the question of who bears the bulk of the renovations costs remains a highly controversial issue as it is legally a grey area in Austria.

For instance, Sweden introduced energy efficiency grants dedicated to tenants who usually depend on their landlords to apply for these funds, as a way to overcome the landlord/tenant dilemma and make subsidies more accessible (Cludius et al., 2018). Sweden has reduced its overall and building- sector GHG emissions extensively mainly through two instruments: it introduced a CO_2 tax (114 EUR/tCO_2) and an all-inclusive rent system with an all you can heat flat rate (including tax savings). As a result, the landlord pays utility costs and is incentivized to reduce energy consumption and avoid carbon taxes by retrofitting and replacing inefficient heating systems (Agora Energiewende, 2021). The landlord benefits from reduced heating costs by switching to more efficient heating systems. Simultaneously, retrofitting costs are not passed to the renters.

Eco-Social Tax Reform

The introduction of a carbon tax on petrol, diesel, natural gas, heating, oil, and coal in Austria is a stepping-stone to the decarbonisation path. As affected companies pass the higher production costs onto consumers, particularly the areas of space heating and transport will be affected. Therefore, the responsibility for achieving the climate goals is outsourced to the consumers. As the costs for a CO_2 tonne gradually increases, households who exchange the means of transportation and heating toward renewable energy on time have an advantage, while others may face substantial price increases. The so-called “eco climate bonus” favours households in the rural part of Austria. These research results showed that energy poverty predominantly occurs in cities and among renters. As, renters are less likely to negotiate and decide on the heating system they may use, price signals, such as sharing the CO_2-price costs to incentivise landlords to exchange fossil heating systems are necessary. Otherwise, renters in the city who heat with oil and gas will be hardly affected by the CO_2 tax that companies bypass to end consumers.

Rethinking Energy Consumption: Focusing on Affluent Households

EU GHG emissions are unequally distributed among citizens, with a 25% decrease in emissions among poorer citizens and a 5% increase among the wealthiest over the past 25 years (Sivan Kartha et al., 2020). This calls for a critical public and scientific discussion on effective ways to reduce emissions, such as awareness campaigns, nudges, and energy-saving counselling. For example, research results show that the richest 10% EU citizens were responsible for over a quarter (27%) of EU emissions (Sivan Kartha et al., 2020). Hence, since the carbon footprint increases with income, targeting the highest income deciles is crucial (Malier, 2019; Thøgersen, 2021). Galvin (2013) for instance, found that "heavy energy consumers" often continue to consume large amounts of energy after a retrofit and suggests targeting specific interventions towards this group. By studying households with both low and high energy consumption, we can have a more comprehensive understanding of energy consumption patterns and inform effective energy and climate policy.

The idea that individuals should take responsibility for promoting environmentalism is common in both public discourse and research, so-called "eco-habitus" (Carfagna et al., 2014). However, this must also be supported by government incentives, subsidies, and regulations. Society's increasing emphasis on individualism puts pressure on individuals to adopt sustainable behaviors[250], but there is limited research on the effectiveness of individual pro-environmental behaviors and their impact on the environment (e.g. reducing GHG emissions). Research, if it does not specifically address this critically, reinforces this discussion and expects from consumers to act accordingly in an environmentally-friendly way. Many consumers struggle to identify which behaviors are most impactful and may prioritise low-impact behaviors, even if they have a high pro-environmental self-identity (Thøgersen, 2021). The largest contributors to a person's carbon footprint are transportation (air travel), buildings (heating), and food (Moran et al., 2020).

Shove (2010) for instance, argued against treating behavioural theories as a “holy grail” as they incorporate the logic that individuals have a choice. Clichés, stereotypes and the tendency to attribute the ‘energy poor’ as consumers who are using energy in a ‘wasteful’ way or who have ‘insufficient knowledge’ about sustainable energy consumption are voices of the hegemonic logic of neoliberal thinking, which also makes strong assumptions of ‘deserving’ and ‘non-deserving poor’ (Bridges, 2017; Grossmann and Trubina, 2021; Jenkins et al., 2016). Malier

250 Called the ‘behavioural change agenda’ (Barr and Prillwitz, 2014).

illustrates that lower-income/ energy poor households in France are specifically targeted in poorer neighbourhoods with intervention campaigns because of their alleged "*lack of sensibility for environmental issues: […], the higher the income and the social class, the more one is sensitive to environmental and sustainable development discourses*" (Malier, 2019, p. 1674). Higher income, though, may lead to high environmental awareness, but not lower carbon footprint. Harvey (2007, p. 145) has summarised this neoliberal societal challenge aptly in the following way:

> *"neoliberalism has, in short, become hegemonic as a mode of discourse, and had pervasive effects on ways of thought and political-economic practices to the point where it has become incorporated into the common-sense way we interpret, live in and understand the world" (Harvey 2006, p.145).*

This hegemony has put in motion the acceptance of less state intervention but transferring greater responsibility to individuals (Rose, 1999; Rose and Miller, 1992). Research centred around blaming lower income beneficiaries who receive welfare support and taking responsibility for their own situation (Juhila et al., 2016).

The research in this thesis does not aim to promote reducing daily energy consumption to unsustainable levels. Instead, it sheds light on the structural causes that lead to self-restriction behaviours among social housing tenants. Results, based on the amended theory of planned behaviour, highlight how habits and decrepit building conditions impact self-restriction behaviours. The findings emphasize the need for targeted structural improvements in the worst performing buildings, as an alternative to or in addition to awareness raising campaigns on energy conservation. Crouch (2012) asserts that governments remain the only entities in society with the means to ratify required reforms for long-term sustainability. If not sufficiently counteracted, the energy transition risks exacerbating current inequalities, generating new forms of inequality, or perpetuating existing winners and losers. However, it can also be a catalyst for change, offering alternative ways to alleviate energy poverty, create green jobs, reduce negative externalities, improve welfare and health of EU citizens, and decarbonize the EU.

Instrument	Content and Target Group	Limitations/ Advantages	Level/ Institution
Fuel subsidy: [German: “Sauber heizen für alle”]	Replacement of a fossil fuel heating system heating system with a climate-friendly technology. Specifically targeted at low-income households (lowest three income deciles according to EUROSTAT) living in a single-/two-family house/ terraced house	- Limited to single-family and two-family houses as well as terraced houses - Tenants are not addressed - Earmarked	Funded by federal government implemented with federal states
Out of oil and gas [German: “Raus aus Öl und Gas”]	Boiler replacement multi-storey residential building: building owners or their authorised representative (e.g. property management company) on behalf of the owner of a multi-storey residential building or a terraced house complex with at least three residential units/row houses	In the case of centralisation of the climate-friendly heating system, tenants and apartment owners of individual apartments can also apply for funding, provided they bear the costs of the conversion.	Funded by federal government implemented with federal states
Support for renovation measures	- Mid-to high income households - Sustainably addresses one of the causes of energy poverty (energy inefficiency) - Potentially contributes to overall climate goals by improving energy efficiency	- Lack of access to capital to induce renovation remains - Landlord/tenant dilemma - No connection to social policy resort to provide incentives to energy poor households - Pre- and rebound effects	Federal government and Federal States
- Reduction of energy (heating/ electricity) prices, - Facilitation of payments (instalments) - Acute assistance (basic care, prepayment counter	Specifically targeted at households with payment difficulties or low-income households	- Does not address the causes of energy poverty - Does not incentivise energy efficiency - Granted only to electricity and gas consumers	Energy utilities: Obligation to provide basic supply

- Restrictions in the event of shutdown, one-time subsidies for outstanding receivables)			
Personalised support for energy poor households	- Targeted on case-by-case - Basis by social workers using a checklist - Not restricted by income thresholds but acknowledges more multiple deprivations	- Short-termed - Number of households that are reached limited - Households need to proactively and voluntarily approach	Social NGO Caritas
Information on energy saving measures	- Awareness raising - Aimed in reducing energy consumption - May induce behavioural change (e.g nudges)	- Only partial addressing of target group (not relevant for frugal households) - Attitude-behaviour gap, challenging to break old habits	Klimaaktiv (Federal) + social NGO
Green Electricity Relief	Specifically targeted at low-income households and conditioned to retirees, job seekers, deaf, students receiving study grants, recipients of public funds	- Low up taking rate - Not adequately targeted towards low energy poor households	Federal Ministry for Sustainability and Tourism, Energy regulator
Eco Social Tax and Eco Climate Bonus	- CO_2 tax started in 2022 with 30 €/per tonne - 100 € Climate bonus - Climate bonus contains a regional compensation	- Low-income households get the same as high-income households - Privileges households in rural parts of Austria - There is no special support for tenants. They have the problem that they cannot choose their heating and still have to pay the CO2 tax.	Federal tax office Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

Table 39 Energy Poverty Instruments in Austria (Source: E-Control, 2023; Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology, 2023; Klimaaktiv & Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology, 2023; Kommunal Kredit Public Consulting, 2023a, 2023b).

13.3 Limitations of the Study and Directions for Future Research

Several methodological and conceptual limitations of this study must be discussed to be transparent and to guide future research. This chapter discusses twelve limitations and presents recommendations for improving the validity and reliability of future research in this field.

First, the lack of an official energy poverty definition on the EU level obstructs monitoring endeavours and developments over the time. A common pan-European definition of energy poverty would clarify what is meant by energy poverty and increase recognition and prominence. Harmonized, dedicated, and improved data collection at the EU level would enable comparable assessments and facilitate evidence-based policy design. There is no dedicated energy poverty survey or standardised household micro data, which captures energy expenditures. Moreover, energy consumption and energy efficiency data are not harmonised. Since expenditure-based approaches typically rely on energy costs, the estimates should be analyzed with caution due to their respective limitations. Consensus-based approaches are better suited to understanding energy poverty, among other reasons, due to their easier data handling. To address this, it is recommended to establish a dedicated European-wide survey on energy poverty. Moreover, the EU-SILC datasets should be improved so that energy costs are included in the questionnaire (Karpinska and Śmiech, 2020). A recommendation for Austria is to implement an updated national definition that is not only based on expenditure-based metrics, and a monitoring system for energy poverty as, for instance, in Spain (Tirado Herrero et al., 2018; Tirado-Herrero, 2017).

When using EU-SILC proxies, an additional challenge arises in the validity of the survey question related to the ability to afford to keep homes adequately warm. To enhance validity, adjustments could be made to the wording of the question in order to expand the focus from mere affordability issues to take into consideration other reasons for being unable to keep homes adequately warm, such as an inadequate heating system or housing inefficiency. Instead of relying on a pre-defined temperature level at home (e.g. set between 18°C and 20 °C), a comparison between households' subjectively preferred and actually achieved temperature levels, as proposed in the primary survey, could enhance the discussion.

Furthermore, it is important to include disaggregated data across the EU, particularly with respect to gender and age. This aligns with the European Parliament’s 2016 request to include gender in all energy policies and establish a link to vulnerable consumers and energy poverty (Feenstra and Clancy, 2020).

One potential source of limitation of various identification procedures is the error of exclusion of households that are energy poor (Dubois, 2012). This limitation can be minimized by expanding the EU-SILC database and incorporating additional questions on self-restriction behavior in ad hoc EU-SILC surveys, Eurobarometer, or the International Social Survey Program. As MS are required to monitor energy poverty incidences according to the Governance Regulation (2018/1999/EU), a central entity could track how MS defined energy poverty within their national context to foster learning. The Energy Poverty Advisory Hub could provide such information and a platform to track MS progress.

The ***second*** limitation pertains to the characteristics of the sample used in the primary survey data, which may result in an overrepresentation of dissatisfied social housing residents. The author acknowledges the risk of self-selection bias, as some individuals may have been more likely to participate due to the perception that the study criticizes structural housing problems (Gemmill et al., 2012; Groves et al., 2004; Herzog and Kulka; Quinn, 2010). As a result, because the sample is overrepresented with retirees, lower educated and low-income households, generalisations of the results to the broader population should be done with caution.

The ***third*** limitation of the primary survey data relates to the inadequacy of the survey responses, which may result in acquiescence bias. The Latent Class Analysis ("LCA") identified flaws in the survey questions (see Biemer (2011) or Kreuter et al. (2008)), including issues with semantically reversed items that resulted in atypical response patterns. In particular, the behavioral questions exhibited lower reliability, poor factor models, and lower factor loadings (Carlson et al., 2011; Suárez-Álvarez et al., 2018; Woods, 2006). This pitfall has led to the practical implication to exclude these questions from the analysis. Similar difficulties were encountered during the Confirmatory Factor Analysis (CFA), so that some semantically reversed items needed to be removed from the latent construct "energy restriction behaviour". Despite this drawback, without the problematic items, the CFA yielded acceptable model results that point to the structural validity of the models.
The odd response patterns in the study could be due to household inattention or a complicated/ long questionnaire. Other reasons could be that the questionnaire contained too complicated questions or was too long. Some research results have shown that acquiescence bias is more frequent among individuals with lower levels of education or among the elderly (Meisenberg

and Williams, 2008; Rammstedt and Kemper, 2011; Weijters et al., 2010). The sample consists of pensioners with above-average income and households with lower levels of education, which may have had difficulties answering the semantically reversed questions. However, comprehension of reversed items requires higher linguistic skills and verbal ability. This may have overwhelmed elderly participants, leading to difficulties in processing regular and reversed items (Quinn, 2010). As recommended by Suárez-Álvarez et al. (2018), it is not advisable to include a combination of regular and reversed items in the same questionnaire for social housing residents.

The ***fourth*** limitation concerns the exclusion of important energy poverty indicators in the primary survey. Three of the most prevalent issues were:

a. Summer energy poverty

Energy poverty is not only about keeping warm in cold weather but about also keeping cool during hot temperatures and heat waves. Previous research and expert interviews directed to summer energy poverty and too hot indoor temperatures, which can lead to health problems and reduced well-being for vulnerable households (Sanchez-Guevara et al., 2019; Thomson et al., 2019). Social inequalities exist in the risk of exposure, with urban heat islands and poorly insulated homes increasing vulnerability. As weather extremes are predicted to increase due to climate change, vulnerable households are disproportionally at risk of adverse health effects and impairment of well-being because of poorly insulated living spaces without shade (Madrigano et al., 2015; Sánchez-Guevara Sánchez et al., 2020; Santamouris and Kolokotsa, 2015; Thomson et al., 2019). "Investigating summer energy poverty in Austria is crucial due to the increasing heat waves and rising temperatures in Vienna, where the number of heat wave days has risen from 15 in 1995 to 37 in 2018, and overall temperature has increased from 10.4°C to 12.4°C, respectively (City of Vienna, 2021).

Despite diverse climatic zones and culturally dependent expectations of temperature comfort, the demand for air conditioning systems is increasing worldwide, which results in amplified energy consumption (International Energy Agency, 2018). The adoption of air conditioning,[251] however, bears the risk for a social normalisation of resource-intensive consumption standards and the establishment of path dependencies with pressures on electricity grids and increases in

251 In Austrian social housing, installations of air conditioning devices that require interventions on the façade are forbidden (Die Mietervereinigung, 2020).

local and global GHG emissions. Climate targets can be undermined even when the newest air conditioning systems are more energy efficient. The International Energy Agency urges that

> "*the growth in global demand for space cooling is such a blind spot: it is one of the most critical yet often overlooked energy issues of our time*" (International Energy Agency, 2018, p. 3).

b. Arrears on utility bills and energy disconnections from electricity supply

In the case study survey, two proxy consensual-based indicators were excluded due to survey length, namely arrears on utility bills, and the amount of disconnections from electricity supply. Therefore, the estimated amount of energy poor households in social housing reported in this thesis might not be accurate or even be underestimated.

c. Heat or eat dilemma

The primary survey lacked questions on trade-offs, such as the heat or eat dilemma. The primary survey lacked questions on trade-offs, such as the heat or eat dilemma. A study by Papada and Kaliampakos (2016) found that 75% of Greek respondents felt forced to reduce other basic needs in order to cover energy needs. Future research could include questions on severe deprivation. The primary survey did not focus on severe decisions to reduce energy consumption (e.g. instead of wearing a pullover before turning on the heater, respondents could wear a jacket and turn off the heater when they are at home).

This ***fifth*** limitation acknowledges the challenging applicability of the proposed multidimensional energy poverty indicator (MEPI): progress was made in this thesis capturing the multidimensional nature of energy poverty in Austria utilising EU-SILC data and a survey of social housing residents in Vienna. However, despite the innovative character to capture hidden energy poverty, the development of the MEPI can be complex to operationalize and adapt to other regions in the EU as data on energy self-restriction behaviors are not yet available. Energy poverty definitions should be generic but also illustrate context dependent specificities of the regions (Robinson et al., 2018a). Further analysis is needed to compare discomfort levels and the severity of self-restriction behaviours in different regions of Europe (e.g. East or South Europe).

The ***sixth*** limitation concerns the CFA and SEM and the inadequate number of items per latent construct, and the resulting methodological difficulties. The use of only two items for operationalizing influencing latent factors (e.g. environmental intentions, internal perceived behavioral control) may limit the study results. Ideally, three or more items are desired per latent construct. Although CFA and the SEM model results indicated acceptable levels of model fit, in future studies, it is advisable to use more than two items for measuring the corresponding latent constructs. However, this also requires higher data collection efforts and a longer survey.

The **seventh** limitation concerns the questionnaire design and the range of Likert scales. The range of the response scale from 1 (disagreement) to 4 (agreement) was chosen based on the pre-test in the social housing. Larger Likert scales are recommended for several statistical methods that require normally distributed data, such as SEM (maximum-likelihood estimator). Non-normal data can produce inflated model test statistics and under-estimated standard errors. While Satorra-Bentler adjustment provides a solution to correct this issue, however, it is not an optimal solution. This pitfall results in the fact that the ‘full information maximum likelihood’ option was not applied and sample size decreased during the model estimation. For instance, socio demographics could not enter the SEM as convergence issues occurred.

The ***eighth*** limitation is related to sample bias and survey language. The study did not ask households about their migration background, which has been found by other researchers to increase the risk of energy poverty (Großmann and Kahlheber (2017) as well as Drescher and Janzen (2021)). During the expert interview with the Caritas, households with migration background were mentioned as a target group in need of support. 30.2% of the population in Vienna has a foreign origin and does not hold Austrian citizenship (Stadt Wien, 2019). However, access to social housing is difficult for newcomers, refugees[252], and people with a migration background as eligibility is conditioned on providing two years' proof of residence at the same address in Vienna. In 2015, the city's government introduced a bonus system for long-term residents for Vienna's housing ticket, which has made it even more difficult for people with migration background to access social housing (Aigner, 2019).[253] Nevertheless, the questionnaires were distributed in the German language, which may have affected the sample and response rate (Font and Méndez, 2013).

The ***ninth*** limitation of the study is the low sample size and response rate of 6% in the social housing survey. This low response rate could be attributed to a variety of factors: participation fatigue, a complex questionnaire, limited relevance, perceived lack of benefits from

252 Aigner highlighted that refugees face a major challenge to enter social housing, and they are pushed to renting apartments in the private rental market, which are usually more expensive (rents in the regulated private sector rose by 66.8% between 2000 and 2010). Rents are 1/3 higher in the private market compared to the social housing market in Vienna (Trokner 2017).

253 Only since 2001, people with a migration background may enter social housings (Demokratiezentrum Wien, 2015).

participation, forgetfulness, or mistrust in surveys. To address this limitation, future research can consider implementing various strategies to improve response rates, such as providing greater incentives, involving key stakeholders, such as housing caretakers (in German: HausbesorgerInnen and HausbetreuerInnen) or gatekeepers as multipliers, and conducting additional face-to-face interactions through tenant advisory boards or information campaigns during tenancy meetings.[254] This study acknowledges the low response rate and the need for validation in future representative research. Nevertheless, a sample size of 412 for both SEM and LCA methods was considered adequate, based on rule-of-thumb recommendations, and met the required minimum sample size of 200 for SEM and 70 for LCA (Gerbing and Anderson, 1985; Wurpts and Geiser, 2014).[255]

The ***tenth*** limitation of the study is the use of self-reported data, that may be influenced by social desirability, recall bias, and other inaccuracies in reporting actual energy behaviours (Bell et al., 2019). Anonymity and confidentiality were ensured in order to mitigate social desirability bias. However, the validity of self-reported data is a common criticism, as respondents may suffer from memory decay and inaccurate self-judgment to judge their own behaviour accurately (Ewert and Galloway, 2009; Gatersleben et al., 2002; Kormos and Gifford, 2014; Milfont, 2009; Podsakoff et al., 2003). Furthermore, Hills (2012b) stressed that for subjective energy poverty measures cultural, generational, and demographic determinants influence participants' responses. Hills points to inconsistencies across respondents.

Nevertheless, a recent meta-analysis by Vesely and Klöckner (2020) found only small correlations (r = .06 -.11) between social desirability and self-reported environmental actions, and distortions in this survey were likely due to unreflective answers, poor memory, and misinterpretation of questionnaire items. A pre-test was conducted with students, researchers and social housing residents to minimize the likelihood of misinterpretation.

The study's results based on self-reported data may not accurately reflect the full scope of energy restriction behaviors as the survey was conducted during the non-heating season and may not have captured the behaviour when it is more noticeable. Further studies, including

254 Unfortunately, it was planned to place informational material in form of a one-pager of the survey on front doors of the buildings, but 'Wiener Wohnen' declined this request, as well as, displaying their logo on the cover letter of the survey.

255 Moreover, two general comments on the Confirmatory Factor Analysis (CFA) and the Structural Equation Modelling (SEM) results must be addressed: firstly, some latent factors contained only two items, which may contribute to the moderate fit of the models. Ideally, in CFA and SEM, models require at least three indicators for each latent variable. Secondly, there are limitations to this analysis, including the moderate sample size that resulted from using the Satorra-Bentler estimation method, which excludes the full-information maximum likelihood estimation method. Despite this, Iacobucci (2010) argued that if the structural path model is not overly complex, then samples of size 50 or 100 are sufficient.

actual energy consumption and efficiency data, during the heating season would provide more accurate validation of energy restriction behaviours.

The ***eleventh*** limitation of the study is that it does not assess actual energy use before and after the retrofit (in kWh or GHG terms) in order to analyse potential rebound effects (Chitnis et al., 2014). This would have required a more sophisticated research design and a longer data collection period. A further note of caution is due here since the retrofit occurred up to a maximum of five years ago and responses to behavioural change questions following the retrofit may lead to biases due to memory limitations, over- or underestimation, or social desirability.

The ***twelfth*** limitation concerns the collection of cross-sectional survey data at one point in time. This study was cross-sectional and descriptive and should be interpreted with caution, and causality of the latent construct cannot be implied.

In summary, all practical attempts to minimise the limitations listed above have been undertaken to increase validity and reliability of the research and improve the generalizability of the findings. The survey data results are a snapshot ot the current state of energy poverty in social housing in Vienna at a given point in time. These findings can serve as a foundation for future research in this area and can inform policy decisions aimed at addressing energy poverty and improving living conditions for residents.

14. Conclusion

In this chapter, the major findings of the research project are reaffirmed. The main purpose of the thesis was to provide answers to the research questions "*How can we explain energy poverty in Austria? Who suffers from energy poverty? And are current policies able to tackle energy poverty and climate change at the same time in Austria*?" The research employed a mixed method approach based on pragmatism, which gave the opportunity to answer questions simultaneously using semi-structured qualitative interviews, policy analysis, and with primary and secondary survey data. The qualitative methods examined expert knowledge on energy poverty, housing, and climate policy in Austria. By using a quantitative approach, vulnerable groups and building segments were identified in Austria, and primary data were gathered on self-restriction behaviors and various determinants of energy poverty among residents of social housing in Vienna.

Energy poverty is a complex and multi-layered problem that necessitates multidimensional solutions. The phenomenon can be explained using a combination of multiple indicators: objective (expenditure-based), subjective (consensual), and a combination of both. EU-SILC data from 2019 and primary data from retrofitted and non-retrofitted social housing tenants in Vienna were analyzed.

The analysis of EU-SILC data revealed that energy poverty in Austria has a gendered aspect, with higher risk observed among women, single parents, single women living on a pension, elderly individuals, and households that have experienced critical life events. Tenants in social housings or private rental, in multi-storey buildings constructed between 1945 and 1980, and in cities are particularly affected. Depending on the applied definition, the research results show a range of 4-12% energy poor households in Austria. Energy poverty is a situation where individuals cannot afford to meet their household energy needs. As a result, households may be forced to reduce their energy consumption due to high costs, or alternatively, prioritize energy usage over other essential needs, which can lead to further financial strain.

To advance the identification of energy poor households, a research gap was identified, which highlighted the role of self-restricting behaviours to avoid high utility costs. Therefore, this thesis proposed a fresh look at hidden energy poverty by offering an alternative method for evaluating self-restricting energy behaviours. The items and methods can be used in future research in conjunction with large-scale surveys to assess energy poverty. The expenditure-based hidden energy poverty indicator was extended, and a consensual aspect of self-restrictions was added to account for underconsumption and energy deprivation. For the first time, a latent class analysis was used to identify self-restriction behaviors indicating hidden energy poverty in the non-retrofitted social housing sector in Vienna. The analysis revealed that a significant number of tenants in social housing utilize self-restriction behaviors.

Both - the primary and secondary - survey analyses indicated heterogeneity of energy poverty risks meaning that each of the indicators reflects a different aspect of energy poverty, and it suggests that there are clear limitations of using single indicators to gain a full picture. The current benchmark indicator used in Austria reflects only a part of the reality of energy poverty, while also underestimating the problem, as the inefficiency of buildings is not included in the indicator calculation. Therefore, this study contributed to the recent energy poverty debates by developing an integrative model to energy restriction behaviour. Multiple influencing factors were identified including ingrained habits, housing faults, environmental attitudes, external and internal perceived behavioural control, social norms, and positive environmental intentions (please see Table 37 for detailed hypothesis test results).

As the Austrian government aims to become climate-neutral by 2040, the risk of vulnerable households being left behind the energy transition becomes a more prominent political problem. The energy transition runs into danger that it may i. enhance current inequalities, ii. produce new or different forms of social inequalities, or iii. preserve existing “winners” and “losers”. Combating energy poverty is a challenge primarily because it lies at the intersection of social, housing, climate and energy policy. The research found that different government departments require coordinated intersectorial cooperation at the national, regional, and local level. However, the analysis revealed that Austria's multilevel governance structure priorities separate areas of responsibility instead of integrating policies vertically, horizontally, or diagonally. To pursue effectively both climate and social objectives, policymakers should consider social hardship and policy targeting, while avoiding silo-based thinking between departments. The decarbonization of the building sector poses a range of challenges that demand a comprehensive package of policy measures. To address these challenges, policies should be tailored to the unique needs and circumstances of various building sectors, such as private, social, and communal buildings, and incentivize targeted implementation in the worst performing buildings. Increasing energy efficiency where affected households live is the silver bullet, since - in contrast to increasing income or reducing energy prices - it not only offers longer termed permanent financial relief for the households concerned, and addresses the root of the problem, but also contributes decisively to reducing CO_2 emissions and thus protects the climate ("win-win-win").

Ensuring access to energy such as electricity, gas, and heating is essential for an individual's ability to meet their basic needs and participate in society. Therefore, short-termed financial measures to avoid disconnections prevent other multiple problems from aggravating or occur. Moreover, measures that strengthen protection against disconnections during winter are necessary. Nevertheless, current subsidies and programs in Austria are predominantly short-termed and miss their target because they are poorly tailored to the groups of energy-poor individuals identified in this research. EU and national laws create loopholes that hinder the achievement of climate neutrality by 2050. Austrian Tenancy Law results in conflicting interests, and in the end the renovation rate is paralysed since a decade. This is currently aggravated due to increased construction and building material prices and craftworkers' shortages. When renovations are performed that do not result in warm-rent neutrality, this can pose a problem for tenants, as they can no longer afford to pay the rent as the overall housing costs increase.

The establishment of a political will to address energy poverty effectively is contingent upon the ability to define, identify, and measure the extent of the problem. Given that energy poverty is determined by political actors, there is the possibility that certain populations affected by energy poverty may be excluded from consideration, as has been observed in the case of Austria. Moreover, if skimping on energy remains a blind spot, the participation of vulnerable households in the energy transition is in danger.

This research suggests that there is unlikely to be a one-size-fits-all approach to combat energy poverty due to diverse national causes and consequences of energy poverty across different regions or populations. As Austrian tenants are highly affected, incentives to retrofit must be developed that consider local contexts and are compatible not only economically but also socially. Therefore, policies must address the tenant-landlord dilemma.

The key recommendations are:

Adopting a formal, harmonised, and official definition of energy poverty and incorporating it into legislation is crucial for all Member States for both statistical and subsidy purposes. Additionally, it is recommended that Member States adopt an inclusive definition of energy poverty that accounts for the main contributors to energy poverty in the national contexts. The absence of a proper definition hinders the ability to assess the extent of the issue accurately, monitor its evolution, and evaluate the efficiency of current solutions. To tackle energy poverty effectively, subsidies must be administered more precisely and comprehensively, incorporating energy efficiency measures, such as thermal upgrading, in programs aimed at supporting vulnerable households. A comprehensive, long-term national strategy (e.g. sectoral roadmap) with a timescale, interim milestones, science-based binding targets is necessary to achieve this objective.

Households that experience energy poverty often encounter difficulties when attempting to access subsidies because of the confusing, bureaucratic nature of the process, a lack of clarity in program requirements, or other factors, such as reluctance to apply for welfare support. To streamline the process and make it more accessible to all households, the establishment of a local 'one-stop shop' contact point is recommended, which would provide comprehensive, free, and independent information and help throughout the application process. Such an approach would simplify the funding process and benefit not only energy-poor households. "European climate targets have been adopted and transferred to national levels, but smaller administrative units lack clear linkage and scaling. To develop measures, responsibilities must be clearly defined for each unit, and a multilevel governance structure is required to increase effectiveness in climate protection.

A sharp rise in energy prices has prompted many energy providers to increase their tariffs, exacerbating energy poverty, particularly considering inflation. The COVID-19 pandemic has only added to the financial burden on energy-poor households, making it even more urgent to address this growing problem. Rising system costs for a sustainable energy infrastructure and technology transition also add to the long-term burden. The recent quarterly data reveals a concerning trend: in 2021 (survey date February to July 2021), 2.0% of Austrian households reported that they could no longer adequately heat their homes, and in Q2 2022, the number had increased to 9.2%! This means that nearly 750,000 people in Austria were unable to heat their homes properly before the onset of the 2022 winter season (Statistik Austria, 2022a). To address these challenges, a package of immediate aid and medium-term measures is needed, including a waiver on shut offs, increased heating subsidies, and a climate and energy assistance fund.

To conclude, to prevent the exacerbation of social inequalities, policies must address and mitigate social inequalities resulting from climate change and ensure that vulnerable households are not left behind during the energy transition. Additionally, it is crucial to understand the differences between forced and voluntary self-restrictions on energy consumption of vulnerable households. As self-restrictions may be common and 'normal' for some households, this could add pressure on vulnerable households. A holistic, intersectoral approach is necessary, encompassing social, housing, climate, and energy policies to avoid silo-thinking. This involves collaboration and coordination among stakeholders, partnerships between governments, civil society, and the private sector, as well as the need for community engagement and participation.

Women are more likely to be energy poor in Austria than men; therefore, inclusive gender and intersectional-aware policies and programs must be adopted to effectively address the diverse needs, underlying structural and systemic causes of energy poverty. By addressing the root causes instead of just symptoms, the energy transition can create green jobs, reduce negative externalities, increase health, and decarbonise the EU while ensuring that nobody is excluded from participating because of financial constraints. The energy transition can be a catalyst for change that offers alternative ways to ease energy poverty. For this, the causes must be addressed in a holistic way and not just the effects mitigated.

15. Abstract

English

Using a concurrent triangulation design, this dissertation investigates energy poverty in Austria, with a focus on social housing in Vienna. A novel indicator of hidden energy poverty is proposed using latent class analysis on survey data, revealing that numerous households employ self-restrictive behaviours to lower energy consumption in order to save money. Rationing of energy consumption is related to energy inefficient buildings and multiple further factors, including ingrained habits, environmental attitudes, external and internal perceived behavioural control, social norms, and positive environmental intentions. Furthermore, the EU-SILC data (2019) analysis shows that households at high risk of energy poverty can be found throughout Austria, in the periphery, in large owner-occupied houses, and in multi-storey buildings in the city. The predominant household composition indicates that energy poverty is deeply gendered and interconnected with other socio-democratic variables such as age, low-income households with children, and the elderly are also at high risk. The primary and secondary survey analyses indicate heterogeneity of energy poverty risks, meaning that single indicators cannot provide a full picture of energy poverty.

The multilevel policy analysis reveals that despite national strategies, institutional barriers at the federal, state, and local levels persist, calling for a more ambitious policy approach from Austria and the EU. This is why the EU is advised to develop a clear-targeted political strategy to give energy poverty more visibility, and establish a sustainable stakeholder dialogue to ensure that energy needs of the estimated 50 to 125 million Europeans living in energy poverty are met. Increasing the rate of large-scale renovation activities in the EU and Austria is necessary to address energy poor households and achieve the stated climate targets. Considering the current soaring inflation and high energy prices, timely and structured action is required to ensure that energy-poor households are not left behind in the process of achieving climate neutrality. The key question is, can the Green Deal practice what it preaches and lead the EU to be the first continent in the world that is climate neutral in a fair and socially just manner by 2050?

Deutsch

Diese Arbeit untersucht Energiearmut in Österreich. Durch ein Triangulationsdesign werden die österreichischen Bemühungen zur Bekämpfung von Energiearmut näher analysiert. Es wird ein neuer Indikator für versteckte Energiearmut vorgeschlagen, der auf der Grundlage von Umfragedaten von Bewohner*innen des sozialen Wohnungsbaus in Wien mittels einer latenten Klassenanalyse ermittelt wurde. Die Ergebnisse zeigen, dass ein beträchtlicher Teil der Haushalte ihren Energieverbrauch einschränken, um damit Geld zu sparen. Die Rationierung des Energieverbrauchs steht im Zusammenhang mit energieineffizienten Gebäuden und mehreren weiteren Faktoren, darunter tief verwurzelte Gewohnheiten, Umwelteinstellungen, externe und interne wahrgenommene Verhaltenskontrolle, soziale Normen und positive Umweltabsichten. Darüber hinaus zeigen die Ergebnisse der Analyse der EU-SILC-Daten (2019), dass Haushalte mit einem hohen Risiko für Energiearmut in ganz Österreich zu finden sind, in der Peripherie, in großen Eigentumshäusern und in mehrstöckigen Gebäuden in der Stadt. Es wurde festgestellt, dass die am stärksten von Energiearmut bedrohten Gruppen Mieter*innen und Frauen sind. Die vorherrschende Haushaltszusammensetzung deutet darauf hin, dass Energiearmut stark geschlechtsspezifisch ist und mit anderen soziodemographischen Variablen wie dem Alter zusammenhängt; einkommensschwache Haushalte mit Kindern und ältere Menschen sind ebenfalls stark gefährdet.

Die Analyse der Energiearmutspolitik auf mehreren Ebenen zeigt, dass Österreich ehrgeizigere Maßnahmen ergreifen sollte, um Energiearmut zu lindern, da institutionelle Hindernisse auf Bundes-, Landes- und lokaler Ebene zum Fortbestehen in Österreich beitragen. Trotz der Bemühungen, das Problem durch nationale Energie- und Klimapläne und nationale langfristige Sanierungsstrategien anzugehen, bleibt das Problem fragmentiert in verschiedenen Ministerien angesiedelt und wird von der österreichischen Bundesregierung nur unzureichend angegangen. Auf EU-Ebene ist es ratsam, eine klare politische Strategie zu entwickeln, um Energiearmut mehr Sichtbarkeit zu verleihen und sicherzustellen, dass die Energiebedürfnisse der schätzungsweise 50 bis 125 Millionen Europäer, die von Energiearmut betroffen sind, erfüllt werden. Das Tempo der Sanierungsmaßnahmen in der EU und in Österreich muss beschleunigt werden und energiearme Haushalte müssen entsprechend adressiert werden, um die erklärten Klimaziele zu erreichen. Die Schlüsselfrage lautet: Kann der Europäische Grüne Deal, was er verspricht, in die Tat umsetzen und die EU zum ersten klimaneutralen Kontinent der Welt machen, und das auf faire und soziale Weise bis 2050?

Appendix A

Expert interview guide in German

1. Klimapolitische Ziele

- 1.1. Deckt diese Liste aus Ihrer Sicht die wichtigsten Ziele ab? Welche Ziele sollen hinzugefügt, gestrichen oder umformuliert werden?
- 1.2. Sind diese Ziele explizit in Strategiedokumenten oder verbindlichen Verpflichtungen festgelegt, oder implizit als mehr oder weniger ausgesprochener Konsens zwischen verschiedenen Akteuren?
- 1.3. Mit welchen Indikatoren werden diese Ziele erfasst und auf ihre Zielerreichung hin beobachtet?
- 1.4. Welche Maßnahmen gibt es, um diese Ziele zu erreichen?
  - 1.4.1. Objektbasierte Maßnahmen: Förderungen für Sanierung, Förderungen für Tausch des Heizsystems, Gebäudestandards für Neubauten
  - 1.4.2. Subjekt- bzw. haushaltsbezogene Maßnahmen: Informationskampagnen, Vor-Ort-Beratungen, Steuern auf Energieträger
  - 1.4.3. Wer ist für diese Maßnahmen zuständig?
  - 1.4.4. Welche Bevölkerungssegmente werden von diesen Maßnahmen erreicht?
  - 1.4.5. Welche Gebäudesegmente werden von diesen Maßnahmen erreicht?
  - 1.4.6. Welche Maßnahmen werden geplant oder diskutiert, sind aber noch nicht umgesetzt?

2. Sozialpolitische Ziele

- 2.1. Deckt diese Liste aus Ihrer Sicht die wichtigsten Ziele ab? Welche Ziele sollen hinzugefügt, gestrichen oder umformuliert werden?
- 2.2. Sind diese Ziele explizit in Strategiedokumenten oder verbindlichen Verpflichtungen festgelegt, oder implizit als mehr oder weniger ausgesprochener Konsens zwischen verschiedenen Akteuren?
- 2.3. Mit welchen Indikatoren werden diese Ziele erfasst und auf ihre Zielerreichung hin beobachtet?
- 2.4. Welche Maßnahmen gibt es, um diese Ziele zu erreichen?
  - 2.4.1. Objektbasierte Maßnahmen: Wohnbauförderung, Mietrechtsgesetz, gemeinnütziger und kommunaler Wohnungsbau
  - 2.4.2. Subjekt- bzw. haushaltsbezogene Maßnahmen: Wohnbeihilfe, Heizkostenzuschuss
  - 2.4.3. Wer ist für diese Maßnahmen zuständig?
  - 2.4.4. Welche Bevölkerungssegmente werden von diesen Maßnahmen erreicht?
  - 2.4.5. Welche Gebäudesegmente werden von diesen Maßnahmen erreicht?
  - 2.4.6. Welche Maßnahmen werden geplant oder diskutiert, sind aber noch nicht umgesetzt?

3. Balance: Abstimmung beider Politikfelder aufeinander

- 3.1. Welchen Einfluss haben die einzelnen klima- und sozialpolitischen Ziele aufeinander? *[Mit Buntstiften grün=positiv, gegenseitig unterstützend; rot=negativ, widersprüchlich; grau=neutral schraffieren. Kurze Begründung notieren.]*
- 3.2. Welche geteilten Interessen oder Interessenskonflikte bzw. welche institutionellen Kooperationen oder Barrieren stehen hinter diesen positiven/negativen Einflüssen?
- 3.3. Kennen Sie bereits umgesetzte oder geplante Maßnahmen, die gleichzeitig auf klima- sowie auf sozialpolitische Ziele ausgerichtet sind?
  [zB Wohnbauförderung an ökologische Standards und Einkommensgrenzen binden]
- 3.4. Welche Bevölkerungssegmente sind kritische Gruppen aus klimapolitischer Sicht (hohe Emissionen, hoher Energieverbrauch)? Welche sind kritische Gruppen aus sozialpolitischer Sicht (arm oder armutsgefährdet)? Wie überlappen sich diese Gruppen?
- 3.5. Welche Gebäudesegmente sind aus klimapolitischer Sicht kritisch? Und welche aus sozialpolitischer Sicht?

English translation of topic guide for the expert interviews

1. Climate policy-related goals

1.2. In your view, does the list cover the most necessary climate goals in Austria? What goals should be added, deleted or rephrased?
1.3. Are these goals explicitly stated in strategic documents or binding obligations, or implicitly more or less broad consensus between various actors?
1.4. Are there indicators out there to evaluate the goals and how are they observed with reference to goal attainment?
1.5. What kinds of measure(s) exist to achieve a goal?
  1.5.1. Object-based measures: subsidies for retrofitting; subsidies for the exchange of the heating system; building standards for new buildings.
  1.5.2. Subject- & household- based measures: information campaigns (energy literacy) , on-site consultation; taxes on energy provider.
  1.5.3. Who is responsible for the measure?
  1.5.4. What kind of population segments are reached with this measure?
  1.5.5. What kind of building segments are reached with this measure?
  1.5.6. What kind of measures are being planned or discussed, but are not implemented yet?

2. Social policy-related goals

2.2. In your view, does the list cover the most necessary social goals in Austria? What goals should be added, deleted or rephrased?
2.3. Are these goals explicitly stated in strategic documents or binding obligations, or implicitly more or less broad consensus between various actors?
2.4. Are there indicators out there to evaluate the goals and how are they observed with reference to goal attainment?
2.5. What kinds of measure(s) exist to achieve a goal?
  2.5.1. Object-based measures: housing subsidy; tenancy/rent law, limited-profit and social housing
  2.5.2. Subject- & household- based measures: housing benefits; heating subsidies;
  2.5.3. Who is responsible for the measure?
  2.5.4. What kind of population segments are reached with this measure?
  2.5.5. What kind of building segments are reached with this measure?
  2.5.6. What kind of measures are being planned or discussed, but are not implemented yet?

3. Balance: Integration and coordination of both policy spheres

3.2. What kind of influence do the climate and social goals have on each other?*]*
3.3. What kind of shared interests or conflicts of interests are there? And what kinds of institutionalized cooperation's or constraints exist in relation to the positive/negative influences?
3.4. Do you know implemented or planned measures which tackle both climate and social policy goals? [e.g. housing subsidies that are conditioned to ecological standards and income thresholds]
3.5. What are the population segments that are critical (vulnerable) from climate policy perspective (high emissions, high energy consumption)? What are the critical population segments from social policy (poor or at-risk of being poor)? How do these groups overlap?
3.6. What kind of building-related segments are critical from climate policy perspective? And, which from social policy perspective?

Number	Policy Sphere and Home Institution of the Expert Interview Partners
1	Federal Ministry for Sustainability and Tourism, Section IV/4 Energy efficiency and buildings, and Section IV/1 Climate policy coordination
2	E-Control, the Austrian energy market regulator
3	Executive Office for the Coordination of Climate Protection Measures, City of Vienna
4	Wien Energie, a regional energy utility company
5	Environmental protection office, City of Graz
6	Caritas Verbund-Stromhilfefonds
7	Federal Ministry for Labour, Social Affairs, Health and Consumer Protection, Section V European, international and social issues
8	MA50 Housing research, City of Vienna
9	Chamber of Labour, Vienna
10	Social welfare office, City of Graz
11	Nachhaltigkeitsministerium Federal Ministry for Sustainability and Tourism, Section IV/4 Energy efficiency and buildings, and Section IV/1 Climate policy coordination
12	Chamber of Labor Styria
13	Housing Professor, University of Vienna, Expert in Housing
14	Wiener Wohnen (Social Housing Vienna)
15	Senior researcher Economic University Vienna, Housing expert

Table 40 List of Interviewees
Note: Additionally, three expert interviews have been conducted to receive updates and updated information.

Criteria	Circumstances about the classification of the criterion as a social hardship situation
Income	• People who receive a minimum income, a minimum pension with a compensation allowance • Long-term unemployed people who are involved in a labour market policy project • MobilePass owners • Households where energy costs account for more than 10% of household income • People who are not entitled to minimum income (people with limited residence permits and asylum seekers) • People receiving childcare allowance and grant / allowance
Sickness	• Households in which recipients live on care allowance • People with life support devices • Handicapped persons (handicap card) • The chronically ill (e.g. cancer) • People who are supervised • Mentally ill • People with a current addiction problem
Living situation	• Formerly homeless people or families living in an assisted facility • People at risk of eviction
Family situation	• Single parents with children (0 to 15 years) • Single / expectant mothers or families (0 to 15 years)
Debts	• Rent arrears • Residues at Wien Energie, already switched off or threatened by it • Indebted persons / persons with seizures • People working on their debt settlement
Life crisis	• Separation / divorce • Death in the family • Violence in the family • Job loss • People who have a probation service (Verein Neustart) • People who have refugee status • People with an on-going asylum procedure

Table 41 Energy Poverty Criteria of Wien Energie (Source: Wien Energie 2013).

BALANCE - Balancing climate and social housing policies			PRIMÄRE ZIELE			SEKUNDÄRE ZIELE						
		Sozialpolitik	Leistbares Wohnen	Adäquate Qualität der Ausstattung in der Wohnung	Vermeidung von Armut und sozialer Exklusion	Vermeidung residentieller und sozialer Segregation	Verringerung von Altersarmut	Verringerung von Energiearmut	Stärkung der Wohnungsgemein-nützigkeit	Vereinfachung und Neuregelung der Mietregulierung	Schaffung und Erhalt von kommunalen Wohnbau	Wohnungs- & Haus-eigentumsbildung erleichtern
	Klimapolitik											
PRIMÄRE ZIELE	CO2-Emissionen reduzieren auf max. 5 Mio t im Gebäudesektor bis 2030											
	Sanierungsquote von durchschnittlich 2% bis 2020 und 2030											
	Ab 2025 müssen 25 Jahre alte fossile Heizkessel ausgetauscht werden											
SEKUNDÄRE ZIELE	Endenergieverbrauch Richtwert von 1050 Petajoule bis 2020 & Primärenergieeffizienz um 25-30% verbessern											
	Energiebewusstsein in der Bevölkerung erhöhen											
	Ausstieg von fossilen Heizmitteln sozial verträglich gestalten											
	Umstellung auf ausschließlich erneuerbares Bio-Methan im öffentlichen Gasnetz											
	Bis 2030 100% des österreichischen Stroms aus erneuerbaren Energiequellen											

Figure 46 Matrix Used During the Expert Interview

Appendix B

	Survey in %	Frequency
Total valid household‘s		412
Sex		
Male	33.83	136
Female	66.17	266
Employment status		
Full-time	23.69	95
Part-time (< 30 hours)	9.73	30
Homemaker	4.49	18
Pensioner	48.63	195
Unemployed	8.48	34
Civil service/in training/schooling	4.99	20
Household income		
< 500 €- 800 €	10.53	36
801 € - 1.400 €	28.1	96
1.401 €- 2.000 €	25.22	86
2.001 € 2.700 €	19.06	65
> 2.700 €	17.01	58
Welfare benefits (multiple responses)		
Unemployment benefit	8.25	34
Means tested minimum income	10.44	43
Pension	39.81	164
Childcare allowance	2.91	12
Fuel allowance	0.24	1
Care allowance	7.77	32
Housing benefit	6.55	27
Family allowance	12.62	52
Education		
Compulsory school	17.18	67
Training or secondary school	43.85	171
AHS/BHS (including A-level)	22.05	86
University/College	16.92	66
Life events (multiple responses)		
Birth of a child	2.20	8
Serious illness	11.29	41
Event of death	4.68	17
Divorce	1.65	6
Unemployment	7.99	29
Caring person	5.23	19
Person moving out	3.86	14
Person moving in	3.58	13
Retrofit		
Yes	46.60	192
No	53.40	220
Time spend at home		
Less than 8 hours	7.73	29
8-12 hours	31.47	118
12-18 hours	35.2	132
More than 18 hours	25.60	96
Preferred room temperature		
18°C or less	2.00	8
19°C - 20°C	21.958	88

21°C - 22°C	50.12	201
23°C or more	25.94	104
Heating system		
District heating	49.74	194
Gas- central heating	33.85	132
Central heating (gas/ oil)	4.62	18
Electric heater	5.38	21
Coal or wood oven	0.26	1
Several heating systems	6.15	24
Cost related variables	**Mean Ø**	**Standard Deviation**
Pre- retrofit (N=129)	366.34	161.09
Post- retrofit (N=133)	393.4	168.47
Not retrofitted (N=198)	422.80	147.44
Rent costs per square meter		
Pre- retrofit (N=129)	6.28	SD: 2.26
Post- retrofit (N=132)	6.71	SD: 2.32
Not retrofitted (N=195)	6.77	SD: 2.11
Heating in €		
Pre- retrofit (N=118)	71.82	SD: 35.20
Post- retrofit (N=15)	66.38	SD: 34.26
Not retrofitted (N=184)	66.49	SD: 28.15
Energy in €		
Pre- retrofit (N=116)	58.9	SD: 32.23
Post- retrofit (N=123)	55.0	SD: 30.54
Not retrofitted (N=188)	62.5	SD: 41.27
M^2 (N= 398)		
Retrofitted (N=182)	58.72	SD: 16.77
Not retrofitted (N=219)	63.18	SD: 18.70
Number rooms (mean) (N= 403)	2.61	SD: 0.95

Table 42 Descriptive Statistics of Case Study (Source: Case Study)

Appendix C

	Coef.	Std. Err.	z	P > z	[95% Conf. Interval]	
1. Class	**Reference category**					
2. Class						
Constant	0.2546252	0.352977	0.72	0.471	-0.437197	0.9464473
Item 1						
1	0.5002484	0.327486	1.53	0.127	-0.1416123	1.142109
2	-0.8842647	0.262706	-3.37	0.001	-1.399159	-0.3693705
Item 2						
1	0.2428628	0.3659917	0.66	0.507	-0.4744678	0.9601934
2	-3.182915	1.079003	-2.95	0.003	-5.297721	-1.068109
Item 3						
1	1.443596	0.5131	2.81	0.005	0.4379388	2.449254
2	-1.04149	0.3438191	-3.03	0.002	-1.715365	-0.3676189
Item 4						
1	0.1768531	0.2915461	0.61	0.544	-0.3945667	0.7482729
2	-2.070358	0.5657248	-3.66	0	-3.179159	-0.9615582
Item 5						
1	0.7274171	0.2822112	2.58	0.01	0.1742933	1.280541
2	-0.5489669	0.2560195	-2.14	0.032	-1.050756	-0.047178
Number of observation	215					
Log likelihood at zero	-148.84					
Log likelihood at convergence	-613.57					

Table 43 Latent Class Regression Results for Not Retrofitted Sample (Source: Case Study)

Agreement to the statements	Not self-restricting vs. self-restricting
Item 1: Not self-restricting vs. self-restricting	1.00
Item 2: I do not heat all the rooms because the warmth distributes well to other rooms	-0.24**
Item 3: I do not heat all the rooms because the flat reaches comfortable temperatures without heating	-0.19*
Item 4: I do not heat all the rooms because the flat does not get warm for structural reasons	0.26**
Item 5: My flat has comfortable temperatures	-0.18**

Table 44 Validation of Items in Case Study Vienna (Source: Case Study) Spearman Correlation Results Variable 1: Dummy, 1=self-restricting. Variables 2 - 6: 4-step Likert response scale from 1=strongly disagree to 4=strongly agree.

Interpretation: It is presumed that energy saving behaviours, which may be sensible and of little inconvenience to normal-income households, add further pressure on already materially deprived households if they are forced to these behaviours. Correlations of the self-restricting / not restricting class affiliation with further items that indicate reasons for self-rationing heating. Items 2 and 3 indicate other reasons than hidden energy poverty; as is to be expected, these items are negatively associated with self-restricting behaviour (r=-.24; r=-.19). The positive correlation with Item 4 implies that households are forced by building conditions to self-restriction (r=.26). The negative correlation with item 5 shows that self-restricting households undercut their comfort level (r=-.18).

Appendix D

		Not Retrofitted				Retrofitted			
Latent contructs	**Items**	**Mean**	**SD**	**Missings in %**	**N**	**Mean**	**SD**	**Missings in %**	**N**
Environmental attitudes	Att1: I try to save energy with my behavior.	3.2	0.9	8.6	201	3.3	1.0	3.1	186
	Att2: Energy-saving practices in heating are important to me.	3.1	0.9	10.0	198	3.2	1.0	6.2	180
	Att3: I think it is important to use less energy and recourses for heating.	3.2	0.9	6.8	205	3.4	0.8	7.3	178
	Att4: I have the ability and the knowledge of heating energy-efficient.	3.1	1.0	9.1	200	3.2	0.9	5.2	182
Social norms	SN1: Friends draw my attention to energy-efficient heating behaviour.	1.5	0.9	11.3	195	1.5	0.9	7.8	177
	SN2: Most of my friends have an energy conscious heating behaviour.	2.7	1.2	12.3	193	2.6	1.3	9.9	173
	SN3: People who are important to me want me to close the window if I heat.	2.6	0.9	13.6	190	2.5	1.0	12.5	168
Internal Perceived Behavioural Control	PBC1: I can decide myself when and how often I heat.	3.6	0.8	6.8	205	3.8	0.7	5.2	182
	PBC2: I am capable to control how cold or warm it is in the apartment.	3.6	0.8	3.6	212	3.8	0.6	4.2	184
External Perceived Behavioural Control	D1: I do not heat all rooms because there is not a radiator in every room.	1.8	1.2	35.0	143	1.9	1.3	39.0	117
	D2: I do not heat all rooms because the radiator is not working there.	1.4	0.9	36.8	139	1.5	1.0	44.8	106
	D3: I do not heat all the rooms because the apartment does not get warm for structural reasons.	1.8	1.1	33.1	147	1.5	0.9	42.7	110
Behavioural Intention	Intention 1: I have the intention to turn down the heating in the night.	3.2	1.0	9.1	200	3.5	0.9	2.6	187
	Intention 2: In the future, I will pay attention not to overheat my apartment.	3.4	0.9	9.1	200	3.3	1.0	5.2	182

Table 45 Variables Used in the Structural Equation Modelling (Source: Case Study)

Latent constructs	Items	Mean	SD	Missings in %	N
Habits	I am heating as much as it is comfortable without paying attention to the costs.* (g4)	2.4	1.0	10.0	198
	I use the heating in my everyday life without thinking about it.* (g8)	3.0	1.0	10.0	198
	In transition periods, I try to use the heating as less as possible. (g9)	3.2	0.9	5.5	208
Energy behaviour	**Before I turn on the heating, I put on a pullover. (g1)**	2.5	1.2	11.8	194
	I often turn on the heating in the night if I am cold*	2.5	1.2	9.6	199
	On cold days, I am heating longer (half a day) on high temperatures (over 23 degrees)*	2.9	1.0	14.1	189
	I close the door between the room, where I heat and where I do not heat. (g6)	2.6	1.2	5.0	209
	If it is cold outside, I often sit next to the heater in order to stay warm. (g7)	1.8	1.0	9.6	199
	I turn off the radiator when I leave the apartment.	2.0	1.1	14.1	189

Table 46 Endogenous Variables of the Structural Equation Modelling Used in the Not Retrofitted Case Study (Source: Case Study). Note: Variables that remained in the final SEM are indicated in bold font.

Latent contructs retrofitted	Items	Mean	SD	Missings in %	N
Rebound	BEFORE the retrofit, I put on a pullover if I was cold. Now I turn on the heating. (rg1rev)	1.7	1.0	11.5	171
	Since the retrofit, if I am cold I turn on the heating more often in the night. (rg3rev)	1.5	0.9	11.5	170
	Since the retrofit, I heat without paying attention to the costs. (rg4rev)	1.7	1.1	11.5	171
Energy coping/ behaviour	**Since the retrofit, I turn off the heating if I leave the apartment. (rg2)**	2.5	1.3	12.50	168
	Since the retrofit, I do not heat long (half a day) on high temperatures (over 23 degrees) any more. (rg5)	2.5	1.2	13.0	167
	I close the door between the room, where I heat and where I do not heat.	2.5	1.2	3.1	186
	If it is cold outside, I often sit next to the heater in order to stay warm.	1.6	1.0	5.1	183
	I use the heating in my everyday life without thinking about it.	2.0	1.1	4.7	183
	In transition periods, I try to use the heating as less as possible. (rg9)	3.3	0.9	2.6	187

Table 47 Endogenous Variables of the Structural Equation Modelling Used in the Retrofitted Case Study (Source: Case Study) Note: Variables that remained in the final SEM are indicated in bold font.

Goodness of Fit Statistics

The Chi Square Test: The χ2- test is the most common method for evaluating the goodness-of-fit of a model. An insignificant χ2 ($p > .5$) suggests that the model fits the data well. For models with about 75 to 200 cases, the chi-square test is a reasonable measure of fit. But for models with more cases (400 or more), the chi square is almost always statistically significant. Therefore, χ2 is highly sensitive to sample size and may cause an overestimation of even minor differences between the observed and the predicted matrix. This can lead to erroneous rejection of acceptable solutions. Hence, χ2 tests are very conservative and often produce a significant p-value when in fact there is a good model fit. Many researchers use other model fit indices, as they are more reliable to assess model fit (Iacobucci, 2010; Lei and Wu, 2007).
Absolute Fit Index: An absolute measure of fit presumes that the best fitting model has a fit of zero. The measure of fit then determines how far the model is from perfect fit. These measures of fit are typically “badness” measure of fit in that the larger the index, the worse the fit of the model is.

The **Root Mean Square Error of Approximation (RMSEA)** is the most popular absolute measure of fit and reported in most papers. RMSEA is based on $\chi 2$ but adjusted for model parsimony (d.f.) and sample size (n). A value of RMSEA smaller than > 0.05 indicates a good fit, a value between 0.05 and 0.08 an adequate fit.
The **coefficient of determination** is the fraction (or percentage) of variation explained by an equation of a model. It is a measurement of overall "goodness of fit". The coefficient of determination is thus like R^2 in linear regression (is calculated as the sum of squares of regression divided by the sum of squares of error).
The **p of Close Fit (PCLOSE)** measure is a one-sided test of the null hypothesis that the RMSEA equals .05, that is called a close-fitting model. If p is greater than .05 (i.e., not statistically significant), then it is concluded that the fit of the model is "close." Hence, values above > 0.05 show a good model fit.
Standardized Root Mean Square Residuals (SRMR) index is an absolute fit index that is not sensitive to violations of distributional assumptions (Iacobucci, 2010). It indicates how much difference exists between the observed data and the model. Values for the SRMR range between zero and one, with well-fitting model obtaining values less than 0.05 (Byrne, 2001) or 0.08 (Hu and Bentler, 1999). Values smaller than 0.10 demonstrate a good fit (Kline, 2005).
Incremental Fit Index can be analogously interpreted as R^2, in which a value of zero indicated having a poor model and a value of one indicates having the best possible model. Incremental Fit Indices compare a target model with a restrictive baseline mode.
Tucker Lewis Index is an incremental measure of fit index, that is also called the non-normed fit index or NNFI (Hair et al., 2014). It does not penalise adding more parameters. It compares the current model with the baseline model analysing the difference in the ratio. Values between .90 and .95 are considered acceptable, above .95 are good, and below .90 are considered to be a poor fitting model.
Comparative Fit Index (CFI) is interpreted as the Tucker Lewis Index. A value of CFI greater than .95 is good (Hair et al., 2014).
Table 48 Goodness-Of-Fit Indices Used in the Structural Equation Models

Confirmatory Factor Analysis and Structural Equation Modelling Results

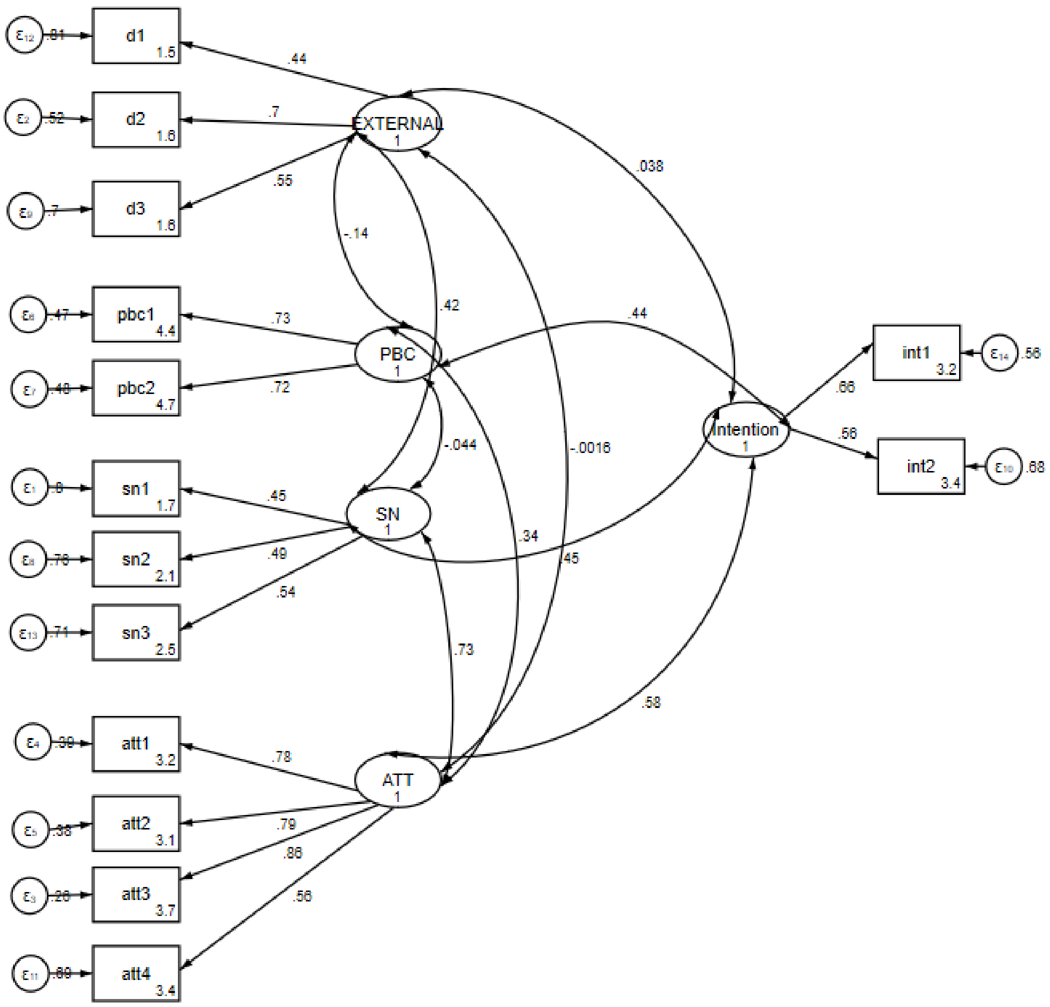


Figure 47 CFA - Structural Model 1 (Source: Joint Sample)

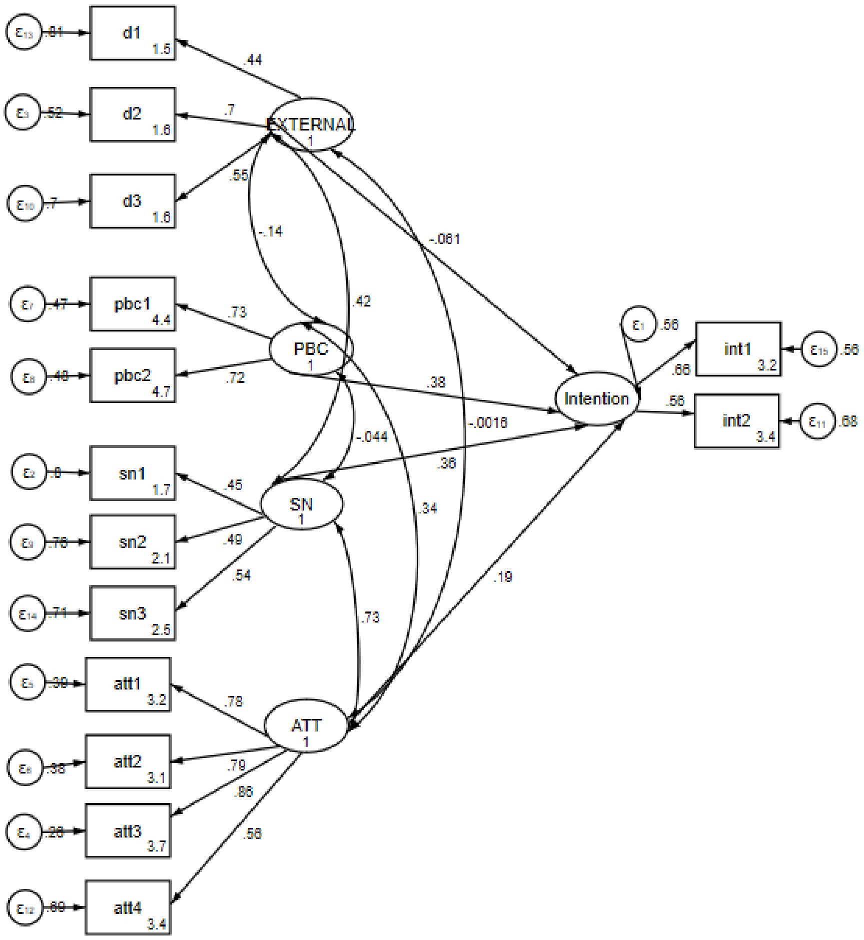


Figure 48 SEM - Structural Model 1 (Source: Joint Sample)

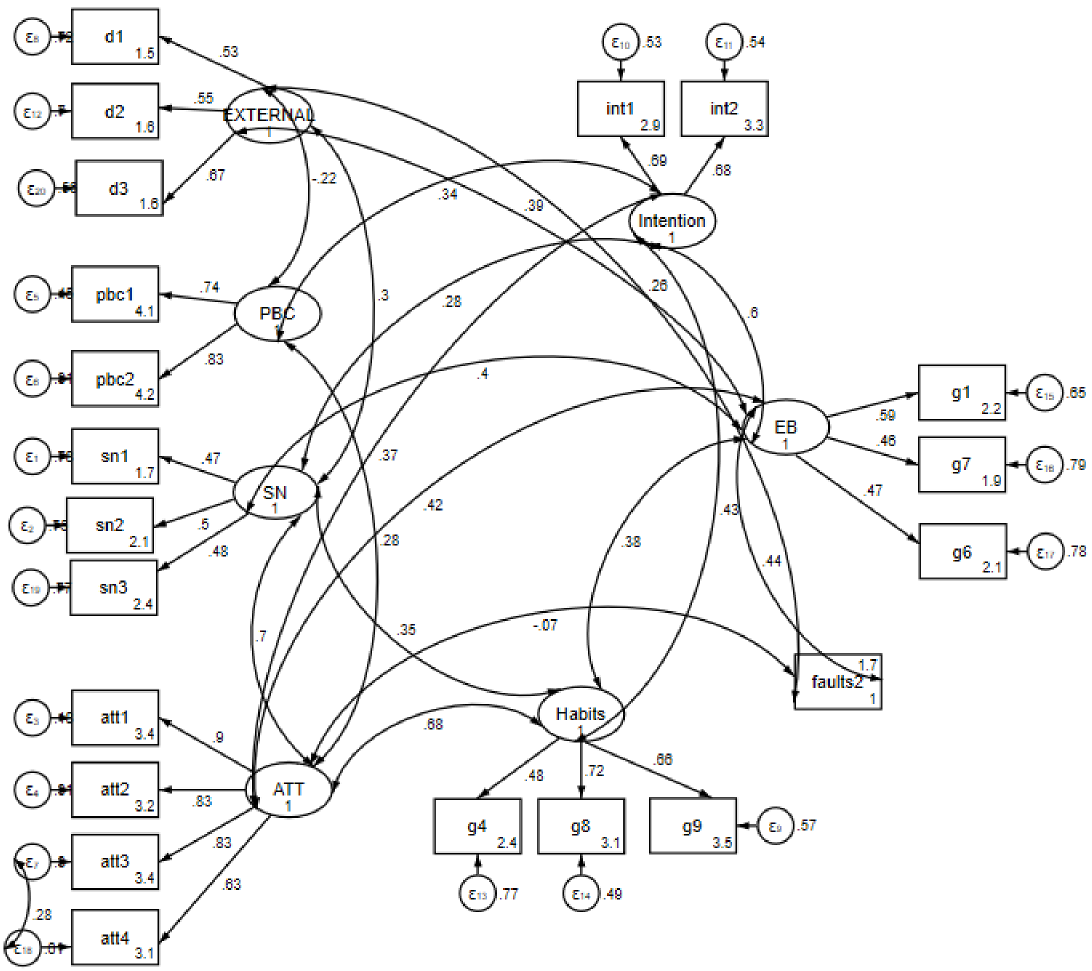


Figure 49 CFA - Structural Model 2 (Source: Not Retrofitted Sample)

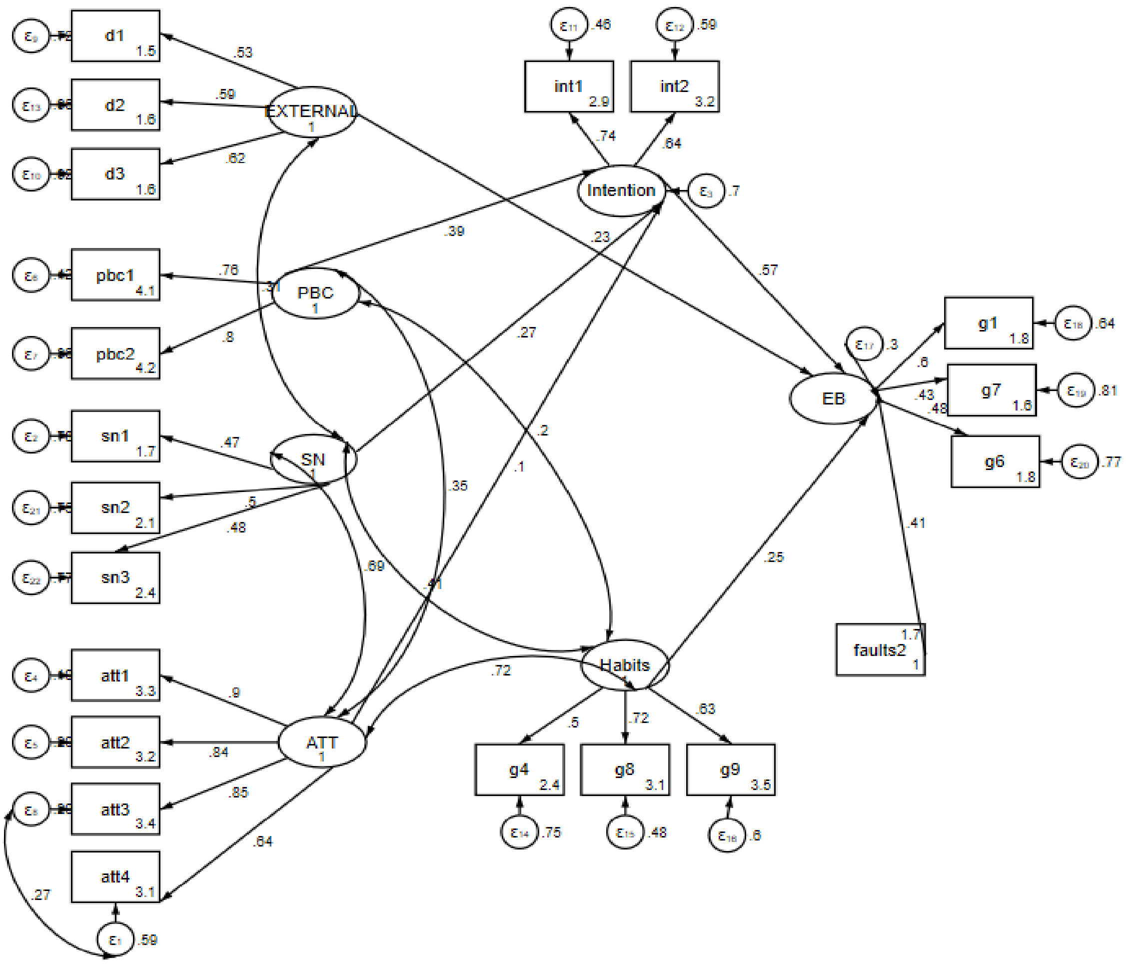


Figure 50 SEM - Structural Model 2 (Source: Not Retroitted Sample)

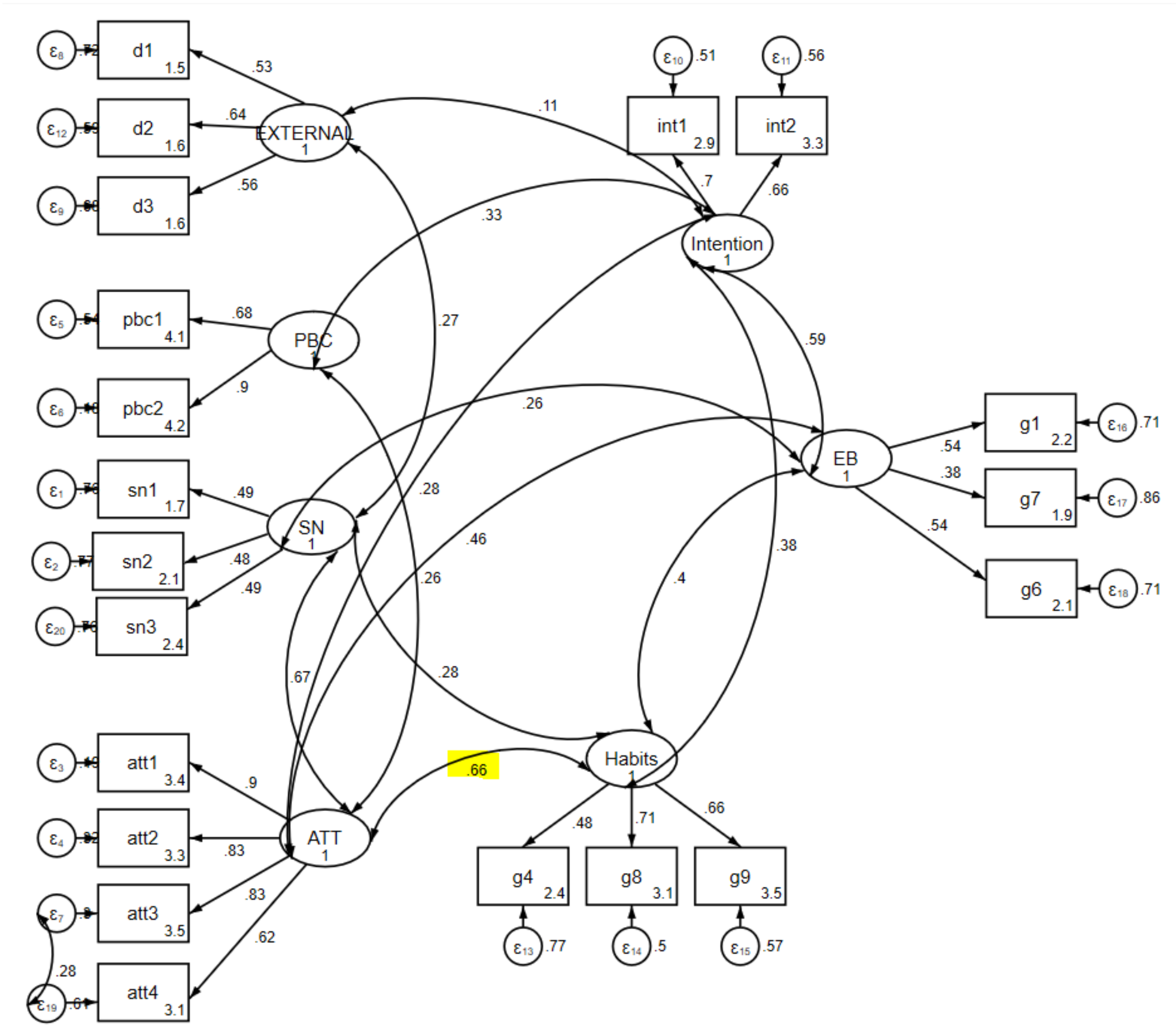


Figure 51 CFA - Structural Model 3 (Source: Not Retrofitted Sample)

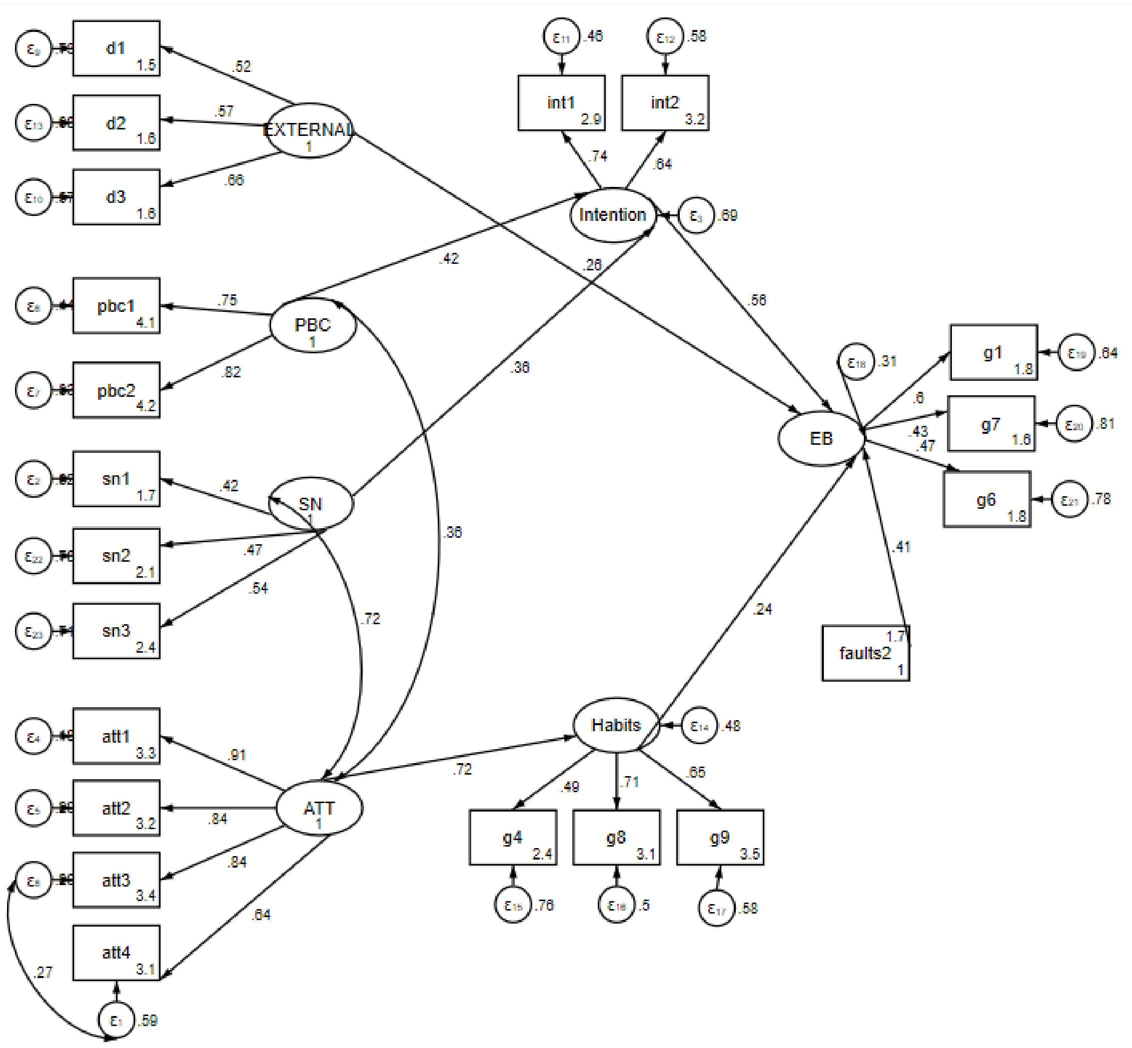


Figure 52 SEM - Structural Model 3 (Source: Not Retrofitted Sample)

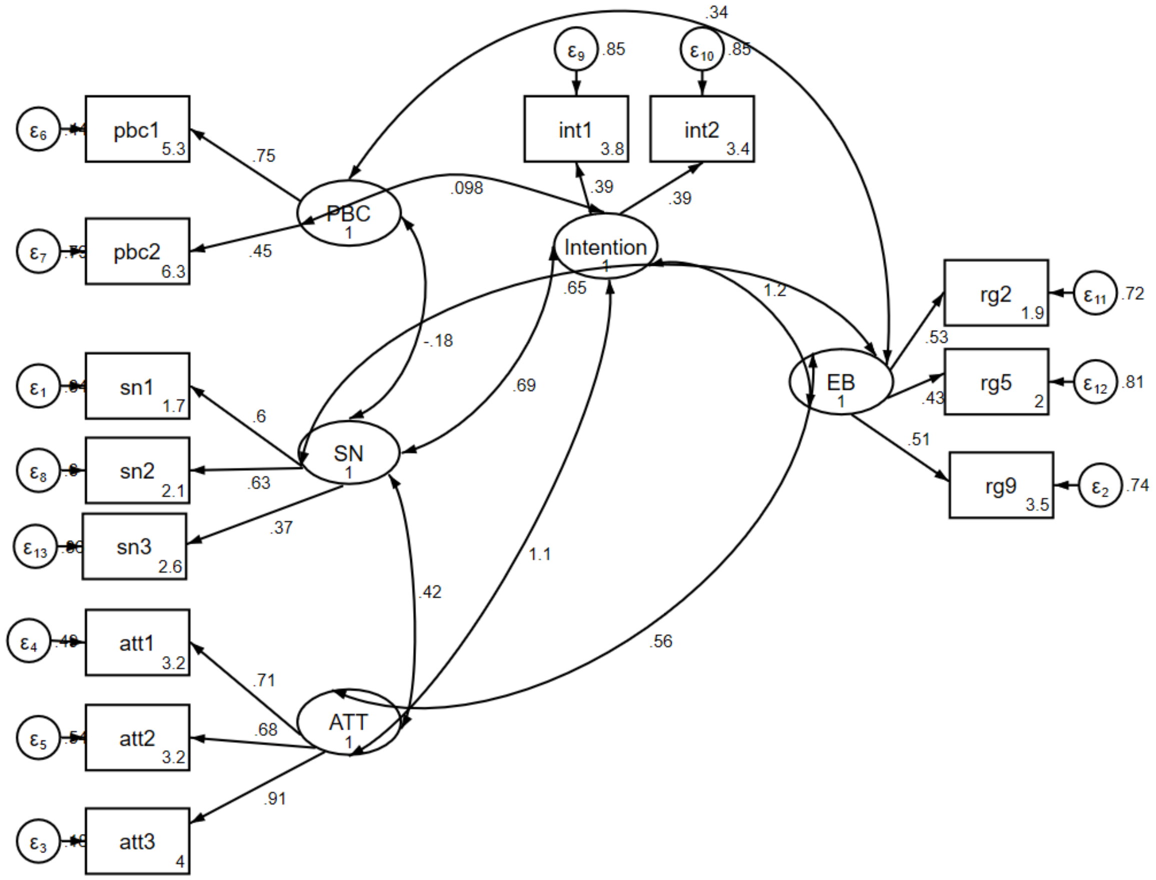


Figure 53 CFA - Structural Model 4 (Source: Retrofitted Sample)

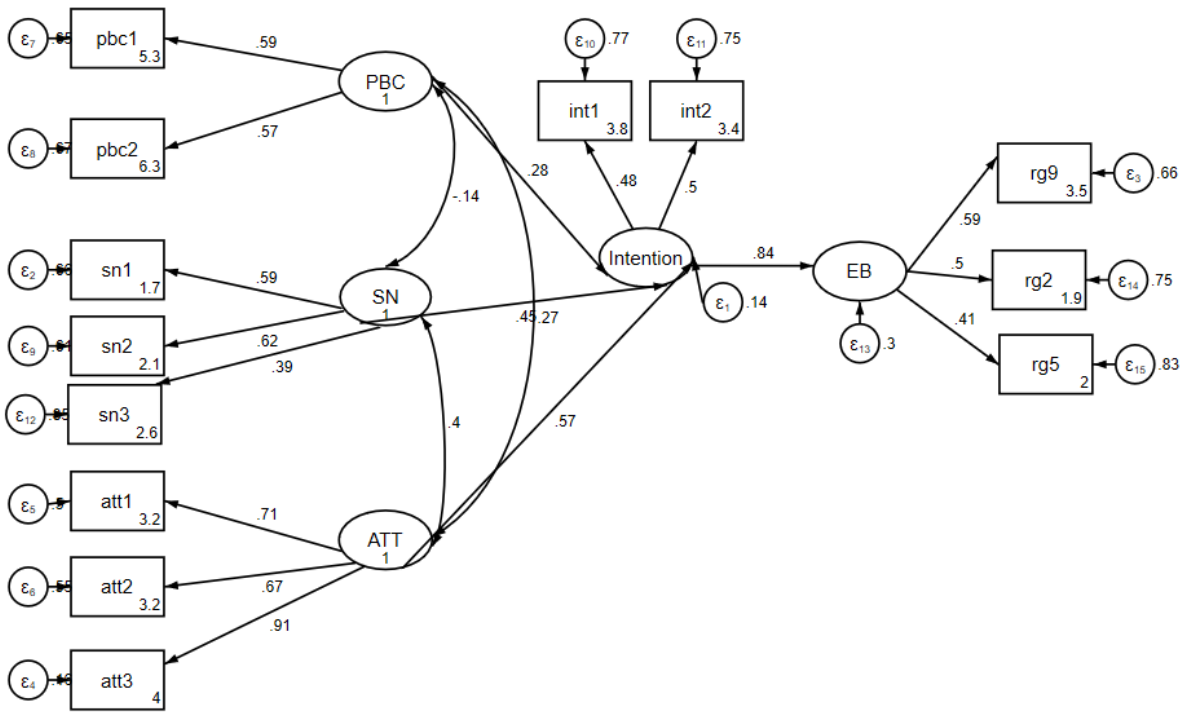


Figure 54 SEM - Structural Model 4 (Source: Retrofitted Sample)

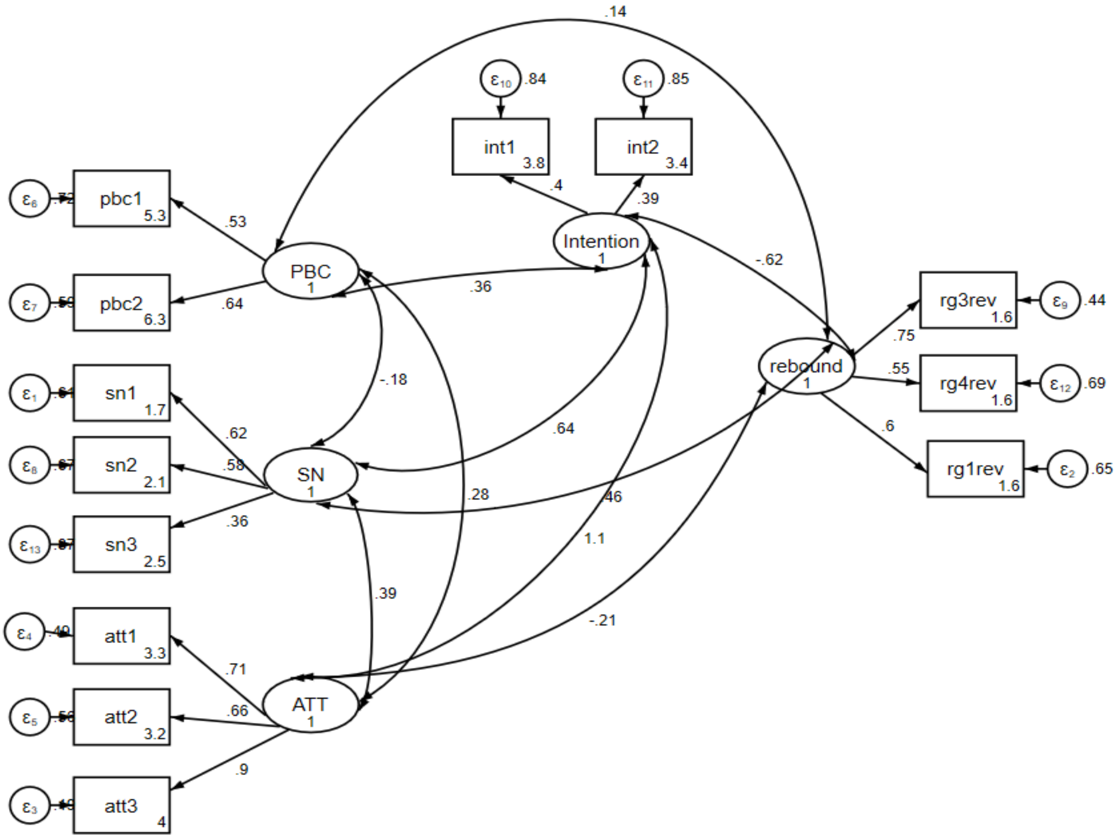


Figure 55 CFA - Structural Model 5 Final Model (Source: Retrofitted Sample)

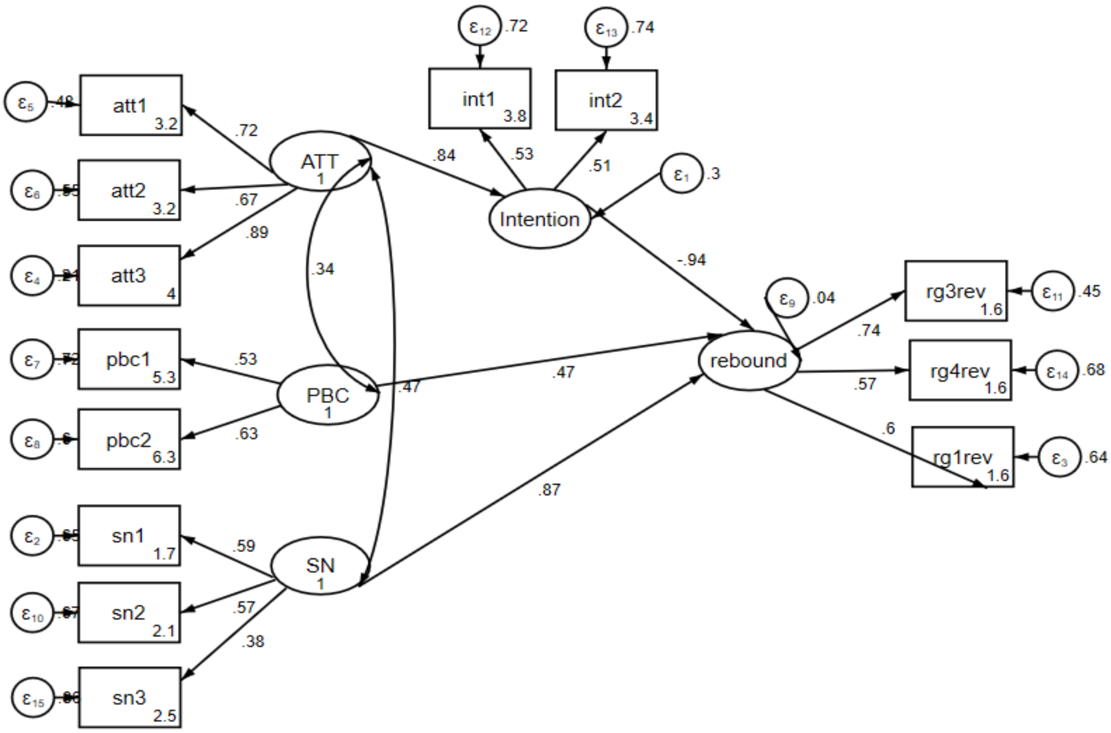


Figure 56 SEM - Structural Model 5 Final Model (Source: Retrofitted Sample)

Appendix E

Alles elektrisch; Außenfassade in schlechtem Zustand
Es sollten neue, dichte Fenster installiert werden
Rechnung zu hoch für Verbrauch
Ich habe eine extrem warme Wohnung in dieser Wohnungsanlage, aber die meisten sind "saukalt"
Habe eine Gemeindewohnung von meinem Vater übergeben bekommen mit einer Gasheizung und Holzfenstern. Das war eine Zumutung. Von Wr. Wohnen aus bekam ich keine Sanierung, Fernwärme ließ ich über Wien Energie machen + Fenster und Balkontür im Wohnzimmer.
Sanierungen inklusive Wärmedämmung sollte in Wien vorangetrieben werden, momentan überwiegt der Neubau
Wenn ich im Winter lüften möchte, weil ich es als zu warm empfinde, schaltet sich die Heizung von selbst ein und ich will das gar nicht! Weil Fernwärme das so macht! Das ist nicht umweltfreundlich
Wir würden uns über eine Dämmung freuen. Es wird dauernd Gerümpel beim Mistplatz abgestellt
Fenster gehören renoviert, Fassade sollte gedämmt werden
Gangfenster undicht, Haustür immer kaputt
Am Gang vor der Wohnung immer viel zu heiß; Gebäudezustand nicht besonders gut, aus Mitte der 50er-Jahre, Mauerstärze 60 bzw 45cm Ziegel!
Man sollte sich für Gebäudedämmung was einfallen lassen, die Wohnzimmer-Außenwand ist nur eine Platte!!
Fenster Holzfußboden gehören repariert;meine Wohnanlage gehört saniert
Seit Isolierung alles OK; Seit Bau (1973) keine Sanierung; Das alte Haus sollte renoviert und neue Fenster eingebaut werden
Da keine Benützung des Heizkörpers in der (offenen) Küche, ist dieser unnötig und teuer (hohe Verdampfung des Kontrollröhrchens ohne Benutzung).
Ich finde die Heizkosten mehr als hoch, jedes Jahr Nachzahlung und ich heize auf Stufe 3 im Wohnzimmer; Öfter Wasser durch das Dach; Nicht Gedämmt und zwei Untergeschoße die immer offen sind; Stiegenhaus seit Fertigstellung (1964!) nie wieder ausgemalt; Außenmauern dämmen; Die Heizungen und Fassade gehört renoviert
Habe in jedem Raum ein Thermostat; Gemeindebau gehört renoviert (schlechte Dämmung)
Fenster mit guter Dichtung, dass es nicht kalt reinzieht.
Seit ich in der Wohnung wohne, wird von einer Sanierung gesprochen, aber es geschieht nix. Fenster sind wie Vogelhäuselsprissel und schließen nicht mehr richtig und die Wände sind kalt im Winter und alles ist heiß im Sommer, weil die Glasflächen so groß und unbeschattet sind.
Fassadenisolierung wäre empfehlenswert
Haben den Dachboden isolieren lassen, obwohl Gemeindebau! 6000,-€!
Fassade ist nicht isoliert! Fenster mit guter Dichtung, dass es nicht kalt reinzieht.
Ich muss meine Wohnung fast nie heizen, offenbar ist die Lage genau in der Mitte des Blocks ein Vorteil. Mein Problem ist aber die Hitze im Sommer. Thermische Sanierung nötig! Absolute Fensterdichtheit wird vom Rauchfangkehrer beanstandet; schlecht isolierter, alter Gemeindebau
Wir heizen seit 56 Jahren mit Keller; Dauerbrandofen Koks und Holz
Ich beziehe Öko-Strom und daher sind meine Stromkosten so niedrig
Eine Haussanierung: Fenster!! Und evl. Dämmung der Fassade würden die Heizkosten senken und unsere Gesundheit (Zugluft) zu Gute kommen; Ausbau von Fernwärme unbedingt!
Beim Sanieren nicht sparen
Aufgrund dünner Wände ist der Winter zu kalt; die Heizungen sind alt und heizen nicht gut
Fenster sind schlecht, Dämmung auch; alte (undichte) Fenster, keine Dämmung, alte minderwertige Bausubstanz
Leider keine Wärmedämmung; Das Haus müsste gedämmt werden; Heizen ist sehr teuer geworden
Altes Haus - fehlende Sanierung; Fotovoltaik und Solar sollte gefördert werden
Sehr alter Gemeindebau, keine Wärmedämmung, Fenster sehr undicht
Fenster sind sehr schlecht isoliert; Neu Fassade dringend benötigt!!! Im Sommer wie auch im Winter sind die Stiegen(!) sehr warm; Fassade und Regenrinnen kaputt; Habe E-Speicher Heizung;

keine Ahnung, (Anm., weiter hinten:) Wozu diese Fragen?? Wird eh nichts gemacht;
Sanierung wurde vor Jahren angekündigt, aber stillschweigend abgesagt. Ich bin mit dem Gebäudezustand trotzdem zufrieden. Mein Gemeindebau ist Mitte der 70er gebaut worden. Thermische Dichtheit war damals scheinbar ein Fremdwort. Dort wo meine Fernwärme Heizkörper stehen ist keine vollwertige Wand sondern ein dünnes Stahlblech das lackiert ist.
Klassischer Fertigbetonbau. Ich kann nicht mal ein Loch stemmen da überall beton ist. Eine Heizung mit gegulienen (? regulirendem??) Thermostat + gedämmte Fassade; Keine Fassadendämmung, Lüftungssystem schlecht; Probleme mit Kinderzimmer= zu kalt, Fassade
Fassade + Fenster in sehr schlechtem Zustand (+ zerbrochene Scheiben) Problem ist bekannt, Sanierung verschoben oder abgesagt
Gebäude gehört saniert
Beim Einzug 2002 wurde mir gesagt, dass das Haus gedämmt wird
Wärmedämmung, neuer Putz, neuer Zugang zu den Stiegen und Mistkübeln
Ich habe die Wohnung meiner Cousine und ihren Mann übernommen und wohne jetzt 1 1/2 Jahre hier. Die Miete (Gemeinde)wurde gleich mal auf 100€ erhöht, ohne dass irgendetwas saniert oder sonstiges gemacht wurde. Die Einstufung meiner Heiz- und Stromkosten hat sich nicht geändert obwohl ich alleine lebe. Ich hatte bei der Jahresabrechnung zwar ein Plus von 190€, wurde aber dennoch im darauf folgenden Jahr gleich eingestuft.
Dämmung erhöhen, Fenster erneuern
Fenster und Fassade sind renovierungsbedürftig
Dämmung fehlt
Das ganze Gebäude gehört saniert
Ungünstiger Mix aus Fernwärme für die Raumheizung und Gastherme für die Warmwassererzeugung. Da das Haus in den frühzeitig saniert wurde, ist die Wärmedämmung nicht zeitgemäß (zu dünn; Gebäude gilt aber wohl als Wärmesaniert).
Das Gebäude ist sehr schlecht isoliert, die Heizkörper sollten auch einmal (nach 45!! Jahren) ausgetauscht werden, mit Thermostat, das im oberen Bereich des Heizkörpers ist
Das Haus ist nicht isoliert!!! Die Balkontüre außen müsste dringend gestrichen werden!
Ja, neue Fenster
Wann wird unser Bau isoliert (Wärmedämmung)
Schlechte Fassade und undichte Fensterrahmen
Gebäudesanierung wurde laut Wr. Wohnen nicht auf Undichtheit geprüft (10 Jahre Garantier! Nicht genützt!) Fenstereinbau undicht / Kälteeinbruch bei Rahmen!
Unbedingt EU-konforme Fenster fürs ganze Haus + isolierte Fassade
Es ist wichtig sich mit dem Thema "Energie sparen" zu befassen
undichte Fenster
Ja in unserer Anlage, Stiege 8 über 55 Jahre und keine Fassade isoliert, und kein Heizkörper im Gang und nicht erlaubt Fenster öffnen. Überall feucht, bei starkem Gewitter Keller-Waschküche überflutet
Dringend renovierungsbedürftig
Hätte lieber Fernwärme
Dass sich Wiener Wohnen mehr bemüht. Tut sie nicht
Neue Fassade - Dass die Wände mehr warm sind
Trotz abgedrehter Heizung, ist Heizung warm! Alte undichte Fenster, zugig, immer kalter Boden, wenn Fenster offen
Undichte Fenster
Das Gebäude ist nicht richtig isoliert, deshalb müssten wir uns im Winter die ganze Zeit erwärmen. Die Fenster sind alt und halten die Wärme nicht.
Haus, 5 Stock nur 1 kl. Klappe zum Lüften
Bessere Isolierung bei Fenstern notwendig
Teure Miete bzw. zu hohe Mietkosten
Fenster und Türen zu alt und undicht
Hoffentlich wird unser Haus bald saniert!
Fenster gehören neu
Fehlende Wärmedämmung-Fassade, undichte Fenster

Das Haus ist gar nicht isoliert. Auf den Gängen ist es heiß. Und so geht Energie verloren. Eine Dämmung wäre notwendig.
Haus ist O.K. Fernwärme zu Teuer
Das(s) mein Heizkörper nur unten zum Aufdrehen
Schlecht gedämmter Dachboden, im Sommer sehr heiß, im Winter sehr kalt
Pfuscharbeiten einstellen = Das mehr überwachen = dann entsteht kein Schimmel oder Decke bröselt nicht ab. Schon gemeldet = wird aber eh wie immer nur im Pfusch ausgebessert!!
Mehr Wohnungen sanieren! Seit der Gebäudesanierung heizen wir gar nicht mehr! (Da kein Bedarf)
Es ist schade, dass sich die Heizung nicht steuern lässt
Seit der Sanierung gibt es in den EG-Wohnungen Schimmel
Das Haus wurde nicht saniert. Der Verdunstungszähler ist ein ungenaues Messinstrument zu Ungunsten der Mieter. Im Sommer zu hohe Verdunstung auf der Süd- bzw. Westseite!!! →wird bald saniert
Bei der Sanierung wurde der Müllplatz nicht eingehegt, daher werden die Betriebskosten jedes Jahr höher
Generalsanierung seit 2017 ausständig
Unsere Wohnung liegt zwischen anderen und ist daher warm.
Wir fühlen uns leider wie in einem Nylonsack
Diese Wohnung ist von Anfang an eine Fehlplanung
60er-Jahre-Bau = mangelhaft bis gar nicht gedämmt
Umwelt schützen, und mehr Energie sparen
Ich heize nicht so oft und habe so hohe Heizkosten
Wir haben seit ca. einem Jahr keinen Haustor und Kellerschlüssel - etliche Kellereinbrüche
Musste 1990 die Fenster auf eigene Kosten sanieren lassen weil es sonst noch jahrelang gezogen hätte
Sanierung = Fenstertausch + Jalousien
Ich muss aufgrund der hohen Heizkosten extrem aufpassen wie oft ich einschalte, nur so viel, dass es nicht ganz kalt wird
Wärmedämmung ist gut und schön, aber es hätte auch etwas gegen die unsägliche Hitze in den Wohnungen/Stiegenhaus im Sommer unternommen werden müssen! Angesprochen auf Kühlung (Fernkälte, Dachbegrünung, Fassadenbegrünung oder andere kühlende Maßnahmen) wurden wir nur belächelt.
Therme - Heizung selbst eingebaut – ca. 1977 da nicht vorhanden
Es ist sehr angenehm hier zu wohnen
Die Jalousien sollte man nachbekommen
Wir haben im 5. Stock die Waschküche und einen viele Jahre benutzten Trockenboden. Seit der Sanierung dürfen wir diesen nichtmehr benutzen und müssen auch bei 30 Grad unsere Wäsche in den Trockner geben und verbrauchen unnötig viel Gas
Bin zufrieden wie es ist
Pfusch am Bau
Ich hätte mir gewünscht, dass bei Dämmung, Fenster u allen Sanierungsarbeiten auf Qualität geachtet worden wäre und nicht auf billig
Ich finde die Kosten für so eine kleine Wohnung zu hoch - zu wenig Grünanlagen
Ich find Kachelofen mit Nachtstrom am bequemsten
Haus noch nicht saniert!!! Nur innen teilweise
Da ich eine DG-Wohnung habe, die gut saniert ist, heize ich kaum. Die Energiekosten gehen eher auf Kosten des Warmwassers
Gut, dreckig
Dieser Bau ist 1955 errichtet und hat keine Wärmedämmung
(Anm.: An anderer Stelle) Unter mir befindet sich der Kelle. 3 Räume grenzen an den Gang, trotz Wärmedämmung habe ich eine sehr kalte Wohnung.
Gasetagenheizung, Tag/Nacht-Absenkung vor und nach der Sanierung. Fenster bri Bezug selbst getauscht. Fassadendämmung und Dach wirkt sich positiv aus. Weitere Heizmöglichkeit ein Schwedenofen
Es gab keinen Putz im Keller in den Fenstern

Ständig verschmutztes Durchhaus. Urin + Erbrochenes
Haus hat im Keller cm-dicke Sprünge
Alle Außenwände sind naß(!) und schimmelig
Vor meiner Türe ist ein Dachfenster, dass sich nicht öffnen lässt. Dadurch ist es im Sommer viel zu heiß
Habe digitale Heizkörperventile
Nach der Sanierungsarbeiten (Dämmung) sommerliche (über 30 Grad) Innenraumtemperaturen sind UNVERSTÄNDLICH
Innentüren kaputt oder verzogen ist nicht saniert
Krankheit, Pension bestimmt auch Heizverhalten
Verschmierte Wände Bemalte Wände beim Eingang und Rückseite
Ja, dass es für Dachgeschoße Klimaanlagen geben sollte
Ich habe eine Gemeinde Wohnung, vor der Sanierung habe ich durchschnittlich jedes Jahr 1300€ zum Nachzahlen gehabt! (4 Jahre) habe den Anbieter gewechselt, aber es hat nicht viel gebracht. Der Staat sollte in solchen Fällen zumindest bei Gemeindebauten welche teils Staatsabhängig sind Maßnahmen setzen bzw. die Mieter unterstützen. Zahle seit 3-4 Jahren monatlich! Ca. 250€ an Heizkosten.
Die Sanierung dauert bereits mehr als drei Jahre
In einer Erdgeschoßwohnung wäre eine ordentliche Kellerdecke Kellerdeckendämmung extrem wichtig
Generalsanierung zu 95% positiv zu bewerten
Die Sanierung läuft seit etwa drei Jahren, die wichtigsten Sanierungsarbeiten bezüglich Wärmedämmung wurden vermutlich im Jahr 2017 fertiggestellt.
Insgesamt bin ich aber sehr zufrieden mit der Dämmung der Wohnung - ich merke einen großen Unterschied zu der unsanierten Wohnung meiner Eltern.
Die Sanierung wurde nicht vernünftig durchgeführt. Problemtisch ist die Staubentwicklung durch falsch verdichtete Böden. Im BD gibt es Probleme mit der Ventilation und Feuchtigkeit.

Retrofitting project management timeline of Wiener Wohnen

1. Starting phase

Construction management inspects housing condition and the Facility Management analyses data on the quality of the buildings. Creation of time concepts and finance plan.[256]

2. Project preparation

2.1 Building stock analysis: what should be retrofitted? Retrofitting possibilities and inventory analysis of damaged components; recommendation report;

2.2 Retrofitting variants: how should be retrofitted (e.g. Thewosan, maintenance, or renovation of the base)? Implementation of the award procedure for project developers and, if necessary, accompanying control; conducting the initial meeting on site; collection and presentation of the state of the object; approval for implementation of a retrofitting variant by the portfolio group; submission of the project to wohnfonds_wien.

3. Execution preparation

3.1 Planning and submission: portfolio-group → Decision on the retrofitting project plan. The selected renovation variant is worked through in compliance with the specified parameters (quality, costs, and deadlines). Filing at the authorities; carrying out the tenant information; if necessary holding a tenant meeting; a tenants' meeting must be held before the project is submitted to the arbitration board.

256 CO2 savings are not addressed in the first phase (I13). When asked whether there are any guidelines for how much CO2 should be saved, the following answer was given: “No. We count with the energy certificate to the extent that you can receive the funding/subsidy. It is important for us that the funding is awarded. So that we achieve certain values.

3.2 Authorized procedure: building permit procedure, funding procedure, handling of the arbitration board procedure

3.3 Execution planning and execution details

3.4 Award of contracts: preparation of tender documents; implementation of procurement procedures according to the Federal Procurement Act; award of construction works and services around the retrofit

4. Retrofitting execution

Tender documentation and detailed time plan; holding the (second) tenants' meeting if necessary; carrying out tenant information according to the communication plan; notification of the start of construction internally, at the authorities as well as the MA 50 **-** arbitration board and the wohnfonds_wien; construction and execution of retrofit

5. Project completion: Audit report, rectification of defects and post processing

Liebe Mieterin, lieber Mieter!

Dieser Fragebogen beschäftigt sich mit den Themen Heizgewohnheiten und Heizkosten. Vielen Dank, dass Sie sich die Zeit zum Beantworten des Fragebogens nehmen. Die Beantwortung der Fragen dauert etwa **15 Minuten** und sollte durch eine erwachsene Person Ihres Haushaltes erfolgen.

Mit Ihren Ansichten und Meinungen tragen Sie dazu bei Maßnahmen zu entwickeln, die Ihre Wohnkosten senken und gleichzeitig umweltfreundlich sind. Um das sicher zu stellen, würden wir gerne erfahren, wie zufrieden Sie mit Ihrer Wohnung oder des Wohngebäudes sind. Nutzen Sie die Gelegenheit, hierzu etwas zu sagen, denn SIE haben die Expertise vor Ort.

Diese Befragung ist Teil des Forschungsprojektes BALANCE, welches im Rahmen des Klima- und Energiefonds gefördert und von der Universität Wien durchgeführt wird. Die Universität Wien arbeitet nach den gesetzlichen Bestimmungen des Datenschutzes. Ihre persönlichen Daten werden vertraulich behandelt und die Auswertung erfolgt in anonymisierter Form.

Wir bitten Sie sehr um Ihre Unterstützung, in dem Sie den ausgefüllten Fragebogen entweder in dem beiliegenden, frankierten Antwortkuvert mit der Post retournieren oder online ausfüllen. Nutzen Sie dazu folgenden Link https://bit.ly/2wkw6NL oder den QR-Code.

Mitmachen lohnt sich, denn mit ein wenig Glück können Sie bei der Verlosung von **100 Einkaufs-Gutscheinen für Billa, BIPA, Thalia und viele mehr im Wert von 25€** gewinnen. Um teilzunehmen, geben Sie am Ende Ihre Kontaktdaten an. Jeder Vierte gewinnt!

Wenn Sie über Ergebnisse dieser Forschung informiert werden möchten oder bei Fragen wenden Sie sich gerne an Kristina Eisfeld, M.A.: Tel.: 01/ 4277 – 49276, E-Mail: kristina.eisfeld@univie.ac.at

Vielen Dank für Ihre Mithilfe!

Univ.-Prof. Yuri Kazepov, PhD
Kristina Eisfeld, M.A.

1. In welchem Jahr sind Sie in Ihre Wohnung gezogen?

Im Jahr__________

2. Wie groß ist Ihre Wohnfläche?

__________ m²

3. In welchem Stock liegt Ihre Wohnung?

☐ Unterstes Stockwerk ☐ Dazwischen liegendes Geschoss ☐ Dachgeschoss

4. Wie viele Räume hat Ihre Wohnung (ohne Bad, WC, Küche und Vorzimmer) insgesamt?

Anzahl der Räume: __________

5. Haben sich Ihre Wohnkosten in den letzten Jahren geändert?

	Stark gestiegen	Ein wenig gestiegen	Etwa gleich geblieben	Ein wenig gesunken	Stark gesunken
Heizkosten	☐	☐	☐	☐	☐
Stromkosten	☐	☐	☐	☐	☐
Miete (inkl. Betriebskosten)	☐	☐	☐	☐	☐

6. Treten die folgenden Probleme in Ihre Wohnung auf?

	Ja	Nein	Trifft nicht zu
Feuchte Wände, Fensterrahmen oder Fußböden (Schimmel)	☐	☐	☐
Undichtes Dach	☐	☐	☐
Kalte Außenwände	☐	☐	☐
Kalter Boden	☐	☐	☐
Undichte Fenster	☐	☐	☐
Schlecht gedämmte Gebäudehülle/Fassade	☐	☐	☐
Fehlende Regelungsmöglichkeit für das Heizsystem	☐	☐	☐
Sonstiges:			

7. Welche Raumtemperaturen bevorzugen Sie, wenn es draußen kalt ist?
(Wenn Sie es nicht genau wissen, bitte schätzen Sie so genau wie möglich.)

☐ 18°C oder weniger ☐ 19°C – 20°C ☐ 21°C – 22°C

☐ 23°C oder mehr ☐ Ich weiß nicht

8. Erreichen Sie diese bevorzugten Temperaturen in Ihrer Wohnung?

☐ Ja ☐ Nein. Warum nicht?________________________________

9. Welches Heiz- bzw. Kühlsystem haben Sie in Ihrer Wohnung?

Fernwärme	☐
Gas-Etagenheizung	☐
Zentralheizung (Gas/Öl)	☐
Kohleofen	☐
Elektroheizung	☐
Infrarotheizung	☐
Holzofen	☐
Klimaanlage	☐
Ich weiß nicht	☐
Sonstiges:	

10. Haben Sie in den letzten Jahren an einer Energieberatung teilgenommen?

☐ Ja, im Jahr: ________

☐ Nicht sicher

☐ Nein

11. Falls ja, konnten Sie durch die Energieberatung Ihr Heiz- bzw. Stromkosten senken?

☐ Ja ☐ Nein ☐ Nicht sicher

12. Wie schätzen Sie Ihren Heizverbrauch ein?

☐ Ich denke, ich nutze die Heizung mehr als der Großteil der Wiener.

☐ Ich denke, ich nutze die Heizung gleich viel wie der Großteil der Wiener.

☐ Ich denke, ich nutze die Heizung weniger als der Großteil der Wiener.

☐ Ich denke gar nicht über meinen Heizverbrauch oder den von anderen nach.

13. Wie hoch sind Ihre monatlichen Wohnkosten?
(Falls Sie es nicht genau wissen, bitte schätzen Sie so genau wie möglich.)

Heizkosten	_______________€
Stromkosten	_______________€
Miete (inkl. Betriebskosten)	_______________€

14. Wie viele Räume beheizen Sie, wenn es draußen kalt ist?

Anzahl der Räume: ________

15. Falls Sie nicht alle Räume heizen. Warum nicht?

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Weil ich damit Kosten spare.	☐	☐	☐	☐
Weil ich es so gelernt habe.	☐	☐	☐	☐
Weil ich damit Energie spare.	☐	☐	☐	☐
Weil es in manchen Räumen keine Heizung gibt.	☐	☐	☐	☐
Weil dort der Heizkörper nicht funktioniert.	☐	☐	☐	☐
Weil die Wohnung aus baulichen Gründen nicht richtig warm wird.	☐	☐	☐	☐
Weil manche Räume nicht benützt werden.	☐	☐	☐	☐
Weil die Wärme sich in die anderen Räume gut verteilt.	☐	☐	☐	☐
Weil manche Räume auch ohne Heizen eine angenehme Temperatur haben.	☐	☐	☐	☐

16. Verglichen mit ähnlichen Haushalten, wie bewerten Sie die Höhe Ihrer Heizkosten?

☐ Ich denke, ich zahle für die Heizung mehr als der Großteil der Wiener.

☐ Ich denke, ich zahle für die Heizung gleich viel wie der Großteil der Wiener.

☐ Ich denke, ich zahle für die Heizung weniger als der Großteil der Wiener.

☐ Ich denke gar nicht über meine Heizkosten oder die von anderen nach.

17. Sagen Sie uns bitte, inwieweit diese Ansichten für Sie persönlich zutreffen:

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Bevor ich die Heizung aufdrehe, ziehe ich mir einen Pullover an.	☐	☐	☐	☐
Ich drehe oft die Heizung in der Nacht auf, wenn mir kalt ist.	☐	☐	☐	☐
Ich schalte die Heizung ab, wenn ich die Wohnung verlasse.	☐	☐	☐	☐
Ich heize so, dass es angenehm ist, ohne auf Kosten zu achten.	☐	☐	☐	☐

In meiner Wohnung herrschen angenehme Temperaturen.	☐	☐	☐	☐
An kühlen Tagen lasse ich die Heizung länger (halben Tag) auf hoher Temperatur (über 23 °C).	☐	☐	☐	☐
Ich kann selbst bestimmen, wann und wie oft ich heize.	☐	☐	☐	☐

18. Welche Aussagen treffen auf Sie zu?

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Ich schließe die Tür zwischen beheizten und nicht beheizten Räumen.	☐	☐	☐	☐
Bekannte haben mich auf energiesparendes Heizverhalten aufmerksam gemacht.	☐	☐	☐	☐
Wenn es kalt ist, sitze ich häufig neben der Heizung, um warm zu bleiben.	☐	☐	☐	☐
Mir ist Energiesparen beim Heizen wichtig.	☐	☐	☐	☐
Ich verwende in meinem Alltag die Heizung ohne darüber nachzudenken.	☐	☐	☐	☐
Ich finde es wichtig möglichst wenig Energie und Rohstoffe zum Heizen zu verbrauchen.	☐	☐	☐	☐
Die meisten meiner Bekannten heizen möglichst energiesparend.	☐	☐	☐	☐
Ich verwende die Heizung während der Übergangszeit so wenig wie möglich.	☐	☐	☐	☐
Menschen, die mir wichtig sind, möchten, dass ich das Fenster schließe während ich heize.	☐	☐	☐	☐

19. Bitte geben Sie an, wie sehr die folgenden Aussagen auf Sie zutreffen:

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Ich werde in Zukunft darauf achten, dass ich meine Wohnung nicht überheize.	☐	☐	☐	☐
Ich habe die Absicht die Heizung in der Nacht zurückzudrehen.	☐	☐	☐	☐
In der Wohnung ist es manchmal zu heiß.	☐	☐	☐	☐
Ich versuche mit meinem Heizverhalten Energie zu sparen.	☐	☐	☐	☐
Ich habe die Fähigkeiten und das Wissen energiesparend zu heizen.	☐	☐	☐	☐

Ich bin selbst im Stande zu bestimmen, wie kalt oder warm es in der Wohnung ist.	☐	☐	☐	☐
Aufgrund von Problemen in der Wohnung, habe ich die Absicht umzuziehen.	☐	☐	☐	☐
Ich bin selten in der Wohnung, weil sie zu kalt ist.	☐	☐	☐	☐
Im Großen und Ganzen bin ich mit meiner Wohnung zufrieden.	☐	☐	☐	☐

Abschließende Angaben zu Ihrer Person

20. Gibt es etwas, das Sie uns zum Thema Heizen oder Gebäudezustand mitteilen wollen?

21. Geben Sie bitte den Straßennamen Ihres Wohnhauses an (ohne Hausnummer):
(Wird benötigt, um Wiener Wohnen auf mögliche Mängel in der Wohnanlage hinzuweisen.)

22. Geben Sie bitte Ihr Geschlecht an:

☐ Weiblich ☐ Männlich ☐ Anderes

23. Welchen Erwerbsstatus haben Sie?

☐ Vollzeit berufstätig ☐ Teilzeit berufstätig (< 30 Std.) ☐ Hausfrau/Hausmann

☐ Pension ☐ Zurzeit arbeitslos ☐ Wehr-/Zivildienst

☐ In Ausbildung ☐ Schule/Studium

24. Was ist Ihre höchste abgeschlossene Ausbildung?

☐ Pflichtschule ☐ Lehre oder Mittelschule (ohne Matura)

☐ AHS/BHS (mit Matura) ☐ Universität/Kolleg/FH

☐ Anderes: _____________

25. Bezug von wohlfahrtsstaatlichen Leistungen (Mehrfachantworten möglich):

☐ Arbeitslosengeld ☐ Mindestsicherung ☐ Pension

☐ Kinderbetreuungsgeld ☐ Heizkostenzuschuss ☐ Pflegegeld

☐ Wohnbeihilfe ☐ Familienbeihilfe ☐ Sonstiges: _______________

26. Wie viele Personen leben in Ihrem Haushalt?

_____	Kleinkinder (0-2 Jahre)	_____	Kinder (3-12 Jahren)	_____	Jugendliche (13-17 Jahre)
_____	Erwachsene (18 - 65 Jahren)	_____	Erwachsene (>65 Jahre)		

27. Wie viele Stunden pro Tag verbringen diese Personen maximal in der Wohnung?

☐ Weniger als 8 Stunden ☐ 8 - 12 Stunden ☐ 12 -18 Stunden ☐ Über 18 Stunden

28. Sind in den letzten 12 Monaten eines oder mehrere dieser Lebensereignisse eingetreten?

☐ Geburt von Kindern ☐ Schwere Krankheit ☐ Todesfall im Haushalt

☐ Scheidung ☐ Arbeitslosigkeit ☐ Zu pflegende Person

☐ Auszug von Personen ☐ Zuzug von Personen ☐ Trifft nicht zu

29. Wie hoch ist Ihr verfügbares Haushaltseinkommen pro Monat?

(Bitte geben Sie das monatliche Nettoeinkommen aller Haushaltsmitglieder inkl. zusätzlicher Einkünfte oder Beihilfen wie Wohnbeihilfe, Kinderbetreuungsgeld, Arbeitslosengeld, etc. an. Falls Sie es nicht genau wissen, geben Sie eine Schätzung an, da dies sehr wichtig für uns ist.)

☐ Bis 500 € ☐ 501 € bis 800 € ☐ 801 € bis 1.400 €

☐ 1.401 € bis 2.000 € ☐ 2.001 € bis 2.700 € ☐ Mehr als 2.700 €

☐ Keine Angabe ☐ Ich weiß nicht

Ich möchte an der Verlosung teilnehmen: ☐ Ja ☐ Nein

Ich möchte an einer weiteren Befragung teilnehmen: ☐ Ja ☐ Nein

Falls ja, bitten wir Sie um Angabe Ihrer Kontaktdaten:

Vorname, Nachname: ____

Straße, Hausnummer: ____

Postleitzahl, Ort: ____

E-Mail Adresse: ____

Telefonnummer: ____

Datenschutzerklärung: Der Fragebogen wird selbstverständlich vertraulich behandelt, womit eine vollständige Anonymität gewährleistet wird. Personenbezogene Daten werden ausschließlich von den ProjektpartnerInnen des Projekts BALANCE, **Universität Wien** verwendet und nicht an Dritte weitergegeben. Ihre persönlichen Daten werden entsprechend den Bestimmungen der Datenschutzverordnung (DSGVO) verwendet und anonymisiert. Diese Daten werden gelöscht, sobald sie nicht mehr benötigt werden. Sie haben jederzeit das Recht zum Widerruf dieser Zustimmung durch formlose Mitteilung an die Universität Wien.

Vielen Dank für Ihre Teilnahme – Sie haben uns damit sehr geholfen!

Liebe Mieterin, lieber Mieter!

Dieser Fragebogen beschäftigt sich mit den Themen Heizgewohnheiten, Heizkosten und Gebäudesanierung. Vielen Dank, dass Sie sich die Zeit zum Beantworten des Fragebogens nehmen. Die Beantwortung der Fragen dauert etwa **15 Minuten** und sollte durch eine erwachsene Person Ihres Haushaltes erfolgen.

Mit Ihren Ansichten und Meinungen tragen Sie dazu bei Maßnahmen zu entwickeln, die Ihre Wohnkosten senken und gleichzeitig umweltfreundlich sind. Um das sicher zu stellen, würden wir gerne erfahren, wie zufrieden Sie mit der Sanierung Ihrer Wohnung oder des Wohngebäudes sind. Nutzen Sie die Gelegenheit, hierzu etwas zu sagen, denn SIE haben die Expertise vor Ort.

Diese Befragung ist Teil des Forschungsprojektes BALANCE, welches im Rahmen des Klima- und Energiefonds gefördert und von der Universität Wien durchgeführt wird. Die Universität Wien arbeitet nach den gesetzlichen Bestimmungen des Datenschutzes. Ihre persönlichen Daten werden vertraulich behandelt und die Auswertung erfolgt in anonymisierter Form.

Wir bitten Sie sehr um Ihre Unterstützung, in dem Sie den ausgefüllten Fragebogen entweder in dem beiliegenden, frankierten Antwortkuvert mit der Post retournieren oder online ausfüllen. Nutzen Sie dazu folgenden Link https://bit.ly/2wkw6NL oder den QR-Code.

Mitmachen lohnt sich, denn mit ein wenig Glück können Sie bei der Verlosung von **100 Einkaufs-Gutscheinen für Billa, BIPA, Thalia und viele mehr im Wert von 25€** gewinnen. Um teilzunehmen, geben Sie am Ende Ihre Kontaktdaten an. Jeder Vierte gewinnt!

Wenn Sie über Ergebnisse dieser Forschung informiert werden möchten oder bei Fragen wenden Sie sich gerne an Kristina Eisfeld, M.A.: Tel.: 01/ 4277 – 49276, E-Mail: kristina.eisfeld@univie.ac.at

Vielen Dank für Ihre Mithilfe!

Univ.-Prof. Yuri Kazepov, PhD
Kristina Eisfeld, M.A.

1. In welchem Jahr sind Sie in Ihre Wohnung gezogen?

   Im Jahr__________

2. Wie groß ist Ihre Wohnfläche?

   __________ m²

3. In welchem Stock liegt Ihre Wohnung?

   ☐ Unterstes Stockwerk ☐ Dazwischen liegendes Geschoss ☐ Dachgeschoss

4. Wie viele Räume hat Ihre Wohnung (<u>ohne Bad, WC, Küche und Vorzimmer</u>) insgesamt?

   Anzahl der Räume: __________

5. Welche Raumtemperaturen bevorzugen Sie, wenn es draußen kalt ist? (Wenn Sie es nicht genau wissen, bitte schätzen Sie so genau wie möglich.)

   ☐ 18°C oder weniger ☐ 19°C – 20°C ☐ 21°C – 22°C

   ☐ 23°C oder mehr ☐ Ich weiß nicht

6. Erreichen Sie diese bevorzugten Temperaturen in Ihrer Wohnung?

   ☐ Ja ☐ Nein, warum nicht?____________________________

7. Haben Sie in den letzten Jahren an einer Energieberatung teilgenommen?

   ☐ Ja, im Jahr: ______

   ☐ Nicht sicher

   ☐ Nein

8. Falls ja, konnten Sie durch die Energieberatung Ihre Heiz- bzw. Stromkosten senken?

   ☐ Ja ☐ Nein ☐ Nicht sicher

9. Wie viele Räume beheizen Sie insgesamt, wenn es draußen kalt ist?

   Anzahl der Räume: __________

10. Falls Sie nicht alle Räume heizen. Warum nicht?

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Weil ich damit Kosten spare.	☐	☐	☐	☐
Weil ich es so gelernt habe.	☐	☐	☐	☐
Weil ich damit Energie spare.	☐	☐	☐	☐
Weil es in manchen Räumen keine Heizung gibt.	☐	☐	☐	☐
Weil dort der Heizkörper nicht funktioniert.	☐	☐	☐	☐
Weil die Wohnung aus baulichen Gründen nicht richtig warm wird.	☐	☐	☐	☐
Weil manche Räume nicht benutzt werden.	☐	☐	☐	☐
Weil die Wärme sich in die anderen Räume gut verteilt.	☐	☐	☐	☐
Weil manche Räume auch ohne Heizen eine angenehme Temperatur haben.	☐	☐	☐	☐

11. Wie schätzen Sie Ihren Heizverbrauch ein?

☐ Ich denke, ich nutze die Heizung mehr als der Großteil der Wiener.

☐ Ich denke, ich nutze die Heizung gleich viel wie der Großteil der Wiener.

☐ Ich denke, ich nutze die Heizung weniger als der Großteil der Wiener.

☐ Ich denke gar nicht über meinen Heizverbrauch oder den von anderen nach.

12. Wissen Sie, welche Sanierungsarbeiten an Ihrem Gebäude durchgeführt wurden?

☐ Sanierung oder Austausch der Fenster ☐ Dämmung der Außenwände

☐ Dämmung der obersten Geschossdecke (Dach) ☐ Tausch des Heizsystems

☐ Dämmung der Kellerdecke oder des Kellerbodens ☐ Ich weiß nicht

☐ Andere Maßnahmen: ___________________

13. Wann wurde Ihr Gebäude saniert?

☐ Im Jahr ______ ☐ Ich weiß nicht

14. Wie wurden Sie vor der Sanierung über bevorstehende Umbaumaßnahmen informiert?

☐ Gar nicht ☐ Informationsbrief ☐ Aushang

☐ Veranstaltung ☐ Sonstiges: ___________________

15. Wie haben sich Ihre Wohnkosten durch die Sanierung Ihres Gebäudes geändert?

	Stark gestiegen	Ein wenig gestiegen	Etwa gleich geblieben	Ein wenig gesunken	Stark gesunken
Heizkosten	☐	☐	☐	☐	☐
Stromkosten	☐	☐	☐	☐	☐
Miete (inkl. Betriebskosten)	☐	☐	☐	☐	☐

16. Welches Heiz- bzw. Kühlsystem hatten/haben Sie in Ihrer Wohnung?

	Vor der Sanierung	Nach der Sanierung
Fernwärme	☐	☐
Gas-Etagenheizung	☐	☐
Zentralheizung (Gas/Öl)	☐	☐
Kohleofen	☐	☐
Elektroheizung	☐	☐
Infrarotheizung	☐	☐
Holzofen	☐	☐
Klimaanlage	☐	☐
Sonstiges: ___________________	☐	☐
Ich weiß nicht	☐	☐

17. Verglichen mit ähnlichen Haushalten, wie bewerten Sie die Höhe Ihrer Heizkosten?

☐ Ich denke, ich zahle für die Heizung mehr als der Großteil der Wiener.

☐ Ich denke, ich zahle die Heizung gleich viel wie der Großteil der Wiener.

☐ Ich denke, ich zahle für die Heizung weniger als der Großteil der Wiener.

☐ Ich denke gar nicht über meine Heizkosten oder die von anderen nach.

18. Wie hoch sind Ihre MONATLICHEN Wohnkosten vor und nach der Sanierung?
(Falls Sie es nicht genau wissen, bitte schätzen Sie so genau wie möglich.)

Vor der Sanierung		Nach der Sanierung	
Heizkosten:	________________€	Heizkosten:	________________€
Stromkosten:	________________€	Stromkosten:	________________€

Miete (inkl. Betriebskosten):	______________€	Miete (inkl. Betriebskosten):	______________€

19. Wie hat sich der Zustand der Wohnung nach der Sanierung verändert?

	Besser geworden	Gleich gut geblieben	Gleich schlecht geblieben	Schlechter geworden	Trifft nicht zu
Feuchte Wände, Fensterrahmen oder Fußböden (Schimmel)	☐	☐	☐	☐	☐
Undichtes Dach	☐	☐	☐	☐	☐
Kalte Außenwände	☐	☐	☐	☐	☐
Kalter Boden	☐	☐	☐	☐	☐
Undichte Fenster	☐	☐	☐	☐	☐
Schlecht gedämmte Gebäudehülle/Fassade	☐	☐	☐	☐	☐
Fehlende Regelungsmöglichkeit für das Heizsystem	☐	☐	☐	☐	☐
Sonstiges:	☐	☐	☐	☐	☐

20. Bitte geben Sie an, wie sehr die folgenden Aussagen auf Sie zutreffen:

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Ich schließe die Tür zwischen beheizten und nicht beheizten Räumen.	☐	☐	☐	☐
Bekannte haben mich auf energiesparendes Heizverhalten aufmerksam gemacht.	☐	☐	☐	☐
Wenn es kalt ist, sitze ich häufig neben der Heizung, um warm zu bleiben.	☐	☐	☐	☐
Mir ist Energiesparen beim Heizen wichtig.	☐	☐	☐	☐
Ich verwende in meinem Alltag die Heizung ohne darüber nachzudenken.	☐	☐	☐	☐
Ich finde es wichtig möglichst wenig Energie und Rohstoffe zum Heizen zu verbrauchen.	☐	☐	☐	☐
Die meisten meiner Bekannten heizen möglichst energiesparend.	☐	☐	☐	☐
Ich verwende die Heizung während der Übergangszeit so wenig wie möglich.	☐	☐	☐	☐

Menschen, die mir wichtig sind, möchten, dass ich das Fenster schließe während ich heize.	☐	☐	☐	☐
Ich habe die Fähigkeiten und das Wissen energiesparend zu heizen.	☐	☐	☐	☐
Ich habe die Absicht die Heizung in der Nacht zurückzudrehen.	☐	☐	☐	☐

21. Bitte geben Sie an, wie sehr die folgenden Aussagen auf Sie zutreffen:

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Vor der Sanierung habe ich einen Pullover angezogen, wenn mir kalt war. Jetzt heize ich mehr ein.	☐	☐	☐	☐
Seit der Sanierung, drehe ich nun öfters die Heizung in der Nacht auf, wenn mir kalt ist.	☐	☐	☐	☐
Seit der Sanierung schalte ich die Heizung ab, wenn ich die Wohnung verlasse.	☐	☐	☐	☐
Seit der Sanierung heize ich ohne auf Kosten zu achten.	☐	☐	☐	☐
Vor der Sanierung war ich selten in der Wohnung, weil es zu kalt war. Jetzt brauche ich nicht mehr groß darüber nachzudenken.	☐	☐	☐	☐
Seit der Sanierung heize ich nicht mehr lange (halben Tag) auf hoher Temperatur (über 23 °C).	☐	☐	☐	☐
Aufgrund von Problemen, die durch die Sanierung entstanden sind, habe ich die Absicht umzuziehen.	☐	☐	☐	☐
Ich kann selbst bestimmen, wann und wie oft ich heize.	☐	☐	☐	☐

22. In welchem Ausmaß treffen folgende Behauptungen auf Ihre Wohnung zu?

	Stimme völlig zu	Stimme eher zu	Stimme eher nicht zu	Stimme gar nicht zu
Im Großen und Ganzen bin ich mit meiner sanierten Wohnung zufrieden.	☐	☐	☐	☐
Meine Wohnung hat sich durch die Umbauarbeiten verbessert.	☐	☐	☐	☐
In meiner Wohnung herrschen angenehmere Temperaturen als vor der Sanierung.	☐	☐	☐	☐

Seit der Sanierung wird es in der Wohnung manchmal zu heiß.	☐	☐	☐	☐
Ich werde in Zukunft darauf achten, dass ich meine Wohnung nicht überheize.	☐	☐	☐	☐
Ich bemühe mich mit meinem Heizverhalten Energie zu sparen.	☐	☐	☐	☐
Ich bin selbst im Stande zu bestimmen, wie kalt oder warm es in der Wohnung ist.	☐	☐	☐	☐

Abschließende Angaben zu Ihrer Person

23. Gibt es etwas, das Sie uns zum Thema Heizen, Sanierung oder Gebäudezustand mitteilen wollen?

24. Geben Sie bitte den Straßennamen Ihres Wohnhauses an (ohne Hausnummer):
(Wird benötigt, um Wiener Wohnen auf mögliche Mängel in der Wohnanlage hinzuweisen.)

25. Geben Sie bitte Ihr Geschlecht an:

☐ Weiblich ☐ Männlich ☐ Anderes

26. Welchen Erwerbsstatus haben Sie?

☐ Vollzeit berufstätig ☐ Teilzeit berufstätig (< 30 Std.) ☐ Hausfrau/Hausmann

☐ Pension ☐ Zurzeit arbeitslos ☐ Wehr-/Zivildienst

☐ In Ausbildung ☐ Schule/Studium

27. Was ist Ihre höchste abgeschlossene Ausbildung?

☐ Pflichtschule ☐ Lehre oder Mittelschule (ohne Matura)

☐ AHS/BHS (mit Matura) ☐ Universität/Kolleg/FH

☐ Anderes: _____________

28. Bezug von wohlfahrtsstaatlichen Leistungen (Mehrfachantworten möglich):

☐ Arbeitslosengeld ☐ Mindestsicherung ☐ Pension

☐ Kinderbetreuungsgeld ☐ Heizkostenzuschuss ☐ Pflegegeld

☐ Wohnbeihilfe ☐ Familienbeihilfe ☐ Sonstiges: ______________

29. Wie viele Personen leben in Ihrem Haushalt?

_____	Kleinkinder (0-2 Jahre)	_____	Kinder (3-12 Jahren)	_____	Jugendliche (13-17 Jahre)
_____	Erwachsene (18-65 Jahren)	_____	Erwachsene (>65 Jahre)		

30. Wie viele Stunden pro Tag verbringen diese Personen maximal in der Wohnung?

☐ Weniger als 8 Stunden ☐ 8 - 12 Stunden ☐ 12 -18 Stunden ☐ Über 18 Stunden

31. Sind in den **letzten** 12 Monaten eines oder mehrere dieser Lebensereignisse eingetreten?

☐ Geburt von Kindern ☐ Schwere Krankheit ☐ Todesfall im Haushalt
☐ Scheidung ☐ Arbeitslosigkeit ☐ Zu pflegende Person
☐ Auszug von Personen ☐ Zuzug von Personen ☐ Trifft nicht zu

32. Wie hoch ist Ihr verfügbares Haushaltseinkommen pro Monat?

(Bitte geben Sie das monatliche Nettoeinkommen aller Haushaltsmitglieder inkl. zusätzlicher Einkünfte oder Beihilfen wie Wohnbeihilfe, Kinderbetreuungsgeld, Arbeitslosengeld, etc. an. Falls Sie es nicht genau wissen, geben Sie eine Schätzung an, da dies sehr wichtig für uns ist.)

☐ Bis 500 € ☐ 501 € bis 800 € ☐ 801 € bis 1.400 €
☐ 1.401 € bis 2.000 € ☐ 2.001 € bis 2.700 € ☐ Mehr als 2.700 €
☐ Keine Angabe ☐ Ich weiß nicht

Ich möchte an der Verlosung teilnehmen: ☐ Ja ☐ Nein

Ich möchte an einer weiteren Befragung teilnehmen: ☐ Ja ☐ Nein

Falls ja, bitten wir Sie um Angabe Ihrer Kontaktdaten:

Vorname, Nachname: ____

Straße, Hausnummer: ____

Postleitzahl, Ort: ____

E-Mail Adresse: ____

Telefonnummer: ____

Datenschutzerklärung: Der Fragebogen wird selbstverständlich vertraulich behandelt, womit eine vollständige Anonymität gewährleistet wird. Personenbezogene Daten werden ausschließlich von den ProjektpartnerInnen des Projekts BALANCE, **Universität Wien** verwendet und nicht an Dritte weitergegeben. Ihre persönlichen Daten werden entsprechend den Bestimmungen der Datenschutzverordnung (DSGVO) verwendet und anonymisiert. Diese Daten werden gelöscht, sobald sie nicht mehr benötigt werden. Sie haben jederzeit das Recht zum Widerruf dieser Zustimmung durch formlose Mitteilung an die Universität Wien.

Vielen Dank für Ihre Teilnahme – Sie haben uns damit sehr geholfen!

Appendix F

Logistic Regression

In logistic regression, researchers predict one variable (such as the likelihood of being energy poor) from a set of predictors in a similar way to linear regression. The difference between linear and logistic regressions lies in the fact that the latter is the most appropriate functional form where the dependent variable is dichotomous and thus indicates whether or not an outcome if present. Logistic regression is therefore a well-established statistical method used to analyse and model binary dependent variables. The main objective of this statistical analysis is twofold:

1. to understand the drivers leading households to employ self-restricting behaviours and behavioural change and
2. to assess the probability of being energy poor.

In logistic regression there are two possible outcomes for Y by 0 and 1, which is a probability distribution of the response variable of the Bernoulli distribution p(Y=1)= π (that is the mean of Y takes the probability that Y takes on the value 1) and correspondingly, p(Y=0)= 1- π. The logistic distribution function is s-shaped and has values between 0.0 to 1.0 and beta weights for differing values from negative infinity to positive infinity. Logistic regression assumes that the response is conditionally Bernoulli[257] distributed (produced by a binomial distribution), given the values of the features of the logistic regression function as expressed in equation (1.8):

$$\textit{Probability of } Y \mid x \sim \text{Bernoulli } \left(p = \frac{1}{1+e^{-(\alpha+\beta 1x1+\cdots\beta kxk)}}\right) \quad (0 \le p \le 1) \qquad (1.8)$$

Probability means the number of times the event occurs divided by the number of times the event could occur (possible values range from 0 to 1).

$$\text{Odds } \left(\frac{p}{1-p}\right) = e^{(\alpha+\beta 1x1+\cdots\beta kxk)} \qquad (0 \le \text{odds} \le \infty) \qquad (1.9)$$

The ratio p/(1- p) is called the odds and ranges between 0 and +∞ (not to confuse with probabilities as odds constitute ratio of probabilities). This is the probability that an event will occur divided by the probability that the event will not occur. In logistic regression, the odds are logarithmized to extract logits. The log odd is the natural log of the odds. Logarithmized

257 It models the mean of Bernoulli distribution as a special case of binomial distribution for a single trial. The dependent variable in logistic regression follows Bernoulli distribution by having an unknown probability P. The logit connects the independent variable to the Bernoulli distribution.

odds are not substantively interpretable because of the nonlinear relation to the probabilities (Biesta, 2010, p. 831):

$$\text{logit}(x) = \ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k \quad (-\infty \leq \text{logit} \leq \infty) \qquad (1.10)$$

Where:

1. $P(x)$ *is the probability function* (*e.g. being energy poor*),
2. α is the intercept,
3. β is a coefficient,
4. x is the explanatory variable.

The outcomes ($\beta_{k)}$ can be interpreted in terms of probabilities or in terms of odds.

The actual model contains the natural logarithm of the (odds of y|x): log(odds of y|x)= $\alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_{k.}$ The regression coefficients represent the log(odds of y|x). Through transformation, the (odds of y|x) may be found by computing $e^{\beta x}$. The estimated coefficients in logistic regressions are more complicated to interpret than in linear regression (Backhaus et al. 2003: 431). That's why we may consider a basic 2 x 2 contingency table where the researcher is interested in the relationship between an independent variable being a pensioner (β_1) and experiencing energy poverty (Y) as a dependent variable. Let $x = 1$ for being a pensioner, and x=0 otherwise. Let $y = 1$ if the household is being energy poor, and $y = 0$ otherwise. Table 49 provides hypothetical sample data that will explain odds and odds ratios.

	Pensioner ($x = 1$)	**Not pensioner** ($x = 0$)	
Energy poor ($y = 1$)	30	15	45
Not energy poor ($y = 0$)	10	50	60
	40	65	105

Table 49: Hypothetical Example of Odds Ratio Calculation

Odds describe the ratio of success to ratio of failure of an event. If being energy poor is an event, then the odds of being energy poor are

$$\text{Odds: } \left(\frac{p}{1-p}\right) = \frac{p\ (y=1)}{p\ (y=0)} = \frac{45/105}{\frac{60}{105}} = \mathbf{0.75}$$

The odds of *not* being energy poor are

Odds: $\left(\frac{p}{1-p}\right) = \frac{p\ (y=1)}{p\ (y=0)} = \frac{60/105}{\frac{45}{105}} = \mathbf{1.33}$

Hence, the odds of not being energy poor are higher than the odds of being energy poor. The odds of being energy poor given being a pensioner are

Odds of (y = 1 | x = 1) = $\frac{p\ (energy\ poor\ |\ pensioner)}{p\ (not\ energy\ poor|\ pensioner)}$

$$= \frac{p\ (y = 1\ |\ x = 1)}{p\ (y = 0\ |\ x = 1)} == \frac{p\ (30\ |\ 40)}{p\ (10\ |\ 40)} = \frac{30}{10} = 3$$

Similarly, the odds of a person being energy poor given they are not pensioners is provided by:

Odds of (y = 1 | x = 0) = $\frac{p\ (energy\ poor\ |\ no\ pensioner)}{p\ (not\ energy\ poor|\ no\ pensioner)}$

$$= \frac{p\ (y = 1\ |\ x = 0)}{p\ (y = 0\ |\ x = 0)} == \frac{p\ (15\ |\ 65)}{p\ (50\ |\ 65)} = \frac{15}{50} = 0.3$$

What is an odds ratio (also expressed as *exp(b)*)?

It is the ratio of two odds, namely the odds of success for one group divided by the odds of success for the other group. Odds ratio is a ratio that relates two odds with each other by dividing them. Odds ratios are usually calculated and displayed in logistic regression analysis results as they provide the constant effect of a predictor X, on the likelihood that one outcome will occur. For the energy poor example, it is

Odds-ratio: $\frac{odds\ of\ (energy\ poor\ |\ pensioner)}{odds\ of\ (energy\ poor\ |\ no\ pensioner)} = \frac{odds\ of\ (y = 1\ |\ x=1)}{odds\ of\ (y = 1|\ x=0)} = \frac{(\frac{30}{10})}{(\frac{15}{50})} = \frac{3}{0.30} = 10$

The hypothetical result shows an odds ratio of 10 being a pensioner against not being a pensioner. It means that pensioners are 10 times more likely to be energy poor compared to the remaining rest.

Interpretation help:
OR = 1 Exposure does not affect odds of falling into an energy poverty group
OR > 1 Exposure associated with higher odds of falling into an energy poverty group
OR < 1 Exposure associated with lower odds of falling into an energy poverty group

An advantage is that logistic regressions are flexible compared to other techniques. They do not have assumptions about the distribution of the independent variables as linear regressions. They do not have to be normally distributed, linearity related, or have equal variance within each group. Independent variables can be any combination of binary, ordinal, interval or matric measures (Tabachnick and Fidell, 2001).

While in a linear regression model the OLS method is used, in logistic regression the more general method of maximum-likelihood estimation is applied, that does not require the errors to be normally distributed with a constant variance. Because the dependent variable is a binary, the probability distribution is straightforward the Bernoulli distribution. The log likelihood is maximized numerically by using an iterative algorithm (Collett, 2003).

While in linear regression, we test the hypothesis that all β's = 0 vs. the alternative that at least one is not; we use the F-test to assess the general model. For logistic regression, the likelihood ratio chi-square test is used instead. Calculated from the first and last iteration, (LR)x^2-value evaluates the null hypothesis that all coefficients in the model, except the constant, equal zero (degrees of freedom depend on the number of independent variables). Calculation is based on log-likelihood tests where the log-likelihood of the full model of interest (LL_1) is related to the reduced log-likelihood model without independent variables (LL_0) and only the constant. A highly significant result indicates that all regression coefficients are not equal to zero.

LR x^2= -2 * $(LL_1 - LL_0)$

This is minus two times the difference between the starting and ending log likelihood iteration. Traditional linear regression use R^2 statistics to assess the proportion of variability in the dependent variable that can be explained by the independent variables. For logistic regression, pseudo R^2 is interpreted as analogous to R^2 in linear OLS regressions. There are further R^2 for binary regression models (e.g. Nagelkerke, Cox and Snell etc.).

McFadden's $R^2 =$ 1- $(\frac{LL_1}{LL_0})$.

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