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Assessing Equitable Access to Energy Efficiency in Housing

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THE ENERGY DIVIDE

ASSESSING EQUITABLE ACCESS TO ENERGY EFFICIENCY IN HOUSING

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PREFACE

In front of you lies the master thesis “The Energy Divide: Assessing Equitable Access to Energy Efficiency in Housing”. This thesis is written as the final graduation assignment of the master Management in the Built Environment at the TU Delft, allocated to the theme “Housing Crisis”. The research was conducted during the period February-June 2025.

The idea for this thesis of combining demographics and socioeconomics with energy efficiency stems from the introductory pitches for the graduation laboratory. During the pitches of all the different themes, one particular example gained my interest. It was about how policies about making sustainable renovations obligatory after sale for the worst labels in Belgium. This sparked the idea to start with the topics of sustainability and market dynamics, which later evolved into what the research is now.

The process of conducting this research has been both challenging and rewarding. With the background of an Applied Sciences Architecture and Building Sciences Bachelor (HBO Bouwkunde), approaching every element from an academic perspective was sometimes demanding. In particular, learning SPSS and trying out different quantitative analysis techniques without prior experience required some dedication. Eventually, validating the results with interviews felt rewarding. A lot of interviewees recognised the results discussed. Being invited to present the research to the municipality and later to the RVO felt even more rewarding. Due to a clear research objective, solid preparation, and some flexibility along the way, the entire process felt relatively smooth.

I would like to thank my mentors at the TU Delft, Harry Boumeester and Michaël Peeters, for their guidance and critical feedback. Another word of thanks goes to Martijn Nawroth of Fakton, offering guidance and insights into how a consultant would interpret and present the results, but also to the colleagues for their interest in the research. I also extend my gratitude to the interviewees from Nibud, Vereniging Eigen Huis, TNO, real estate brokers and the municipality. Furthermore, I want to thank Rosa van der Drift for the feedback and for guiding me through the statistical challenges of this research.

I hope this thesis not only contributes to academic understanding but also informs policy and practice aimed at a fairer and more sustainable housing market.

Enjoy reading!

Dylan Schroevers

Delft, 18-06-2025

ABSTRACT

The Netherlands faces severe affordability issues in the owner-occupied housing market. Not only are dwelling prices skyrocketing, but households are also struggling to cover rising energy prices. Meeting climate goals is an additional complexity layer, creating a divide between households able to adapt to the energy transition and ones lagging. Therefore, the distribution of benefits from energy-efficient housing remains uneven. This research investigates how demographic and socio-economic factors influence access to energy efficiency in the Dutch owner-occupied housing market, focusing on three dimensions of social equity, energy costs, wealth growth and access to subsidies. Using a mixed-methods approach, combining data analysis with interviews, the study finds significant disparities between households within the owner-occupied housing market. Lower-income households are underrepresented in better Energy Performance Certificates (EPCs) categories and face barriers in subsidy access. While homes with better EPCs are linked to better energy efficiency and higher value appreciation, these advantages mostly benefit higher-income households. Existing subsidies, although intended well, often reinforce inequality due to complex procedures and distrust of certain households in the government. The study proposes policy directions to improve targeting and equity in subsidy schemes, aiming for a more inclusive and effective energy transition by incentivising, informing and integrating.

KEYWORDS

Dutch Housing Market, Energy Labels, Energy Performance Certificates, Government Subsidies, Market Liquidity, Segmentation, Social Equity, Sustainability

EXECUTIVE SUMMARY

This research investigates the relationship between demographic and socio-economic status and access to energy efficiency in the Dutch owner-occupied housing market. As housing prices and energy costs continue to rise and climate goals become increasingly urgent, ensuring an equitable energy transition is both a social and environmental necessity. The research combines quantitative analysis with qualitative insights to assess whether current market dynamics and subsidy schemes are inclusive or inadvertently drive social inequity.

The main research question is stated as:

"How does demographic and socio-economic status influence the access to energy efficiency in the Dutch owner-occupied housing market in terms of energy costs, wealth growth and access to subsidies?"

The combination of these three dimensions, energy costs, wealth growth and access to subsidies, indicates that demographic and socio-economic status influence access to energy efficiency in housing. Using WoON 2021 survey data, an overview is created of different status groups across Energy Performance Certificates (EPCs). This overview employs cross-tabulations and an ordinal regression analysis. The results reveal a disproportionate share of recently moved high-income groups, older ages, and multi-person households in better labelled dwellings. Therefore, recently moved lower-income, single-person, and younger households more often reside in worse labelled dwellings.

With this overview, the energy costs relative to income can be determined using the ISDE (Investeringssubsidie Duurzame Energie) and NWF (Nationaal Warmte Fonds) monitor 2023. Analysis of these datasets shows that gas and electricity costs per income group showed significant disparities. While wealthier households reside more often in more energy-efficient dwellings, this group uses the most energy and gas in absolute numbers. This can be explained by the fact that these households often reside in larger dwellings. The energy costs relative to income show that lower-income households spend a significantly higher share relative to income on energy and gas than higher-income households. This indicates that the energy cost burden is unequally distributed across income groups.

The second dimension, wealth growth, is determined by the price effects of EPCs. Using NVM transaction data enriched with Springco EPCs data, transaction prices per EPC are examined. Cross-tabulations and a linear regression analysis showed that worse energy labels sell at a discount compared to EPC A. Connecting this to the distribution of household characteristics across EPCs provides insight that certain households living in worse-labelled dwellings occupy a disadvantaged position in terms of wealth growth due to the lower value of the dwelling at the time of sale, but also price effects over time. Furthermore, it is harder to obtain an energy-efficient dwelling due to shorter times on the market, which increases competition and drives up property values.

The interviews with real estate experts confirm several findings for the other two dimensions, as well as show disparities in access to subsidies. Subsidies are more often used by higher-income households, enabling these households to lower their energy costs and increase wealth growth even more. On the other hand, lower-income households are harder to reach, due to existing distrust towards the government, and face financial constraints, deterring this group from energy-efficient renovations.

Furthermore, the municipality grants subsidy via the National Insulation Programme (NIP) and is targeting the households residing in EPCs worse than D. However, since a homeowner has little to no incentive to renew an EPC when there is no intention to sell the dwelling anytime soon, the municipality often works with outdated EPCs. These represent potentially a worse energy-efficiency status of the dwellings, which are in reality already more energy-efficient. Therefore, incentivising homeowners to renew the EPC of the household's dwelling could create better targeting, providing support to households that need it the most, more efficiently. Furthermore, banks could profit from an incentive to renew the EPC as well, improving reporting about the state of the portfolio, as well are more accurate risk assessment.

To overcome these barriers, directions for policy reforms are presented using the three I's. These reforms aim to get rid of problems like outdated EPCs, distrust in the government, complex application procedures, fragmented responsibilities and the lack of upfront capital. It gives direction to be able to incentivise, to inform more efficiently and to integrate the process.

Directions for policy reforms:

- **Incentivise** homeowners to renew EPCs
    - Lower municipal taxes for renewed EPCs (with label jump)
    - Lower mortgage interest rates for renewed EPCs (with label jump)
    - Renew outdated EPCs (before a renovation) by the new homebuyer to create more mortgage capacity
    - Create a 0% NWF loan for VvEs (just like for individuals)
- **Inform** hard-to-reach groups
    - Use borrowed trust of the health sector, community centres, and sports clubs
    - Target groups in dwellings rated worse than D, more efficiently when renewing is incentivised
- **Integrate** application and advisory processes
    - Bundle advice across sectors, integrate efforts of installers, real estate agents and mortgage advisors
    - Create the one-stop shop
    - Use "upfront" subsidies as a discount on installers' invoices

In general, lower-income households are more likely to reside in worse labelled dwellings, spend a higher portion relative to income on gas and electricity, accumulate less housing-related wealth, and face greater barriers to accessing subsidies than higher-income households. Policy instruments such as subsidies and financing schemes have the potential to rebalance these inequities, but only if they are better targeted, more accessible, and trusted by households who need them most. This research shows that current housing market structures and sustainability policies tend to benefit already advantaged groups. To achieve a fairer energy transition, reforms are needed to create equitable access to energy efficiency in housing, by incentivising, informing and integrating.

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K. Regression Linear NVM
L. Reflection

ABBREVIATIONS

Abbreviations	
Abbreviation	**Full text**
BKR	Bureau Krediet Registratie (Credit Registration Office)
BZK	Ministerie van Binnenlandse Zaken en Koninkrijkrelaties (Ministry of the Interior and Kingdom Relations)
CBS	Centraal Bureau Statistiek (Statistics Netherlands)
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
ISDE	Investeringssubsidie Duurzame Energie (Investment Subsidy for Sustainable Energy)
NIP	Nationaal Isolatie Programma (National Insulation Programme)
NVM	Nederlandse Vereniging van Makelaars (Dutch Association of Real Estate Brokers)
NWF	Nationaal Warmtefonds (National Heat Fund)
RVO	Rijksdienst voor Ondernemend Nederlands (Netherlands Enterprise Agency)
SPSS	Statistical Package for the Social Sciences
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (Netherlands Organisation for Applied Scientific Research)
VvE	Vereniging van Eigenaren (Homeowners Association)
WoON	Woon Onderzoek Nederland (Housing Survey Netherlands)

Table 0.1.1 Abbreviations used in this thesis

In this report, the terms "Energy Performance Certificate (EPC)" and "Energy label" are used interchangeably, as well as EPC "rating/ rated" and "label/labelled/labelling".

*Artificial Intelligence (e.g. ChatGPT and Deepl) has been used for the ideation, structuring of subjects and rewriting of parts of this research. It is only used to improve existing findings, **not** to create any new.*

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

This research will examine the influence of demographic and socio-economic status on equitable access to energy efficiency in housing. It is a master's thesis for the master track Management in the Built Environment, with the theme housing crisis.

To show the relevance of this research, this chapter will discuss the context, problem statement, goals and objectives, and societal and scientific relevance. The logic of the research is presented by stating the research questions and the conceptual model. The structure will be shown in the reading guide.

1.1. Housing Crisis and Energy Poverty

Recently, housing prices have skyrocketed by over 12% compared to last year's third quarter (NVM, 2024). Over the last decade, many houses have doubled in value (Lankreijer-Kos, 2024). These rising prices have created significant affordability challenges in the Dutch owner-occupied housing market. The biggest problem underlying the issue is the lack of supply of sufficient housing, due to a sharp decline in the number of new buildings realised over the last decade (Boelhouwer, 2020). As a result, starters and younger households face great difficulties in finding affordable housing (Roessingh, 2025). Not only are these challenges acute for younger generations, but also for low-income groups in general, for whom affordability has become a general problem in the Dutch housing market.

This same group also faces issues regarding “energy poverty”, where approximately 400.000 households struggle with the monthly costs of energy, distributed unevenly over municipalities, see Figure 1.1 (Centraal Bureau voor de Statistiek, 2024). However, it should be said that due to government support, the overall number of households living in “energy poverty” declined from 2019 onwards. Without this support, the proportion of households in energy poverty would have risen from 8.6% to 10.7%.

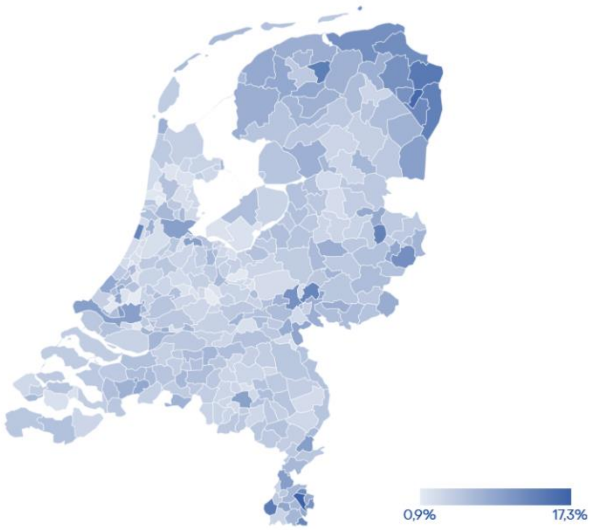

Figure 1.1 Energy Poverty in the Netherlands (CBS, 2024)

However, this support, the Temporary Emergency Fund Energy (Tijdelijk Noodfonds Energie), was discontinued on January 1, 2025 (Eigenhuis, 2024). Although it reopened briefly in April 2025, it closed again after just one week because the entire €56.3 million budget had already been allocated (Kuijper, 2025). Overall, the current situation creates overlapping affordability and energy-cost burdens for low-income groups.

1.2. Social Equity

Social equity is about the equitable management of all institutions serving the public (McSherry, 2021). In this research, social equity is used as an umbrella term for three main pillars, energy costs, wealth growth and access to subsidies. Thus, in the context of this research, this refers to institutions providing financial resources for energy-efficient renovations. These financial resources can help to improve the energy costs burden and wealth growth, closing the equity gap. The three pillars are chosen, not as separate outcomes, but to provide an overview of the current state of the housing market in terms of social equity, measured using Energy Performance Certificates (EPCs) as a proxy. The EPCs give insights into the overall state of a dwelling. This is in terms of energy efficiency, but also for things like construction year, and sometimes an indicator for renovations, most likely also involving other measures related to "natural" renovation moments like a new bathroom or kitchen. Using EPCs as a proxy, creates the opportunity to gain insights into the overall housing situation of certain households, beyond merely energy efficiency.

While social equity is most directly operationalised in the context of access to subsidies, it implicitly shapes the other two pillars through systemic mechanisms of inclusion and exclusion. In this sense, equity does not merely concern the outcomes of the energy transition, but the processes and institutional structures that determine who benefits and who does not. These include factors such as financial capacity, governmental support, and the availability or awareness of information, which often vary across socio-economic groups.

Social equity in housing can be seen as fair access to quality housing and the associated benefits, and that no group bears a disproportionate share of the burdens. According to Oude Engberink (n.d.), the most important dimension of equity in the Netherlands is a "fair income distribution in times of economic prosperity and decline". With current challenges like the housing crisis and energy poverty, strongly influencing affordability issues, this most important dimension should be high up the priority list. Equity in general is broader than this, and involves "meeting communities where they are and allocating resources and opportunities based on individual needs to create equal outcomes for all community members" (United Way NCA, n.d.). It differs from equality because "it recognises that each person has different circumstances, meaning different resources must be allocated based on individual needs for all to thrive" (United Way NCA, n.d.).

Social equity is highly relevant to the housing crisis, since there is a highly unequal housing market in the Netherlands (van Mil et al., 2024). The gap between renters and buyers is growing, since buyers benefit from wealth growth, while renters do not have this opportunity. This gap will not be addressed in this research, since the focus is on the Dutch owner-occupied housing market. However, even once in a position to buy something, it is hard for starters, due to financial constraints, to acquire an energy-efficient dwelling, with high energy costs relative to income as a consequence. Moreover, added to these higher costs are the disadvantages of lower comfort, reduced value appreciation and wealth growth, further widening the gap in the market. As such, social equity in this research is not only a descriptive tool but for the subsidies also a normative benchmark against which policy effectiveness and fairness are assessed.

1.3. Energy Efficiency in Housing

Worldwide, sustainability is becoming an increasingly important factor in real estate, as the sector is responsible for roughly one-third of global CO_2 emissions, with projections that show a possible rise of up to 50% (Magwood, 2020; Quoquab et al., 2022). In the Netherlands, sustainability has also become central to housing policy, driven by climate goals and the EU's net-zero targets and energy costs. The introduction of the EPCs in 2002 by the Energy Performance of Buildings Directive (EPBD) has tried to raise awareness about energy efficiency, promote energy efficiency, support policy implementations and facilitate energy savings in the European Union (Brounen et al., 2009; European Commission, n.d.). The EPCs were introduced because 40% of the energy consumed in the EU is used in buildings. Improving building efficiency is seen as a key pathway to achieving a fully decarbonised building stock by 2050 (European Commission, n.d.).

Another way to encourage sustainable housing, on a national level, is by introducing multiple subsidy schemes and financing options, like the *Investeringssubsidie duurzame energie en energiebesparing* (ISDE) or the *Nationaal Warmtefonds* (NWF), by the *Rijksdienst voor Ondernemend Nederland* (RVO, 2017), to reduce the financial burden for homeowners. Additionally, mortgage agreements have been adapted to incentivise energy efficiency. Since 2024, it has become possible to secure a mortgage of 106% instead of 100% of the property value for energy-efficient interventions, influencing the Loan-to-Value ratio. Homebuyers can also secure higher mortgages for better-rated dwellings because these homes are considered "lower in monthly costs" (Woonnu, 2022).

However, despite the environmental benefits, a dual dynamic has emerged within the Dutch housing market, raising concerns about unintended socioeconomic consequences. Properties with better EPC ratings are often more accessible to higher-income households, who can afford the upfront costs of energy-efficient renovations or new sustainable homes. Some studies indicate that dwellings with better energy efficiency sell for a price premium and, therefore, are less affordable for lower-income groups (Brounen & Kok, 2010; Chegut et al., 2016a). However, other studies argue whether the EPCs create these effects or if other variables have a greater impact (Olaussen et al., 2018; Stangenberg et al., 2020). For instance, A-labelled dwellings may not show additional premiums compared to B-labelled homes, reflecting that thresholds between labels might not be strong market differentiators. This could be caused by the fact that since the labelling was made obligatory in 2015, it became more of an indication. Whereas in the situation before 2015, when it was voluntary, it was an examination of different aspects and specifications, which was more detailed. This examination is made obligatory again from 2021 onwards, however, old indicative labels were still used in transactions till this year. From 2025 on, this is not possible anymore, since the indicative labels had an expiration date of 10 years. However, newly made labels in the period between 2015-2021 still exist, and can still be used for transactions, while other methods were used compared to the NTA8800 that has been used since 2021.

Although subsidies like the ISDE aim to make energy improvements more accessible, they frequently favour higher-income households who can afford upfront renovation costs. These costs present a substantial barrier to energy-efficient renovations (York, 2024). Research by TNO (2024) on the instructions of the Ministry of BZK shows that the ISDE subsidy is mostly granted to households living in dwellings with an energy label C in absolute figures. In total, all labels below label B were granted more subsidies than label B or above. Another result is that the subsidies are granted to mostly high-income households, as the lowest six decile gross income groups (<€83,700) did fewer applications, and thus also were granted fewer subsidies (TNO & CBS, 2024). The highest income group (>€170,600) did relatively 2.2 times more appliances than the lowest income group (<€24,300). Also, the lowest 8 decile groups did the least expensive measures (e.g. insulation of walls and floors), with the fewest impact on energy efficiency, while the highest two decile groups invested in heat pumps, which have a greater effect on energy efficiency (TNO & CBS, 2024). This disparity results in a situation where wealthier households capture both immediate and long-term financial benefits from energy-efficient homes, while lower-income groups face higher energy expenses in less energy-efficient properties.

Other studies have shown that existing renovation subsidies predominantly benefit higher-income households, because of the lack of maximum income thresholds (Fernández et al., 2024). This segmentation in the housing market implies that current energy policies may inadvertently reinforce existing socioeconomic inequalities. Wealthier households can benefit from increasing property values and reduced energy bills, while lower-income households are left in depreciating, less efficient housing, a dynamic that not only limits their residential mobility but may also perpetuate cycles of energy poverty. Moreover, upgrading poorly labelled dwellings has a far greater impact on sustainability goals than renovating already efficient homes, this would be dwellings labelled as C or below. Figure 1.2 shows how the dwellings, based on EPCs levels, are distributed, and the distribution of applicants per EPC level. This shows that target groups living in A or better are responsible for a smaller portion of appliances, whereas C and below are responsible for a larger portion of appliances, compared to their portion in the total target group. A nuance in this observation is that this is about the absolute number of appliances, not about the amount of euros in subsidy given. Subsidies provided for the target groups living in A or better are mostly for heat pumps and larger investments, whereas for C and below, this is more for cavity walls, and floor insulation, having a smaller impact on energy efficiency.

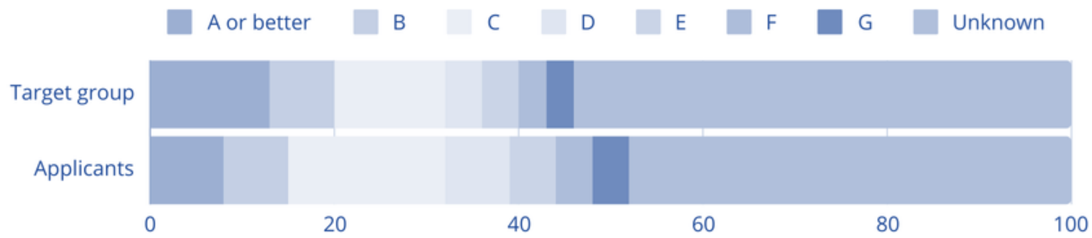

Figure 1.2 Distribution of total EPCs versus Applicants per EPCs level (TNO & CBS, 2024)

1.4. Problem Statement

The Dutch housing market faces significant challenges for the housing sector. An ongoing housing crisis, together with the urgent need to meet national and EU climate goals, creates uncertainty in the housing market. Affordability issues touch upon both challenges since energy-efficient renovations can reduce energy usage and costs but also contribute to wealth growth. To stimulate these renovations, subsidies are provided by municipalities and the government. An equitable distribution of these financial resources is essential to prevent even more inequality in the housing market. However, subsidies tend to reach higher-income groups, due to more awareness or more experience with such application processes. In this way, large portions of subsidies are allocated to households already able to cover expenses for a renovation. In contrast, lower-income households often face financial barriers, limited access to information, and distrust or confusion about subsidy conditions, leading to lower uptake. This raises concerns about the situation that high-income groups benefit from subsidies, and thus wealth growth and lower energy costs, while low-income groups stay behind with higher energy costs and lower wealth growth. The problem can be state as:

The Dutch housing market faces an ongoing housing crisis and sustainability goals, yet these intersect in a way that risks deepening inequality, as energy-efficient renovations bring financial benefits, but are less accessible for certain households.

1.5. Goals and Objectives

The research focuses on creating an overview of the current state of access to energy efficiency in the Dutch owner-occupied housing market. Energy efficiency in housing is examined through three key dimensions, energy costs, wealth growth and access to subsidies, with the EPC as a proxy indicator, to make the dimensions measurable. However, it is hard to conclude whether the results are because of the EPC or because of underlying housing specifications.

The main goal has two parts. First, creating an overview of the three dimensions (energy costs, wealth growth and access to subsidies) and how they are currently distributed across different households. This is the answer to the research question. Secondly, it is to explore whether, and how, this situation can be changed if greater social equity and environmental impact are desired. By initiating this discussion, the research seeks to inform more targeted and effective policymaking, particularly for municipalities and national government bodies aiming to optimise both the societal and environmental impact.

The sub-objectives are to:

- Provide insight into each of the three dimensions individually.
- Identify how these dimensions interact with one another.
- Construct a data-based overview of the inequalities present in the current market.
- Create directions for policy reforms using experience in practice.

1.6. Societal and Scientific Relevance

As the Netherlands faces both a housing crisis and the challenge in meeting climate goals, households are increasingly expected to improve the energy performance of their homes. However, not all owners have equal opportunities to participate in or benefit from this transition. While the energy transition is environmentally needed, it may cause even more inequality between owners able and not able to reap the benefits. Lower-income households, less-educated individuals, and minority groups may face systemic barriers to accessing energy-efficient dwellings, leading to disproportionately high energy costs, missed opportunities for housing wealth growth, and limited access to sustainability subsidies. By examining how demographic and socio-economic factors influence access to energy efficiency, this research contributes to a more equitable energy transition. It provides evidence that can inform national and municipal policy efforts to design more targeted support mechanisms, particularly for vulnerable homeowners who risk being left behind.

Although a growing body of literature has examined the effects of EPCs on market dynamics (e.g. Aydin et al., 2019, 2020; Fuerst et al., 2016; Hyland et al., 2012) as well as on demographic and socio-economic backgrounds on energy efficiency (e.g. Abreu et al., 2020; Donaldson, n.d.; Steenbekkers et al., 2021), fewer studies have integrated these insights with questions of social equity in the owner-occupied housing market. This research fills an important gap by explicitly connecting energy efficiency to demographic and socio-economic backgrounds. It combines energy costs, wealth growth, and access to subsidies to understand what the current situation is and if certain groups are left behind in this transition. Moreover, the combination of quantitative analysis with qualitative insights from interviews offers a methodological contribution that can be replicated or expanded in other contexts. In doing so, this research not only builds on existing knowledge about energy efficiency, financial instruments and policies but also starts the academic debate toward a more socially aware understanding of sustainability.

1.7. Research Questions

To achieve the research goals, the following main research question has been developed:

How does demographic and socio-economic status influence the access to energy efficiency in the Dutch owner-occupied housing market in terms of energy costs, wealth growth and access to subsidies?

As indicated by the question, the research focuses on three main components: energy costs, wealth growth and access to subsidies. To answer the main question, the following subquestions are addressed.

1. ***How are demographic and socio-economic characteristics distributed across EPC categories in the Dutch owner-occupied market?***

This first question sets the stage for the research. It provides an overview of the current distribution of income, age, education and household size across energy labels. This descriptive analysis forms the foundation for interpreting disparities in energy costs, wealth growth, and subsidy access in subsequent questions.

2. ***How do energy costs relative to income vary across income groups in the Dutch owner-occupied housing market?***

The first component of the research is examined with this question. It investigates whether certain groups spend a disproportionately high share of their income on energy and whether this is related to their access to energy-efficient housing. Differences in energy consumption patterns across EPCs are also considered.

3. ***How do the price and time on the market effects of EPCs in the Dutch owner-occupied housing market affect equitable wealth growth?***

This subquestion addresses the market dynamics related to energy efficiency. It assesses whether homes with better EPCs sell at a premium and more quickly. These market effects are then linked to the socio-economic distribution from Subquestion 1 to determine whether specific groups benefit more from rising housing wealth or face disadvantages in accessing energy-efficient homes due to heightened competition.

4. ***How efficient are current subsidy schemes (ISDE/ NWF) in terms of uptake, targeting and overcoming barriers?***

The last sub-question is used to validate quantitative findings with qualitative interviews. The uptake is still based on quantitative methods. However, the efficiency in targeting subsidies and the identification of barriers and ways to overcome these are discussed during the interviews. Efficiency is seen as, is there an equitable access to subsidies across income groups. This question will complete the bigger picture by examining whether certain demographic and socio-economic groups benefit disproportionately from these subsidies. Access to subsidies could influence the probability of renovating, which could decrease energy costs and increase wealth growth. This question also explores potential improvements in policies.

1.8. Conceptual Model

The conceptual model in Figure 1.3 illustrates the framework of this research. The two main concepts are demographic and socio-economic status, and access to energy efficiency in housing. The first concept entails income, age, household size, and education. This relates to equity, which refers to the opportunity to have the same outcome. The difference between equity and equality is illustrated in Figure 1.4.

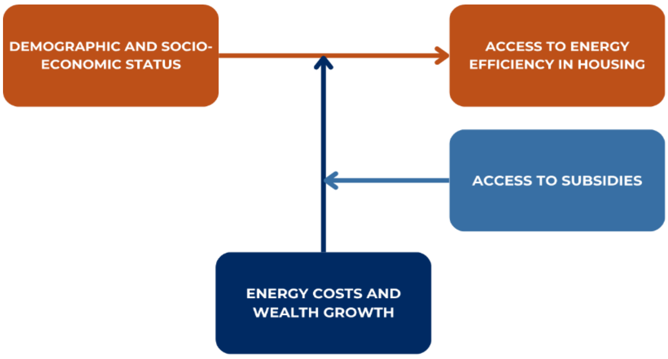

Figure 1.3 Conceptual Model

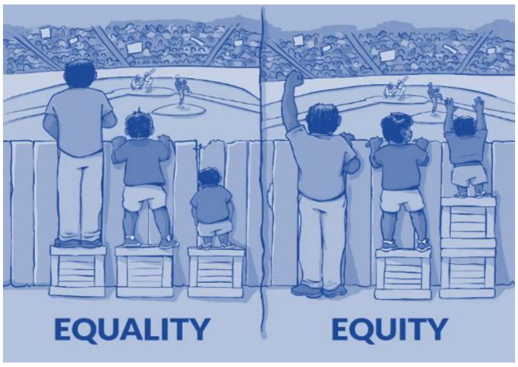

Figure 1.4 Difference equality and equity (IISC, 2016)

Access to energy efficiency in homes refers to the extent to which individuals have equal access to energy-efficient dwellings or equal opportunities to improve energy efficiency in their current dwellings. For this research, only the financial and societal impact is measured, not the environmental impact. Indicators for this concept are the EPCs, energy costs, investment opportunities in sustainability measures and wealth growth due to owning an energy-efficient dwelling.

The relation between these two concepts is influenced by energy costs related to income and wealth growth due to price premiums per EPC, as a mediating factor. This factor explains how access to energy efficiency is influenced by demographic and socio-economic status. Aspects of this concept include energy costs as a share of income, price effects of EPCs, and time on the market. For instance, if certain households based on demographic and socio-economic backgrounds bear high energy costs related to income, the access to energy efficiency in housing is interpreted as lower. Another example is, if EPCs show price effects, then the distribution of households across EPCs tells something about wealth growth, influencing the relation between demographic and socio-economic background and access to energy efficiency in housing.

Then, this mediating factor is influenced by access to subsidies. This is conceptualised as a policy lever that can either reinforce or mitigate the relationship between demographic and socio-economic status and access to energy efficiency in housing. Effective subsidy schemes and targeted distribution could address affordability barriers, enabling lower-income households to invest in energy-efficient measures and participate in the benefits of sustainable housing (lower energy costs, wealth growth). On the other hand, unequal access to subsidies risks deepening social inequities. By examining subsidy distribution data, misalignments are identified where possible, to see how the subsidies influence this relation.

1.9. Reading Guide

The table below provides an overview of the structure of this research (Table 1.1).

Reading guide		
	Chapter	**Content**
1	Introduction	Introducing the context, problem statement, objectives, relevance, research question and subquestions.
2	Theoretical Background	Presenting what is known about the different topics, focused on EPCs, price effects, financial and policy instruments, and the relation between socio-economic background and energy efficiency.
3	Methodology	Explaining the methods used for this research, as well as explaining how all the data was collected and prepared.
4	Quantitative results	Showing the results of all quantitative data, both descriptive and statistical.
5	Qualitative results	Presenting the qualitative results of the interviews, validating the quantitative results.
6	Discussion	Discussing the results, substantiate the results, compare with the literature and identify limitations.
7	Conclusion	Answering the main research question by summarising the main findings.

Table 1.1 Reading Guide

CHAPTER 2

THEORETICAL BACKGROUND

2. THEORETICAL BACKGROUND

This chapter creates the outline of what is already known about the concepts for this research, involving EPCs, energy efficiency in housing, subsidies and the relation to certain demographics and socioeconomics.

The growing focus on enhancing building energy performance to mitigate climate change and reinforce energy security has positioned EPCs as an important subject of the policy discourse across Europe. The objective of EPCs is to provide consumers with information regarding the energy efficiency of dwellings. The intention is that this will stimulate improvements in the quality of the building stock through market forces. In addition to their informative function, these certificates have the potential to influence property market dynamics, including sale prices and time on the market.

The interaction between energy efficiency or performance indicators and pre-existing socioeconomic structures gives rise to questions concerning the beneficiaries of energy-efficient improvements and those who may be left behind. The existing literature reflects an evolving understanding of EPCs as both market signals and environmental policy instruments. The early studies in this review concentrated on their technical foundations and the incorporation of energy performance into housing values. More recent research demonstrates that the effects of EPCs are neither uniform nor purely economic. Energy-efficient dwellings may also contribute to the formation of inequalities between established homeowners on multiple demographic and geographic levels, between high- and low-income and/or educated groups, and between well-resourced and less-resourced regions.

This literature review examines key areas of academic debate, beginning with the historical evolution of EPC frameworks and their associated impact on price, and continuing to consider the role of energy efficiency in time on the market, and socio-spatial inequalities. Furthermore, the review examines the obstacles preventing the widespread implementation of energy efficiency measures, the financial instruments designed to mitigate these obstacles, and the governance structures that shape and direct policy interventions.

2.1. Evolution of the Energy Performance Certificates

The EPCs regime has undergone a substantial transformation since its inception, reflecting broader shifts in European energy and climate policy. Initially introduced as part of the Energy Performance of Buildings Directive (EPBD, 2002/91/EC) and subsequently reinforced by its recasts, EPCs were envisioned as a key policy tool to harness the substantial, cost-effective energy savings potential in the built environment (Economidou et al., 2020). Over time, policy reforms have sought to strengthen the quality, accuracy, and accessibility of EPCs, recognising their potential not only as a mechanism for informing homebuyers and renters but also as a driver for market-based improvements in building energy efficiency. Early iterations of EPC schemes, while new and innovative for their time, often struggled with low uptake and inconsistencies in implementation (Figure 2.1). The figure shows a notable uptake from 2015 on, resulting from new policies that made the labelling mandatory instead of voluntary. Before the obligation, many properties remained uncertified, thereby reducing the effectiveness of the intended market signals that EPCs were designed to provide. In response to these limitations, policymakers initiated a revision of the EPBD, which resulted in the 2010 recast (2010/31/EU) and subsequent amendments that introduced more rigorous assessment procedures, supported by a more robust legislative framework and enforcement mechanisms (Economidou et al., 2020).

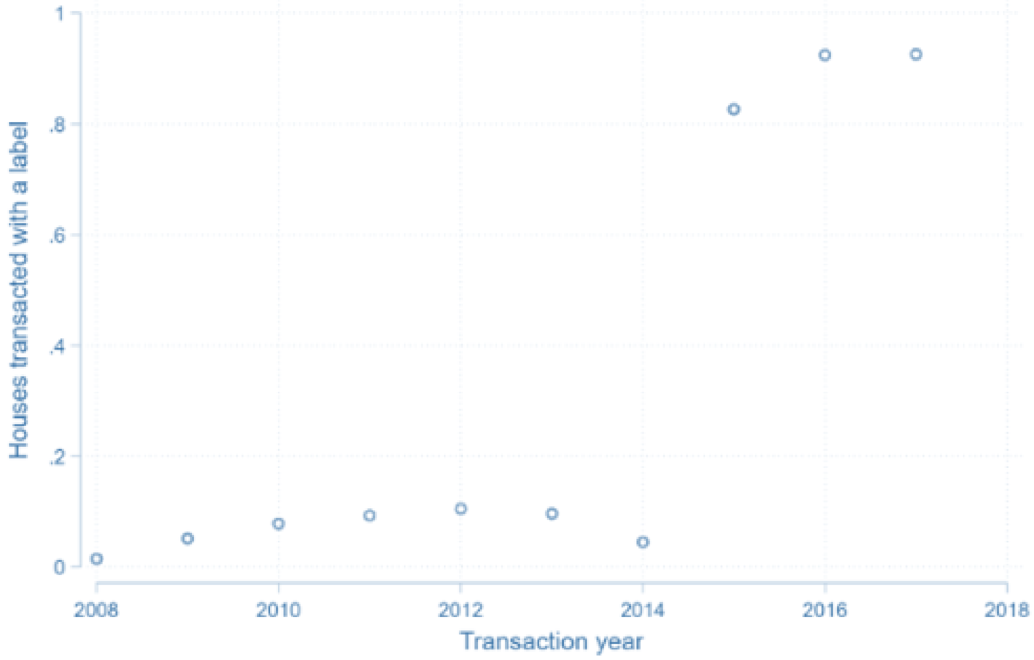

Figure 2.1 Adoption rate of energy labels in the Netherlands (Stangenberg et al., 2020, p. 7)

The assessment procedures of EPC labelling and their accuracy also evolved in the Dutch context. Earlier approaches often employed engineering-based calculations and required on-site assessments by certified experts. While these measures produced accurate evaluations, they carried substantial costs and administrative burdens, limiting widespread adoption. More recent reforms, after the labelling was made obligatory in 2015, have introduced streamlined, mass appraisal-based approaches to reduce costs and increase coverage, albeit sometimes at the expense of informational richness (Aydin et al., 2019; Stangenberg et al., 2020). Since 2021, all new EPCs registered are based on the NTA 8800, creating a solid, consistent way of certifying dwellings. However, recently there is debate about the use of error margins to certify dwellings better than the actual state is (Been & Buijs, 2025).

The European Green Deal's "renovation wave" initiative signals a renewed commitment to strengthening the role of EPCs in decarbonising the building stock (Economidou et al., 2020). This movement aims not only to inform end-users but also to accelerate renovations and stimulate investment in energy-efficient technologies. It is expected to do so by rethinking existing policies addressing barriers for energy-efficient investments, but also to scale up new innovative mechanisms. Besides, it is expected to create tailored financial mechanisms to mobilise all stakeholders and serve as a catalyst for innovation and new opportunities, which extend beyond energy performance in buildings, being also about future resilience to climate change risks and adequate living conditions (Economidou et al., 2020).

2.2. Energy Performance Certificates' Effects on Market Dynamics

A central theme of the literature on building energy performance is the investigation of the extent to which properties demonstrating superior energy efficiency are subject to price premiums. While studies generally find that energy-efficient homes tend to achieve higher transaction prices, the magnitude, drivers, and consistency of these premiums vary across countries, methodologies, and housing segments (Aydin et al., 2020; Brounen & Kok, 2010; Cerin et al., 2014; Chegut et al., 2016a; Fuerst et al., 2015, 2016; Gerassimenko et al., 2024; Olaussen et al., 2018, 2021; Stangenberg et al., 2020). Evidence from multiple contexts supports the idea that enhanced energy performance is capitalised into property values. Chegut et al. (2016) find that in the Dutch affordable housing sector, an A-labelled property can command a premium of 6.3% over a similar C-labelled dwelling. Affordable housing is based on the NHG-threshold (Nationaal Hypotheek Garantie) in the Netherlands, and was at that time €245.000 (Oirschot, 2016), currently at €450.000 (Rijksoverheid, 2024). Brounen & Kok (2010) show that Dutch homes awarded better energy ratings sold at a premium of up to 10.2% (A++ label relative to D), with smaller but still positive increments for B and C ratings. In England, Fuerst et al. (2015) report a 5% price premium for top-tier energy ratings compared to D-rated dwellings. Aydin et al. (2020) note that a 10% increase in predicted energy efficiency can raise a dwelling's market value by around 2.2%, and a 50% efficiency improvement may yield an 11% increment in the Dutch context. Cerin et al. (2014) find similar though context-dependent effects in Sweden, with energy performance premiums linked to factors like property age and price class. Gerassimenko et al. (2024) highlight that sales markets exhibit stronger energy-related price effects than rental markets in Belgium (Flanders), reflecting homeowners' ability to capitalise on long-term savings. Similarly, Hyland et al. (2012) found positive price effects due to energy efficiency, with a significantly stronger effect on the sales market in the Irish context.

Nevertheless, not all research agrees on the direct influence of labels. Olaussen et al. (2018) argues that once accounting for expected energy costs and other dwelling characteristics, energy labels exert limited independent effects on prices in Norway. Stangenberg et al. (2020) observe that homes with favourable labels traded at premiums before labelling, suggesting that labels may confirm rather than create value differentials in the Netherlands. In the Italian context, research has suggested that based on two hedonic regressions, one without apartments and one with, respectively, the first one showed indeed price effects, the second showed no impact on prices (Fregonara et al., 2017). This shows the significance of methodology, even within the same research, there could be two different outcomes.

Further, Olaussen et al. (2021), in the Norwegian context, indicate that real estate agents might not systematically adjust asking prices based on labels, implying that buyers may value observable energy-saving features even without formal certificates. Fuerst et al. (2016) suggest that for some buyers, top energy ratings might serve as a 'green signal', appealing to environmentally conscious segments. This can produce a segmented market in which only the most energy-efficient buildings garner significant premiums, while mainstream buyers may remain relatively indifferent to rating distinctions. These findings show no consistent answer to whether EPCs affect pricing or not. However, even when it where concluded that there is a positive effect, there is still debate on the size of the effects across contexts (Fregonara & Rubino, 2021).

An overview of the discussed literature about EPCs effects on price is shown, see Table 2.1. The shows whether the authors found positive, negative or mixed results. Most of these are positive (9), however, there is debate about whether the EPCs cause these effects or other factors, related to EPCs.

Overview of Literature on EPC Effects on Price and TOM				
Author(s)	**Year**	**Context**	**Pos./ Neg. /Mix.**	**Findings**
Brounen & Kok	2011	Netherlands	Positive (1)	A-labelled dwellings sold at a 12.1% premium over G-labelled.
Hyland et al.	2012	Ireland	Positive (2)	A-rated homes sold at a 9.3% premium relative to D; F/G homes were discounted.
Cerin et al.	2014	Sweden	Positive (3)	Older, lower-priced homes showed energy efficiency premiums.
Fuerst et al.	2015	England	Positive (4)	A/B-labelled dwellings showed strong premiums in square metre price compared to D, especially flats.
Chegut et al.	2016	Netherlands	Positive (5)	Affordable A-label homes sold for 6.3% more than C-labelled ones.
Fuerst et al.	2016	Finland	Positive (6)	Energy-efficient (A, B & C) homes had a 3.3% price premium, relative to D-rated apartments. Lower effect when neighbourhood characteristics where added.
Fregonara et al.	2017	Italy	Mixed (1)	EPCs explained 6-8% of price effects; other factors dominated, like location, physical features and sale year.
Olaussen	2018	Norway	Negative (1)	No significant EPC effect on prices.
Aydin et al.	2019	Netherlands	Positive (7)	EPC-labelled homes sold faster compared to non-labelled homes. EPC A showed 28% faster TOM, while F only showed 6% faster TOM compared to non-labelled dwellings.
Stangenberg et al.	2020	Netherlands	Mixed (2)	Limited added value of EPCs in functioning markets, primarily lower or insignificant effects when location (neighbourhood) effects are accounted for.
Aydin et al.	2020	Netherlands	Mixed (3)	10% energy efficiency increase gives a 2.2% price premium. No evidence that EPCs themselves affects the price.
Olaussen et al.	2021	Norway	Negative (2)	EPCs did not influence asking prices.
Fregonara et al.	2021	Italy	Positive (8)	Strongest impact for improving low-rated homes.
Gerassimenko	2024	Belgium (Flanders)	Positive (9)	A-labelled homes show 42% premium; F-labelled 13% discount compared to D-labelled. Only 15% premium for A and 6% discount for F when location, building period and typology are controlled for.

Table 2.1 Summary of European studies (2011–2024) examining the influence of EPCs on price and TOM (own work)

Another aspect of market dynamics is the time on the market (TOM). Research on this topic offers a limited, but additional perspective on the influence of energy performance on housing transactions. Research has sought to determine whether properties with EPCs are sold at a faster rate on average than those without, thereby providing insight into the role of information and buyer confidence in driving market liquidity (Aydin et al., 2019). In the Netherlands, Aydin et al. (2019) document that energy-labelled homes sold between 2008 and 2016 experienced a 7% to 12% decrease in TOM compared to non-labelled dwellings. This acceleration in sales is attributed to reduced information asymmetry and increased transparency, allowing buyers to make more informed decisions about energy costs, comfort, and potential future savings.

The nature of the label also matters, moving from engineer-certified assessments to indicative mass appraisal-based certificates, due to the change in policy from voluntary to mandatory in 2015, halved the speed-of-sale effect. Aydin et al. (2019) additionally show that top-rated properties, such as those with an 'A' label, sell substantially faster than worse-rated ones. Even less efficient but still labelled dwellings benefit from reduced uncertainty for buyers. Similarly, in the Irish context, Carroll et al. (2024) found that more efficient properties sell faster and that labelling these properties reduced the time-to-sell even further. However, besides these two studies, there are not much other recent studies researching this topic. Therefore, the time on market related to EPCs and energy efficiency remains understudied in the existing body of literature.

2.3. Energy Efficiency and Social Equity

The literature increasingly emphasises how social inequality intersects with the pursuit of energy efficiency in housing. The capacity to invest in, access, and benefit from energy-efficient technologies is not distributed evenly across socioeconomic groups. Patterns of income and wealth stratification shape households' willingness, capacity, and opportunity to undertake energy-saving improvements (Dröes & Van Der Straten, 2024; Ebrahimigharehbaghi, 2022; Fernández et al., 2024). Several studies highlight disparities in the adoption and diffusion of energy-efficient measures, with higher-income households more inclined to improve their dwellings' energy performance (Dröes & Van Der Straten, 2024; Ebrahimigharehbaghi, 2022). Such households benefit from greater financial liquidity and often pre-existing alignment of their wealth status and living conditions, frequently purchasing homes already meeting better efficiency standards (Dröes & Van Der Straten, 2024). In contrast, lower-income households face constraints including limited access to capital, reduced ability to absorb upfront retrofit costs, and lack of informational and institutional support (Ebrahimigharehbaghi, 2022).

Fernández et al. (2024) show that existing renovation subsidies in the Netherlands unintentionally widen the gap between resource-rich households able to leverage these incentives and those lacking such means. These regressive dynamics undermine the environmental and social goals of policy measures. Measures are being aimed to support or help households in need of financial support to make initial investments to become more sustainable or energy efficient. Dröes & Van Der Straten (2024) identify a policy dilemma between reducing carbon emissions effectively and safeguarding vulnerable, low-income households. If interventions disproportionately benefit already advantaged households, those needing cost savings and healthier conditions are left behind. Research by TNO on the instructions of the Ministry of BZK shows that the ISDE subsidy is mostly granted to households living in dwellings with an energy label C in absolute figures (TNO & CBS, 2024). In total, all labels below label B were granted more subsidies than label B or above. Another result is that the subsidies are granted to mostly high-income households, as the lowest six decile groups had fewer appliances, and thus also were granted fewer subsidies (TNO & CBS, 2024). The highest income group (tenth decile group) did relatively 2.2 times more appliances than the lowest income group. Also, the lowest 8 decile groups did the least expensive measures (e.g. insulation of walls, glass and floors), with the fewest impact on energy efficiency, while the highest two decile groups invested in heat pumps, which have a greater effect on energy efficiency (TNO & CBS, 2024).

This disparity results in a situation where wealthier households capture both immediate and long-term financial benefits from energy-efficient homes, while lower-income groups face higher energy expenses in less energy-efficient properties. In the Estonian context it is found that such subsidies can drive regional disparities, by less-privileged areas acquiring fewer subsidies, further worsening socioeconomic differences (Lihtmaa et al., 2018). Strategies promoting energy efficiency risk reinforcing existing inequalities unless specifically calibrated to address underlying socioeconomic disparities. Without targeted measures, including more accessible financing, better dissemination of information, and equitable subsidy distribution, efforts to enhance energy efficiency remain socially uneven.

To give context to how big the groups are and what type of housing and age, Figure 2.2 shows the distribution of energy labels among these subjects. Most notable is that there is a need for renovation in older homes, since these have the lowest labels, but also for detached homes. This combination highlights the complexity of measuring the impact of energy labels on social equity, since most households living in detached homes are high-income groups (Capital Value, n.d.). Therefore, there is also a portion of low-labelled dwellings, occupied by high-income households, while these households apply for most subsidies, as shown above, making a clear division between certain target groups and segmentation based on EPCs not yet possible.

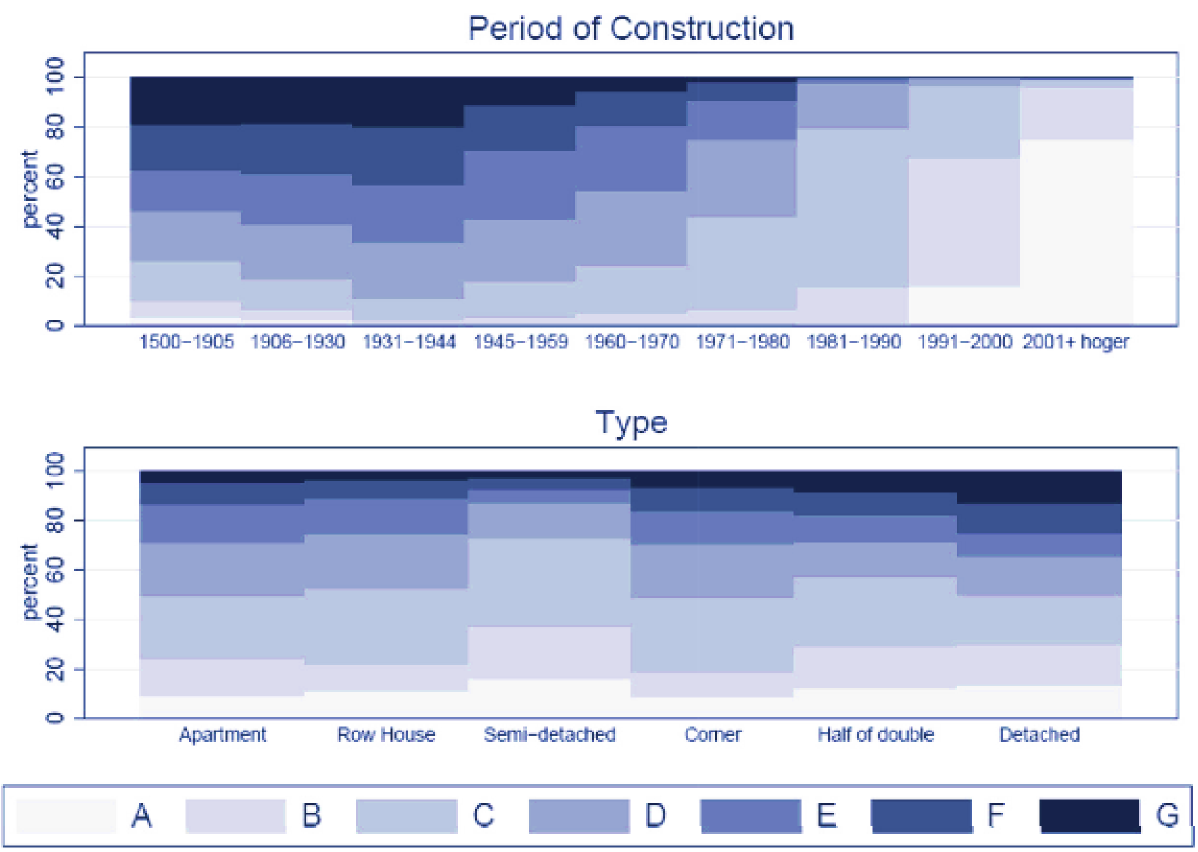

Figure 2.2 Distribution of labels per construction year and housing type (Aydin et al., 2019, p. 8)

2.4. Barriers to Energy-Efficient Renovations

Even when policy frameworks support energy efficiency, various barriers impede households from implementing renovations. These barriers are multifaceted, involving economic, informational, and procedural complexities that disproportionately affect those who might benefit most (Ebrahimigharehbaghi et al., 2019; Kaufmann et al., 2023). High upfront costs, limited access to subsidies, and complex application processes deter many from pursuing energy-efficient retrofits. Ebrahimigharehbaghi et al. (2019) identify costs, lack of subsidies, and the time and effort required to apply for financial support as key hindrances. Even motivated households face bureaucratic hurdles or struggle to find reliable contractors. Such complexities inflate transaction costs and discourage less-resourced households from engaging in efficiency measures (Ebrahimigharehbaghi et al., 2019).

Information asymmetries pose another challenge. Households may lack trustworthy guidance on prioritising measures or finding credible professionals (Ebrahimigharehbaghi et al., 2019). Kaufmann et al. (2023) show that some homeowners remain unaware of local subsidies or simple interventions, excluding them from available support. Without accessible information and user-friendly processes, policies fail to translate resources into realised efficiency gains. Inadequately tailored measures perpetuate inefficiencies. Although incentives exist, their complexity and inaccessibility limit uptake. Streamlining procedures, offering clear guidance, and building trust through transparent and well-monitored programmes are essential (Ebrahimigharehbaghi et al., 2019). Without such improvements, initiatives risk excluding many households and undermining overall effectiveness and equity.

Demographic factors, in particular age, income and household composition, consistently emerge as important determinants of whether homeowners undertake energy efficiency improvements or not. For example, Abreu et al. (2020) show that younger Portuguese homeowners often favour incremental, “little by little”, renovations driven by environmental motives, while older homeowners, despite generally higher disposable income or equity, are primarily driven by comfort or aesthetic benefits rather than broader sustainability arguments.

Dutch and English research confirm these generational differences. The English Housing Survey (Donaldson, n.d.) highlights that older owner-occupiers, many of whom own their homes outright, are less likely to undertake extensive retrofits if they expect limited future occupancy, and thus the payback period is expected to be too long. Meanwhile, younger households, while typically more enthusiastic about green measures, face tighter budgets and may struggle to self-finance even smaller investments. Similarly, (Steenbekkers et al., 2021) show that older or lower-income homeowners often resist costly energy upgrades when the payback period is unclear.

These patterns overlap with key findings from research by Nibud (Bos et al., 2020; van Gaalen et al., 2019). According to van Gaalen et al. (2019), 43% of Dutch homeowners do not intend to take any energy-saving measures within the next five years. This reluctance is closely linked to a lack of clarity about future government incentives and the perception that technology will become cheaper over time. In particular, homeowners who are unaware of their home’s energy label are more likely to postpone improvements (van Gaalen et al., 2019). Younger households, on the other hand, show a higher willingness to invest but often lack the necessary savings, while older homeowners have better access to capital but may question whether the cost of renovation will fully pay off, especially if they expect to move or have a shorter time horizon to use the benefits.

2.5. Financial Instruments for Energy Renovation

Large-scale energy renovations require carefully designed financial instruments. The building sector's complexity, involving diverse stakeholders and property types, calls for nuanced, flexible solutions (Bertoldi et al., 2021). Such instruments must address high upfront costs, risk aversion, and uncertain payback periods. Without effective financial mechanisms, even well-conceived policies may struggle to gain traction. Grants and subsidies, while jump-starting the market, are limited by public budget constraints and may foster free-riders in the European context (Bertoldi et al., 2021). The budget for the Dutch subsidy for sustainability improvements, the ISDE, in 2025 is 550 million, with 176.4 million already claimed by private homeowners in May 2025 and last year 443.2 million was claimed of the 600 million budget (RVO, 2024; RVO, 2025). The budget continues to exist up until 2030, but with this much already claimed, the budget will probably be claimed before that. Most of this budget is claimed for heat pumps and isolation measures. Besides this subsidy, in the Dutch context, it is possible to get a loan or to extend or broaden a mortgage for energy efficiency measures and renovations. This entails a loan for energy efficiency measures via the NWF as a 0% interest loan or via the Temporary Arrangement Mortgage Credit (Tijdelijke Regeling Hypothecair Krediet, TRHK), ranging from €9.000-€25.000 depending on the type of measure (Westerlaak, n.d.). To apply for this loan, an LTI and LTV test are conducted with a minimal income of €33.000. Another way to broaden the mortgage is via the broadening of the Loan-to-Value. This ratio can become 106% instead of the usual 100% when energy-saving measures are taken during renovation (Westerlaak, n.d.).

Havlínová et al. (2022) has observed that mortgage add-ons, low-interest "green loans," and various government-backed guarantees effectively lower some barriers to large-scale or expensive renovations. However, these tools are more accessible to middle- and higher-income households. This is consistent with the findings of Steenbekkers et al. (n.d.), who caution that broad subsidy schemes often target the average homeowner, neglecting to address the unique financial constraints faced by older adults with limited incomes or younger families with minimal savings. Van Gaalen's et al. (2019) research further indicates that while many homeowners would prefer to use personal savings for energy measures, waiting for more attractive financing or clear government direction is a key factor delaying action. Furthermore, consumer credit frequently becomes the only viable option for substantial retrofits, with interest rates being a notable concern. This poses heightened financial risks in the event of a drop in income.

The financial constraints experienced by homeowners also influence their response to EPCs. While an improved EPC rating may theoretically enhance resale value, Abreu et al. (2020) note that less affluent or older owners often lack the resources to act on EPC recommendations for improvement. Bos et al. (2020) confirms that homeowners who already live in energy-efficient (A or B-rated) properties often have higher savings, enabling them to make further improvements if they wish, while those in E, F or G-rated homes, who could potentially reap the greatest environmental and cost benefits, face the greatest financial barriers.

2.6. Policies and Governance in Energy Efficiency

Improving building energy efficiency is as much a governance challenge as a technical one. Policymakers must navigate market imperfections, social inequalities, and spatial disparities to design interventions that balance affordability, accessibility, and environmental goals (Boelhouwer, 2020; Janssen-Jansen & Schilder, 2015; Visscher et al., 2016). Measures often produce uneven results and may reinforce inequities. In the Netherlands, policies historically assisted low-income renters, but large-scale provisions may fail to achieve balanced markets, shifting problems rather than resolving them (Janssen-Jansen & Schilder, 2015).

Recent policy changes restrict mortgage access for certain income groups (Boelhouwer, 2020), and post-crisis interventions can heighten socio-spatial inequalities. Rising prices in urban areas intensify segregation and limit who can afford energy-saving measures. Visscher et al. (2016) criticise current governance instruments as inadequate for ensuring real-world energy savings. Visscher et al. (2016) advocate for rethinking regulatory systems, including stronger enforcement, performance-based incentives, and integrated financial, informational, and technical assistance. Occupant engagement is important, ignoring household behaviour, trust, and perceived complexities risks resistance. Transparent communication, accessible guidance, and genuine participation are necessary to align individual household choices with broader sustainability and equity objectives.

2.7. Conclusion

The existing body of literature on EPCs, market dynamics, and social inequality shows a complex system where environmental policies intersect with economic incentives, entrenched market structures, and longstanding social divides. EPCs have, according to some studies, demonstrated the capacity to influence property values and accelerate housing transactions, indicating that energy performance can serve as a marketable attribute, but other studies showed that the certificates have little to no effect on value or TOM. Besides, the distribution of these benefits and burdens is highly uneven, as existing patterns of wealth and education influence the capacity of households to invest in and capitalise on energy-efficient dwellings. It is possible that policies designed to encourage efficiency improvements may, unintentionally, exacerbate existing inequalities and yield uneven access to financing instruments, subsidies, and reliable renovation support. While significant progress has been made in understanding the impact of EPCs on housing markets, there are still gaps in our knowledge regarding the causal mechanisms through which energy efficiency measures reinforce or mitigate social disparities.

CHAPTER 3

METHODOLOGY

3. METHODOLOGY

This chapter will explain the methodology used for this mixed-methods descriptive research. Multiple datasets are used, creating an overview of the current situation of social equity in terms of energy costs, comfort, wealth growth, and access to subsidies as the quantitative part. Interviews are conducted to validate the results of the quantitative parts, gather information about how the effects are seen in practice and to come up with solutions. The research strategy per phase is discussed in this chapter. After the strategy, the data collection, analysis and management plan are presented, followed by research ethics and output.

3.1. Research Design

This research uses multiple individual researched concepts like EPCs, social equity and market dynamics, to create an overview of the overall situation for social equity in terms of energy costs, comfort, wealth growth, and access to subsidies related to energy efficiency. Therefore, the theoretical research is used in a descriptive way to form an overview of what is known about the relations of the individual subjects. Since it is one of the first to combine these topics into one research, most research stays descriptive, although patterns are also identified and directions to create a more equitable situation are discussed, which is more exploratory and explanatory. After the theoretical research, quantitative data analyses are carried out, with descriptive analysis as well as statistical analysis (Chi-square tests and regression analyses). This part focuses on understanding the demographic and socio-economic backgrounds' effect on energy efficiency, price effects and time on the market of EPCs and access to subsidies. More explorative interviews focus on what is seen in practice and give direction to policy reforms.

The subquestions for this research follow a specific sequence. Because the focus is on energy costs, comfort, wealth growth and access to subsidies, it is necessary to first create an overview of the current situation based on demographic and socio-economic backgrounds. In this way, the price effects of different EPCs can be translated to wealth growth based on these backgrounds, as well as the subsidy allocation can then be tied to certain income groups.

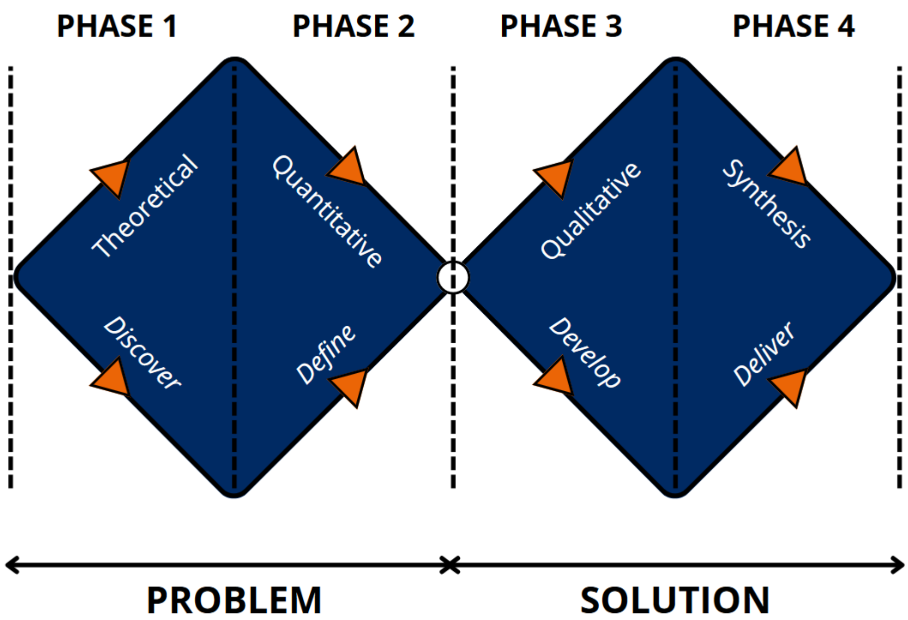

Figure 3.1 Double-Diamond model adjusted to research (Design Council, 2005)

The research follows the double diamond model, which consists of two diamonds (Figure 3.1). The first diamond focuses on the problem with discovering (broadening) and defining (narrowing), the second one on the solution with developing (broadening) and delivering (narrowing) (Design Council, 2005).

Phase 1

The goal of this phase is to understand the relation between energy labels (EPCs) and social equity within the Dutch housing market. This is examined by carrying out a literature review on EPCs, barriers to renovation, financial instruments and policies. The literature review is used to give insights into what is already known about the subject and further define the problem. The outcomes of this phase are the overview of what is expected to be the results of the quantitative research.

Phase 2

This phase is used to define where inequities persist and for whom energy efficiency is least accessible. The first quantitative analysis using *Woon Onderzoek Nederland 2021* (WoON 2021), NVM (Nederlandse Vereniging van Makelaars) transaction data, Springco EPC data, and RVO subsidy data (ISDE and NWF) analysed via cross tabulations creates insights into the patterns related to demographic and socio-economic backgrounds, market effects, and subsidy allocation. Regressions, both multi-linear and ordinal, are used to control for the variables and examine the actual effect of one specific variable. This gives a more accurate insight into the actual effects when other variables are controlled for, rather than just the bivariate relation in the cross-tabulations. Outcomes of this phase are descriptive analysis of patterns related to demographic and socio-economic backgrounds, market effects and subsidy allocation, as well as statistical analysis examining significance and the individual variable effects.

Phase 3

The objective of this phase is to understand how practitioners perceive and experience the identified systemic issues in phase 2. Seven semi-structured interviews were conducted with housing professionals (Nibud, RVO, TNO, Vereniging Eigen Huis, Real estate brokers and a municipality), with the subjects' policy allocation, barriers to renovation, financial instruments and buyers' decision-making discussed. The results give insight into the different perspectives on current shortcomings and practical constraints, as well as unintended effects of well-meaning sustainability policies and directions for policy reforms.

Phase 4

In the fourth phase, the goal is to formulate directions for policy reforms to align energy transition goals with social equity. A synthesis of the results is used to formulate these. Since the research focus is more on creating an overview of the current situation and barriers to equitable access to energy-efficient dwellings, this phase focuses on direction rather than concrete, well-clarified policy recommendations. The outcomes are policy directions targeting more equitable access to sustainable housing. These include subsidy targeting and financial support mechanisms.

3.2. Theoretical Research

The theoretical background focuses on gathering insights into EPCs, why these exist, known market effects, as well as demographic and socio-economic backgrounds. Furthermore, financial instruments and policies regarding energy efficiency are explored.

For the literature review, a systematic literature review is conducted. Therefore, four concepts are distinguished, "Energy Performance Certificates", "Housing market dynamics", "Social inequality" and "Sustainability subsidies". Furthermore, literature that the mentors recommended is used, or is found by "snowballing" the relevant literature and by using tools such as Research Rabbit. The snowballing is done by selecting relevant literature from the searched literature using the systematic approach, mostly in the literature review sections of these documents. Several tools and websites are used to find relevant literature. These entail:

- Scopus
- Web of Science
- TU Delft Repository
- Google Scholar (as a complementary source)
- Research Rabbit (as a complementary tool)

Concepts used to execute the search queries in Scopus (Table 3.1):

Search terms for literature review				
	Concepts: combine with AND			
Search terms: combine with OR	Concept 1: Energy Performance Certificates	Concept 2: Housing market dynamics	Concept 3: Social inequality	Concept 4: Sustainability subsidies
	EPC	Real estate trends	Energy poverty	Government incentives for retrofitting
	Energy labelling	Market liquidity	Income inequality	Green energy subsidies
	Energy efficiency	Time on market	Housing affordability	Public funding for sustainable housing
	Energy ratings for homes	Real estate transactions		
	Energy efficiency certificates	Property value trend		
		Regional housing market segmentation		

Table 3.1 Searching scheme

3.2.1. Literature review structure and query

To create a solid foundation for the research, the following structure is used, for which the literature is searched using the search query. Literature is also later added to the structure to clarify the results found in the analysis.

- Evolution of the Energy Performance Certificates (EPC)
- Energy Performance Certificates' effects on market dynamics
- Energy efficiency and social equity
- Barriers to energy-efficient renovations
- Financial instruments for energy renovation
- Policies and governance in energy efficiency
- Conclusion

Using Table 3.1, multiple search queries were conducted, resulting in literature that was used for the literature review. The exact search queries are presented in Appendix A.

The literature found in Scopus is narrowed down using the following inclusion and exclusion criteria. These are in order of priority. When too few results were shown, the last criteria are turned off, up to the point that there are sufficient sources.

- Time Frame: Studies published from 2015 to the present.
- Subject area engineering.
- Geography: European context, especially the Netherlands.
- Study Type: Peer-reviewed articles, government reports, or reputable white papers.
- Language: English (and Dutch if necessary for local studies).
- Exclusions:
    - Non-empirical studies (e.g., opinion pieces).
    - Studies with outdated energy efficiency frameworks or policies, before EPCs were mandatory in the Netherlands (2014 and older).

3.3. Empirical Research

The empirical part starts with quantitative research on the effects of demographic and socio-economic backgrounds on energy efficiency, followed by price and time on the market effects of EPCs and subsidy allocation. After the quantitative research, interviews are conducted to validate the data-based results and give insight into practice. The research follows a mixed-methods approach, validating data results, to prevent biased outcomes due to biased data. This can be for instance, the fact that the WoON is voluntary and self-reported, this could lead to false entered answers or underrepresentation of certain households. This part will explain what types of descriptive and statistical analyses are used. In later sections, the collection, preparation and analysis methods are discussed.

For this research, the focus is on EPCs as a tool to give insights into energy costs, comfort and wealth growth. The starting point is the idea that behind an energy label, there are certain dwelling characteristics, like construction year, gross floor area and overall state of the dwelling. Therefore, EPCs are used as a tool to examine the effects on social equity in terms of energy costs, comfort, wealth growth and access to subsidies.

The second starting point is the idea of measuring social equity using the dimensions of energy costs, wealth growth and access to subsidies. Social equity in general is about equal access to housing. This research focuses on equal access to energy efficiency in housing, which often starts with equal access to subsidies to renovate the dwelling, reduce energy costs, and increase comfort and wealth growth.

The quantitative research follows the structure of analysing demographic and socio-economic impact on energy efficiency using WoON 2021 data, analysing market effects using NVM transaction data linked to Springco EPC data, and lastly analysing subsidy allocation using the ISDE/NWF Monitor 2023. After this part, the qualitative part starts conducting interviews with seven experts, discussing subsidy allocation, barriers to renovation, financial instruments and buyers decision-making. Lastly, all results are brought together into a synthesis to define directions for policy reforms.

Both descriptive and statistical methods are used. Cross-tabulations are used to see bivariate relations using overrepresentations and are statistically analysed using a Chi-square test. This test investigates whether there is a significant difference between the observed and expected frequencies in the relation between two variables. The result is a p-value. If this value is below 0.05, the difference is unlikely to be due to chance alone, and it is statistically probable that a relation exists between the variables.

While cross-tabulations provide a descriptive overview, the results do not account for the multitude of underlying factors that may influence these outcomes (e.g. income and education). To address this, a regression analysis was conducted, allowing for a more nuanced interpretation by controlling for other relevant variables, such as property type, floor area, year of construction, and location. This approach enables the estimation of the unique contribution of the energy label to a property's sale price, independent of other housing characteristics. Requirements for the cross tabulation (minimum of 5 expected values) and regressions ($n>30$) are checked and all met.

For the first regression, ordinal regression is used. This uses ordinal variables to predict the chance that a category is less or more likely to have a chance on the reference dependent variable, compared to the reference independent variable. For this ordinal regression, the estimate (estimated log-odds ratio) is shown, as well as the odds ratio (exponent of log-odds) to make the table more interpretable by showing percentages. The odds-ratio translates the estimate to an interpretable number, compared to 1.000 of the reference category, the odds-ratio shows the percentage above or below 1.000. This leads to, for instance, results like income group X is 20% more likely (odds-ratio = 1.200) to reside in energy labels A-B than income group Y. Besides the estimate and odds ratio, the other statistic that is used is the p-value. Standard error, Wald (which tests if the coefficient is not 0) and df (degrees of freedom) are disregarded, since these do not add relevant new insights to the results. The regression with all statistics is added as an appendix.

For the second regression, multiple linear regression is used to examine predictors for transaction price. This regression predicts the relations between the transaction price and multiple independent variables. By controlling these other independent variables, the effect of an individual variable can be estimated. The goal is to see whether EPCs affect transaction price and whether this effect is significant and robust. The unstandardised model coefficients (B values) are discussed, along with the standardised coefficients (Beta), which represent the effect on price in euros. The standardised Beta coefficient indicates the strength of the relationship between an independent variable and the dependent variable, measured in standard deviations. It allows for comparison between variables within the model but does not represent a direct effect in terms of percentage. For interpreting actual effects in monetary terms, the unstandardised B coefficient is used. The standardised Beta coefficients are calculated based on z-score standardisation. The standard deviation and t are included in the appendix, but not in the tables, since this only tells the accuracy and significance of the estimation, but so do the Beta and p-value. In this way, the tables are better interpretable. Results could look like, EPC B is worth 30,000 less than EPC A, with $p < .001$ and Beta is 0.100, which indicates a price effect, which is significant but not robust since the low Beta. It would be the case in this example that there is a price effect, but it is more likely that this is caused by other factors than the EPC itself, like a new bathroom or kitchen.

The interviews are fuelled by the results of the quantitative part. In semi-structured interviews, where an interview protocol (Appendix B) is followed, the subjects most relevant to a specific real estate actor are discussed. After the interview, transcribing begins, after which the transcription is analysed based on making connections with the results and other interviews. The interviews are held with:

- **National Institute for Budget Education (Senior scientific employee, Nibud)**
    - On mortgages as a financial instrument to finance energy-efficient measures.
- **Real estate brokers in rural and urban areas (both owners)**
    - On influence of EPCs on buyers' decision-making.
- **Municipality (Strategic advisor energy transition)**
    - About local subsidies (National Insulation Programme, NIP) and spreading of information about the availability of the subsidies.
- **Netherlands Organisation for Applied Scientific Research (Senior scientist/ researcher, TNO)**
    - About the effectiveness of subsidies and loans for energy-efficient measures.
- **Netherlands Enterprise Agency (Senior consultant energy transition and energy poverty, RVO)**
    - On policy behind subsidy, efficiency of subsidies and loans for energy-efficient measures and prioritising of target groups.
- **Association Own Home (Financial specialist, Vereniging Eigen Huis)**
    - About all financial instruments to finance energy-efficient measures.

These interviewees represent different actors, with different perspectives on several scales. For the government, both national and local scales and for the real estate brokers, both rural and urban. TNO is involved since this organisation is responsible for the ISDE/ NWF monitor and research about subsidy allocation. Nibud and Vereniging Eigen Huis gave insights into the financing mechanisms as well as the perspective of homeowners with experience in practice.

Combining the quantitative and qualitative results leads to a synthesis, where direction is given to a more equitable access to sustainability in housing.

3.4. Data Collection

The research uses both quantitative and qualitative data to ensure a mixed-methods approach. The quantitative data that is used is primarily collected via the TU Delft and the graduation company (Fakton), while qualitative data is collected via interviews. All quantitative data is secondary data. The interviews are primary data that is collected.

3.4.1. Quantitative Data

Data used for the quantitative part is secondary data, including:

- NVM transaction data (2015–2023): Includes transaction prices, listing durations, and property characteristics. This data set is provided every year by the NVM to the TU Delft. This is done via a Data Delivery Agreement with Brainbay and the TU Delft.
- Energy label data (accessed via Springco): Will be linked to NVM transactions to ensure accurate matching of the energy label at the time of sale, rather than the current label. The data set is based on certain moments in time where energy labels are scraped from Funda.nl.
- WoON 2021 dataset (Ministry of BZK): Includes detailed demographic information (income, education, age) and includes questions about recent moves and previous dwellings, requiring assumptions to assess residential mobility. This data is available via DANS using an institutional account (Koninkrijksrelaties (BZK) and Statistiek (CBS), 2024).
- RVO/CBS dataset on subsidy distribution: Contains data on subsidies per income group (CBS table: Statistiek (2024) — RVO Report: Koninkrijksrelaties (2024)).

Data is imported into SPSS for statistical analyses, using syntaxes, data preparation and analyses.

3.4.2. Qualitative Data

Primary qualitative data is collected via interviews with the earlier-mentioned interviewees. To do so, audio is recorded, and transcripts are made of the interviews. All interviews were held in Dutch to leave enough room for all interviewees to make nuances and facilitate a smoother process. Quotes are presented in both Dutch and English, to ensure that no nuances are lost in the translation.

Interviewees were contacted via the researcher's network, the graduation company and via contacting researchers on topics relevant to this research. All interviewees signed the informed consent forms in advance, agreeing on terms like anonymisation, sharing of transcriptions and sharing of the results (Appendix C).

An opportunity arose during one of the interviews. The discussion with the municipality led to an invitation to give a presentation about the results of the research, as well as to organise an interactive session to ask for opinions about statements from the municipality together with RVO. During this session, the opinions were noted.

3.5. Data Preparation

The data used for the quantitative part is all secondary data. Therefore, the preparation mainly entailed filter criteria, excluding outliers, variable creation, and recoding. Since the interviews do not need any preparation besides the earlier mentioned recruitment of participants, interview protocol and informed consent forms, these are not discussed in this part.

3.5.1. WoON 2021

The dataset used is the Dutch WoON survey from 2021, a nationally representative sample capturing information about households' living situation. Initial filtering was performed to select a relevant subsample in a stepwise manner. At each step, frequency analyses were conducted to track the number of remaining cases. The initial sample selection was executed in four cumulative steps, filtering only those households relevant for further analysis. Below (Table 3.2) is an overview of the number of cases remaining after each filtering stage:

Number of Cases after Filtering WoON 2021			
Step	**Filter Criteria**	**Unweighted Cases**	**Weighted Cases**
1	eighuura = 1 *(owner)*	26,222	4,631,566
2	+ huko = 1 *(owner-occupied)*	25,974	4,631,566
3	+ hvs = 1 *(independent home)*	25,730	4,580,049
4	+ verhuisd = 1 *(recently moved)*	2,838	546,991

Table 3.2 Cases after each filter step (Data source: WoON 2021)

These filters were constructed and applied using SPSS syntax to ensure reproducibility and consistency. The final filter has 2,838 unweighted and 546,991 weighted valid cases. The weight used is hweegwon, a weight already existing in the dataset which accounts for the non-random sampling design of the survey and enables scaling of the results to the national population level.

Variables created for the WoON 2021 are EPC classes, predicted EPCs for previous dwellings and missing EPCs, and income groups. The EPCs are recoded as A-B, C-D and E-G, creating 3 categories, better labelled, average and worse-labelled instead of 7 different categories. This increases the interpretability of both cross-tabulations and the ordinal regression, since the unweighted distribution gave too few inputs for some individual EPC to get a clear pattern.

The predicted EPCs are based on construction year, to predict the EPC of the previous dwelling, as well as to replenish missing EPCs. Dwellings after 2000 were labelled A-B, in the period 1970-1999 C-D and before 1970 as E-G.

The income categories (Table 3.3) are based on mortgage capacity, based on rough gaps of €100,000 and logical categories, to ensure alignment with the price effects and to examine certain price categories (e.g. mortgage categories).

Income Categories		
Category	**Income**	**Mortgage/ Price Class**
1	<€50,000	<€205,000
2	€50,000-€75,000	€205,000-€336,000
3	€75,000-€100,000	€336,000-€468,000
4	€100,000-€125,000	€468,000-€605,000
5	>€125.000	>€605,000

Table 3.3 Income and mortgage/ price classes to use as variable in analysing demographic and socio-economic effects on energy efficiency (Based on mortgage capacity Excel Nibud (2024) with interest rate of 4%)

All constructed variables were subjected to frequency checks to validate distributions and detect missing data. Cross tabulation analyses were prepared using the CROSSTABS procedure in SPSS. These steps were taken to structure the dataset for robust descriptive insights into the relationships between energy label classes and socioeconomic characteristics.

To further explore how energy label categories relate to socioeconomic and housing characteristics, the dataset was prepared for ordinal regression analysis. This required recoding EPC into the opposite values, so A-B = 3, C-D = 2, E-G = 1. In this way, A-B is the reference category, which is more relevant to the research aim, as it allows the results to be interpreted in terms of the likelihood of residing in an energy-efficient dwelling. All other variables were already coded as ordinal values.

3.5.2. NVM Transaction Data

The dataset used for the price effects and time on the market consists of microdata from the NVM (Dutch Association of Real Estate Brokers) and is replenished with EPC data from Springco. The original dataset has transactions from 2013-2023, but since 2015 onwards, EPCs became mandatory, the dataset is adjusted to only entail transactions after 2015. Valid cases are the transactions that are coupled with an EPC registered before the transaction date. The other filter steps are shown in Table 3.4. The filters are used to remove outliers (see Appendix D for histograms) and create a dataset with relevant transactions to examine the owner-occupied housing markets. It results in 458,605 valid cases, which is 23.9% of the base dataset and 50.5% of all linked cases, due to the fact that for some transactions the EPC is only registered after the transaction.

Number of Cases after Filtering NVM		
Step	**Filter Criteria**	**Valid Cases**
n.a.	Base dataset	1,922,124
n.a.	Dataset with linked EPCs using Springco data	908,567
1	Year transaction ≥ 2015 (mandatory EPCs)	731,061
2	+ Recreational dwelling = 0 or missing (Not recreational)	731,061
3	+ Registration date ≤ Year transaction	501,868
4	+ NVM number = 2-10 (valid property types)	501,868
5	Transaction price between €100,000 and 1,500,000	497,749
6	Time on the market between 0-365 days (1 year)	458,605 (end result)

Table 3.4 Cases after each filter step (Data source: NVM + Springco)

To ensure comparability across time, sale prices were corrected for inflation using CBS price index for existing homes (PBK), setting the year 2023 as reference year (CBS, 2024). In this way, the original transaction prices were recoded into a new variable, where the original price was corrected by the year-specific index. This is also done for the transaction price per square metre. The original PBK had 2015 as reference year, so, all indexes were recalculated to match 2023 = 100. By dividing the original index by 2023's original index, the new index is calculated. This resulted in the index as stated in table 3.5. The index is used to calculate the adjusted transaction prices, by dividing the transaction price by the index.

Price index 2023 = 100	
Year	**Index**
2015	55.4
2016	58.2
2017	62.6
2018	68.3
2019	73.0
2020	78.6
2021	90.5
2022	102.8
2023	100.0

Table 3.5 Price index for existing homes (Index data: CBS, 2024; Data source indexed: NVM 2015-2023)

In preparation for the cross-tabulations, the transaction prices are categorised into five categories for the total price, based on the mortgage classes, and seven categories for the price per square metre, based on distribution of the data. For the duration, gaps of 5 days, 15 days (1/2 month) and 30 days (month) are used, based again on the distribution of the data. This gave the price and duration ranges shown in Table 3.6.

Price and duration categories			
Category	**Price**	**Price (m²)**	**Time on the market**
1	<€205,000	<€2,500	<25 days
2	€205,000-€336,000	<€2,500-€3,000	25-30 days
3	€336,000-€468,000	<€3,000-€3,500	31-45 days
4	€468,000-€605,000	<€3,500-€4,000	46-60 days
5	>€605,000	<€4,000-€4,500	61-90 days
6		<€4,500-€5,000	91-120 days
7		>€5,000	>120 days

Table 3.6 Price and TOM classes to use as variable in analysing EPCs market effects using NVM 2015-2023 dataset

Given the width of the price categories, minor variations in transaction costs, such as differences between buyer's costs (Kosten Koper) and no additional costs to the buyer (Vrij Op Naam), which account for approximately 5% of the purchase price, exert only a marginal influence. As a result, the number of transactions that would shift to a different category due to these cost structures is minimal and does not significantly affect the overall validity of the categorisation. Therefore, further adjustment for these transaction modalities is not deemed necessary.

3.6. Data Analysis

All datasets are analysed in a consistent and structured way to enable a transition from results toward a discussion and conclusion. The methods for analysis are described below.

Descriptive analyses are conducted on all datasets, primarily using cross-tabulations. Cross-tabulations serve to identify overrepresentation or underrepresentation across key variables. This involves detecting whether specific groups show disproportionately higher or lower percentages relative to their share of the total, thereby highlighting odd distributions. These descriptive results are compared to existing literature to assess whether the findings are in line with earlier research.

Statistical analyses complement the descriptive exploration. For the quantitative data, Chi-square tests and regression models are applied. The Chi-square tests determine the significance of observed distributions in cross-tabulations, while the regression models identify the individual effects of variables when controlling for others. In the results chapter, the effects of the variables, and robustness of the effects are discussed. These are analysed with an assessment of whether these effects align with prior studies are presented. The significance testing for Chi-square results and ordinal regression model using the WoON dataset is based on unweighted cases, while the results shown are based on the weighted regression model.

Qualitative analysis of the interviews is conducted thematically. Although seven unique professionals were interviewed, the analysis focuses on identifying common patterns and shared themes across transcripts. Key elements extracted include barriers, drivers of current policy choices, and experiences with implementation in practice. Results are synthesised by finding common ground in perceived barriers, reflections on quantitative findings discussed during interviews, and policy reform recommendations emerging from the conversations.

3.7. Data Management Plan

The Data Management Plan is made using DMPonline. The plan is attached as Appendix E and involves what data is used, how it is collected and how it is stored. Together with the informed consent form and HREC checklist it is send for approval to the HREC.

3.8. Ethical Considerations

The next section will address potential risks and concerns and strategies to mitigate them to ensure ethical standards are upheld throughout the research process. This entails safeguarding participants, ensuring data validity and transparency, and mitigating potential biases. HREC approval is added as Appendix F.

3.8.1. Potential Harm

Involved in this research are quantitative data and qualitative interviews. The interviews will be with employees of organisations of the municipality, government (RVO), TNO, Nibud or a real estate broker. To mitigate potential harm, informed consent will be sought from all interview participants via the informed consent forms. This will include agreeing about the purpose, scope and confidentiality to their contributions, complying with the GDPR. The identities of the participants and sensitive information will be anonymised in all outputs. The data will be stored in secure locations like the TU Delft OneDrive (see all storages in DMP).

3.8.2. Validity of the Research

The interview protocols will be developed in such a way that they address the research questions effectively. The mixed-method approach will ensure validity of the research by first doing the quantitative part, and then the findings will be validated through qualitative research with the interviews with relevant professionals. Efforts will be made to ensure that these findings are generalisable. However, because this is descriptive research, most of the findings will be averages on a national level.

3.8.3. Researcher Position

The researcher acknowledges the potential for bias during qualitative interviews and data interpretation. To address this, a reflective approach will be adopted. This includes recording interviews and reviewing transcripts to ensure interpretations are accurate and objective. Regular feedback sessions with supervisors will act as an additional check on the validity of insights derived from the data. By maintaining transparency about the researcher's positionality, the integrity of the study will be safeguarded. Although the researcher has strong feelings about certain hypotheses, it is not the goal to prove hypotheses. With this descriptive research, the goal is to get a better understanding of how energy efficiency in homes influences socio-economic disparities. So, if the answer is, these do not influence this relation, that is also a noteworthy conclusion.

Not only the researcher can be biased, so can the data be as well. To prevent that conclusions are drawn based on only the datasets, the qualitative part is used. This creates the opportunity to test whether what is seen in the data is also represented in the same way in practice. With opinions and real-world experience and observations of policymakers and real estate brokers, a more holistic view is created, with less risk of biased conclusions.

3.9. Research Output

The deliverable is an overview of the current situation within the owner-occupied housing market regarding equitable access to sustainability in housing. The overview highlights key mechanisms through which social equity is affected in terms of energy costs and comfort, wealth growth and access to subsidy, using EPCs as a proxy. It consists of a set of evidence-based recommendations for improving the design and targeting of sustainability policies to reduce inequalities. This includes a detailed analysis of the current situation on the housing market, regarding demographic and socio-economic backgrounds in relation to sustainability in housing and access to subsidies. Beyond this main goal, the research identifies structural barriers that limit equitable access to energy-efficient housing and proposes actionable strategies to address these barriers. These recommendations aim to support a more socially inclusive energy transition within the housing sector.

CHAPTER 4

QUANTITATIVE RESULTS

4. QUANTITATIVE RESULTS

This chapter shows the results of all quantitative research. This entails a combination of demographic and socio-economic influence on energy-efficiency, price effects and time on the market, and access to subsidies. The results will be tied to energy costs relative to income, wealth growth and access to subsidies. It ends with a segmentation based on the results.

4.1. Demographics and Socio-Economic Variables across EPCs

The first part of the quantitative research is about the relationship between demographics and socio-economic variables on EPCs. The potential relation can be seen as (Figure 4.1):

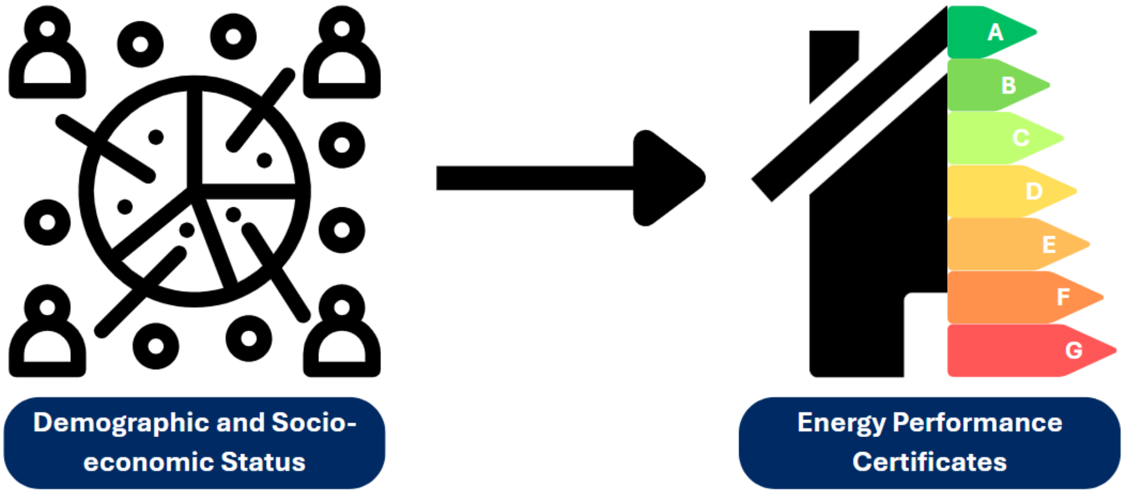

Figure 4.1 Relation between demographic and socio-economic status and EPCs

This relation gives insight into the accessibility to affordable and comfortable housing. The affordability for this section is measured as the portion of the income that is necessary to pay the gas and electricity bills. To examine the relation, cross-tabulations are made as well as an ordinal regression, all based on the WoON 2021. These insights are then linked to gas and electricity usages per income category. Frequencies of all variables are presented in Appendix G.

4.1.1. Cross-tabulations

To explore patterns of social equity in the energy performance of homes, a series of cross-tabulations were conducted between EPC categories and key demographic and socioeconomic variables, being income, education, age, and household composition. These variables were selected because these align with literature. By examining how EPCs are distributed across these groups, insight into whether certain populations are over- or underrepresented in energy-efficient homes is created. This is relevant in the context of the energy efficiency's impact on social equity due to that EPCs gives a rough estimation in energy costs, but also in comfort. Thus, disparities in the cross-tabulations can give insights in whether there is an equal access to comfortable and affordable (in energy costs) housing.

Income

Cross-tabulation EPCs across Income Groups								
		<€50k	€50k - €75k	€75k - €100k	€100k - €125k	>€125k	Total %	Total N
EPC	A-B	36.5%	38.8%	**49.7%**	**53.3%**	**51.6%**	44.6%	244,048
	C-D	**34.6%**	**38.2%**	32.2%	23.0%	25.8%	32.2%	175,918
	E-G	**28.8%**	23.0%	18.1%	**23.7%**	22.7%	23.2%	127,023
Total %		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
Total N		125,878	140,964	128,560	75,550	76,037		546,989

Table 4.1 Share of dwellings per energy label category within each income bracket, based on weighted cases with overrepresentation made bold (Data source: WoON 2021)

The cross-tabulation between income and EPC (Table 4.1) shows statistically significant results ($Chi^2(8)=41.014$; $p < .001$; n=2838). It shows that households with an income below €50.000 have the highest overrepresentation within EPC E-G (28.8% to 23.2% total). As income increases, the share of households in this bad EPC category generally declines, except for the second highest income group (€100.000-€125.000), where the pattern slightly deviates. However, this overrepresentation is not seen for the highest income group, but the pattern is. Although the highest income group does not show a overrepresentation, the underrepresentation is relatively small. This still shows the pattern of higher income groups residing more in bad labelled dwellings, compared to the €75.000-€100.000 income group. From an income level of €75.000 and above, there is a clear overrepresentation in EPC A-B, with in these groups almost all having a 50% or more representation in A-B. In contrast, for the lowest income group, 63.4% resides in C or worse. These findings show a clear gradient, higher-income households are more likely to live in energy-efficient homes, while lower-income households are overrepresented in energy-inefficient dwellings.

The WoON 2024 shows in general the same pattern. Small differences are that in this more recent version the second lowest income group is also overrepresented in E-G, the €75.000-€100.000 group is also overrepresented in C-D and the second highest income group is no longer overrepresented in E-G. The pattern is still, the higher the income, the better the EPC.

This pattern is not surprising and reflects broader economic mechanisms. Higher-income households are more likely to afford newer homes or invest in renovations that improve energy efficiency. Additionally, energy-efficient homes often come at a price premium according to literature, limiting access for lower-income buyers. The pattern could be a clear sign that energy efficiency is not equally accessible, indicating that lower-income groups have less access to energy-efficient dwellings.

Education

Cross-tabulation EPCs across Education Levels						
		Low education	Mid education	High education	Total %	Total N
EPC	A-B	**50.3%**	40.9%	**45.9%**	44.6%	244,048
	C-D	30.6%	**35.9%**	30.0%	32.2%	175,918
	E-G	19.0%	23.2%	**24.1%**	23.2%	127,025
Total %		100.0%	100.0%	100.0%	100.0%	
Total N		60,732	195,672	290,587		546,991

Table 4.2 Share of dwellings per energy label category within each education bracket, based on weighted cases with overrepresentation made bold (Data source: WoON 2021)

Against what was expected, the cross-tabulation of EPC and education, which was expected to be tied closely to income, and thus better EPCs, the Table 4.2 shows that recently moved low-educated households are overrepresented in A-B dwellings (50.3%). This group even shows the largest underrepresentation for EPC E-G. These results remain in the WoON 2024. Another notable overrepresentation is for the mid-educated households in C-D. The results are statistically significant ($Chi^2(4)=9.803$; $p < 0.05$; n=2838). In the WoON 2024, the mid-educated households shift to an overrepresentation in E-G and high-educated households shift to C-D.

This cross tabulation is only for recently moved households. In the results for all survey participants of the WoON 2021 the cross tabulation showed a clear relation between income and education related to EPCs. This could mean that more recently, education is not as closely tied to income as would be expected, reflecting possible higher payouts for practical educated persons.

Another explanation could be that wealth is not taken into account in these tabulations. When education, income and age are cross-tabulated, there is a clear pattern. It shows the higher the education, the higher the income across all age groups. However, a cross tabulation between education and age shows a large overrepresentation for older households in the low-educated category (34.0% compared to 11.1% total). This could mean that the overrepresentation of low educated households in the best labelled dwellings is reflecting older households, benefiting from long term wealth growth, moving to new, better-labelled senior dwellings. With this explanation, the education and EPC are not tight to income, but to wealth growth, which could be far from the expected patterns due to the variable time, to accumulate wealth.

Age

Cross-tabulation EPCs across Age Categories						
		<35 years	35 – 64 years	>65 years	Total %	Total N
EPC	A-B	37.1%	**46.5%**	**62.8%**	44.6%	244,048
	C-D	**35.2%**	31.6%	23.6%	32.2%	175,919
	E-G	**27.8%**	21.9%	13.6%	23.2%	127,024
Total %		100.0%	100.0%	100.0%	100.0%	
Total N		198,808	296,085	52,098		546,991

Table 4.3 Share of dwellings per energy label category within each age bracket, based on weighted cases with overrepresentation made bold (Data source: WoON 2021)

Cross-tabulation of EPC with age (Table 4.3) shows that older households (65+) are significantly overrepresented in EPC A-B homes (62.8%) and underrepresented in EPC E-G (13.6%). Whereas younger households (<35 years) show the opposite pattern, 27.8% reside in EPC E-G homes, and only 37.1% in EPC A-B. The age group between 35–64 falls in between but also leans towards better EPC ratings. Although this initially suggests that older households tend to occupy more energy-efficient homes, further analysis using ordinal regression showed that age alone is not a strong predictor of EPC. This indicates that age-related patterns may be explained by correlated variables such as income, and wealth accumulation. These results are statistically significant ($Chi^2(4)=79.010$; $p < .001$; n=2838). The WoON 2024 shows the same pattern, but with overall less households residing in E-G, reflecting less worse labelled dwellings in the housing stock.

At first glance, this suggests that older households live in more energy-efficient homes. However, this is likely a reflection of homeownership history and accumulated wealth. Many older individuals have lived in their homes longer and may have had the means to accumulate wealth and benefited from risen housing prices. In contrast, younger households are more likely to have rented and just entered the market, often into cheaper and less efficient housing. This same cross-tabulation for all responses showed that the oldest age category mostly resided in the worst labelled dwellings. This aligns with the homeownership history and accumulated wealth, since this reflects that older households live a longer period in the same dwelling, without renovating the dwelling.

Household size

Cross-tabulation EPCs across Household Sizes						
		Single Person	MP without children	MP with children	Total %	Total N
EPC	A-B	34.4%	**45.9%**	**49.1%**	44.6%	244,048
	C-D	**36.6%**	32.0%	29.7%	32.2%	175,918
	E-G	**29.0%**	22.1%	21.2%	23.2%	127,024
Total %		100.0%	100.0%	100.0%	100.0%	
Total N		114,283	238,733	193,974		546,990

Table 4.4 Share of dwellings per energy label category within each household size bracket, based on weighted cases with overrepresentation made bold (Data source: WoON 2021)

Household composition also plays a significant role in EPC outcomes (Table 4.4). Single-person households are overrepresented in EPC E-G (29.0%) and underrepresented in EPC A-B (34.4%), showing a disadvantage in access to energy-efficient housing. In contrast, multi-person households with children are the most likely to reside in EPC A-B homes (49.1%) and the least likely in EPC E-G (21.2%). Multi-person households without children also show a relatively high share in A-B (45.9%). This pattern suggests that single-person households, often more vulnerable financially, have less access to sustainable homes, whereas family households are more often situated in better-performing homes, potentially due to size, housing type, or income. These results are statistically significant ($Chi^2(4)=27.309$; $p < .001$; n=2838). Just as for age, in the WoON 2024 the pattern is the same, with less E-G dwellings overall.

This distribution may be explained by several mechanisms. Single-person households often have lower disposable income, particularly at an older age or among younger adults, which may restrict access to energy-efficient housing. In contrast, families, especially those with children, are often dual-income households and may prioritise newer or more comfortable housing, which tends to have better energy performance. This aligns well with the literature about household sizes and energy-efficiency.

4.1.2. Ordinal Regression

To move beyond descriptive analyses and gain more insight into structural dynamics, an ordinal regression model was applied (Table 4.5). While cross tabulations reveal correlations between energy labels and demographic and socioeconomic variables, the tables do not account for interactions between multiple factors or control for confounding variables. Ordinal regression allows for the simultaneous inclusion of key predictors, income, household composition and age, enabling a more nuanced analysis of the probability of residing in a more energy-efficient home. This approach provides clearer evidence on which variables influence the probability the most, showing whether certain household types systematically face barriers to sustainable housing.

All results reported are based on a weighted regression (n = 546,991.08), while significance is assessed using the unweighted regression (n = 2,838). In this way, the results are more representative for the broader population, as the weights correct for sampling biases and non-response in the WoON survey. However, significance testing is conducted on the unweighted data to reflect the actual sample size. Since the weights already scale the estimates to the national level, using them for significance testing could give a false sense of certainty. This is because the weighted data make it appear as though far more people were surveyed than was actually the case, increasing the likelihood that even small effects appear statistically significant. Weighting helps to estimate what the entire population might look like, but it does not change the number of people who were actually interviewed. Relying on the unweighted data for inference ensures that the level of statistical confidence reflects the true size of the sample.

Housing characteristics are not included, because the regression is used to see which households are more likely to reside in better EPCs. If housing characteristics were included, dwelling preferences would also be controlled for, which could be tight to the demographic and socio-economic variables of which is tried to see the effects. Then, if a high-income household wants to reside in a monumental dwelling because of personal preference, it is not desirable to control for dwelling characteristics. In this way the likelihood of residing in a certain EPC is the outcome of the household's background, not from the characteristics of the dwelling. Another benefit of not including the housing characteristics is the fact that this lead to far less cells with zero frequencies in the regression model, improving the accuracy.

The combination of income, household composition, and age gave the highest Nagelkerke score R^2=0.050. The Nagelkerke R^2 is a measure that shows how well the included variables explain the variance in the dependent variable. In this case the variance of the likelihood of living in an EPC A-B. Adding another variable like education did not improve the regression, neither did adding housing characteristics. While these did increase the Nagelkerke R^2, because of more variables, the AIC (-2 Log Likelihood), went up by a factor of 4. The AIC shows a higher value when new added variables do not improve the regression outcomes. This could be the result of multicollinearity, where these variables are connected to income.

The reference category is set to A-B, thus positive odds-ratio show a higher chance of residing in EPC A-B dwelling, while negative percentages present a lower chance. The complete ordinal regression is shown in Appendix H.

The regression confirms that income remains a significant predictor of energy label outcomes, even when controlling for housing characteristics. Households earning less than €50,000 show 37% lower odds of residing in an A–B labelled home compared to the highest income group, while those earning between €50,000 and €75,000 have 25% lower odds. The groups earning more than €75,000 show no significant difference from the reference category.

In terms of household composition, single-person households are 29% less likely to occupy homes with better energy labels, and multi-person households without children show a 16% disadvantage compared to families with children.

Age also plays a role, just as it showed in the cross tabulations, even when controlling for income and household size. Recently moved households under 35 years old show 68% lower odds of living in better-labelled homes, as well as the age group between 35 and 64 years showing 60% lower odds than the oldest age group to occupy efficient homes.

The regression shows the greatest effects for the age groups. This could be due to the underlying factor wealth, and thus an older age means more time to accumulate wealth. Together with income, which could be affected by household size (single or dual income), the regression reflects an unequal access to better labelled dwellings. Low income, single, and young households show the least access to these A-B labelled dwellings.

Predictors of Residing in an A-B Rated Home				
Variable	**Estimate**	**Odds-ratio**	**Sig.**[b]	**Interpretation**
Income				
<€50k	-0.465	-37%	0.005	Lowest income group has 37% less chance of residing in a A-B labelled dwelling compared to the highest income group
€50k -€75k	-0.288	-25%	0.028	Lowest income group has 25% less chance of residing in a A-B labelled dwelling compared to the highest income group
€75k -€100k	0.077	8%	0.861	Little to no effect compared to the highest income group, also not significant
€100k -€125k	0.067	7%	0.692	Little to no effect compared to the highest income group, also not significant
>€125k	0a	n.a.	n.a.	Reference category
Household composition				
Single person	-0.339	-29%	0.001	Single person households have 29% less chance of residing in a A-B labelled dwelling compared to multi-person households with children
Multi-person without underage children	-0.179	-16%	0.010	Multi-person households without children have 16% less chance of residing in a A-B labelled dwelling compared to multi-person households with children
Multi-person with underage children	0[a]	n.a.	n.a.	Reference category
Age				
<35 years	-1.144	-68%	<.001	Under 35 years households have 68% less chance of residing in a A-B labelled dwelling compared to over 65 years households
35-64 years	-0.926	-60%	<.001	Under 35 years households have 60% less chance of residing in a A-B labelled dwelling compared to over 65 years households
>65 years	0[a]	n.a.	n.a.	Reference category

Table 4.5 Ordinal regression results predicting chance of residing in A-B compared to reference categories (Model fit, $Chi^2(8)=127.405$; $p <.001$; $n = 2838$)

[a] This parameter is set to zero because it is redundant.
[b] Significance based on unweighted regression (n=2838)

4.1.3. Residential Mobility

With the predictive model for energy labels, the labels of previous dwellings are predicted based on construction year. With these predictions, it is possible to compare the labels of current and previously owned dwellings, for recently moved households. This is done to examine whether there is a dynamic residential mobility across the energy labels. A Sankey diagram is made to visualise the residential mobility (Figure 4.2).

Figure 4.2 Residential mobility shown with previous and current EPC (Data source: WoON 2021) (Chi2(4) = 99.650; p < .001; n=2,838)

The Sankey diagram shows a pattern of households that currently own E-G labelled dwellings, generally also owned an E-G labelled dwelling in the past. When viewing the diagram on the left side top to bottom, only a small share of A-B and C-D moved to E-G. Conversely, when viewing from bottom to top, the share of households that now own A-B labelled dwellings increase. Households currently owning an E-G labelled dwelling stem for the largest portion from the group that previously owned an E-G labelled dwelling, as well as the largest portion from A-B stems from a previously owned A-B. From households that previously owned an E-G labelled dwelling, most moved to A-B in absolute numbers, reflecting an upward trend in terms of sustainability. Consequently, of all previous dwellings, E-G had the highest number, whereas for current dwellings, A-B now has the highest overrepresentation. This also seems to indicate a positive trend towards sustainability. However, homeowners who previously owned A-B dwelling show the strongest mobility in currently owning A-B.

The threshold for entering the market of energy-efficient dwellings as well as the fact that once into this market it is easier to remain, suggest that access to energy-efficient dwellings is not equally distributed. Although moving from E-G to E-G could also entail high-income households moving from a monumental dwelling to another monumental dwelling, this scenario is less likely to assume than that low-income households remain stuck in the market of worse labelled-dwellings due to financial constraints.

Together with 4.1.1 and 4.1.2, there is an overview of demographic and socio-economic backgrounds across EPCs. Low-income, young, and single person households reside the most in low-labelled dwellings, while high-income, old and bigger household compositions reside in better labelled dwellings. As showed in Figure 4.2, there is a threshold for entering the better-labelled dwellings, creating a gap between these two groups. Other factors widening this gap are discussed in hereafter, showing energy costs relative to income, wealth growth and access to subsidies.

4.1.4. Energy Costs

From the demographic and socio-economic characteristics of recently moved households, it becomes evident that income and wealth accumulation are important in access to energy-efficient dwellings. To better understand how this affects social equity in energy costs, Table 4.6 presents gas and electricity consumption in relation to income, based on data from the ISDE monitor (ISDE/NWF Monitor, 2023). The gas price used is €1.764 per m^3 and for energy €0.317 per kWh, reflecting average prices in 2023 (CBS, 2025). This is done to recreate the situation as dated in the monitor.

Gas and electricity consumption ISDE monitor					
	Gas usage (price 2023)	Gas usage to income	Electricity usage (price 2023)	Electricity usage to income	EPC
1*	€ 3.131,10	5.9% or more	€ 1.024,86	1.9% or more	**C or worse**
2*	€ 2.954,70	3.9%-5.6%	€ 1.019,16	1.4%-1.9%	**C-D**
3*	€ 3.016,44	2.9%-4.0%	€ 1.044,52	1.0%-1.4%	**A-B**
4*	€ 3.139,92	2.4%-3.0%	€ 1.090,48	0.8%-1.1%	**A-B**
5*	€ 3.625,02	2.8% or less	€ 1.236,30	1.0% or less	**A-B**

Table 4.6 Overview gas and electricity consumption (ISDE/NWF Monitor, 2023)

*Income Categories:

1. *<€53,000*
2. *€53,000-€75,250*
3. *€75,250-€103,800*
4. *€103,800-€129,400*
5. *>€129,400*

The consumption patterns show an interesting trend, households with higher incomes and better energy labels tend to have a higher absolute energy consumption. This may seem counterintuitive, after all, energy-efficient homes should theoretically consume less energy. However, higher-income households generally consume more energy than lower-income households, mainly because this group lives in larger homes that require greater use of energy and gas, even when these dwellings have better EPC ratings. In contrast, lower-income households tend to use less energy, which can be attributed to smaller dwelling types, worse EPC performance, and financial constraints that lead to energy-saving behaviour, often at the cost of comfort.

Despite consuming more energy in absolute terms, higher-income households spend a proportionally smaller share of their income on gas and energy costs compared to low-income households (respectively 2.8% gas and 1.0% energy compared to 5.9% and 1.9%). Lower-income households, who predominantly reside in homes with bad EPC ratings, use less gas and energy in absolute numbers, yet allocate a disproportionately larger percentage of their income to gas and electricity bills.

The percentages in Tables 4.6 clearly demonstrate that based on usage patterns and income distribution, there is no equitable access to affordable housing in terms of energy costs. When combined with the finding that the lowest income groups predominantly occupy the worst-labelled dwellings, it indicates that there is also no equal access to comfortable housing conditions.

4.2. EPCs Price and Time on the Market Effects

Understanding the price and time on the market effects of different EPCs, fuels the debate later about segmentation and accessibility to subsidies, as it shapes wealth growth when tied to the results of part 4.1. If EPCs influence price, this influences wealth growth per household and thus, social equity. The potential relation can be seen as (Figure 4.3):

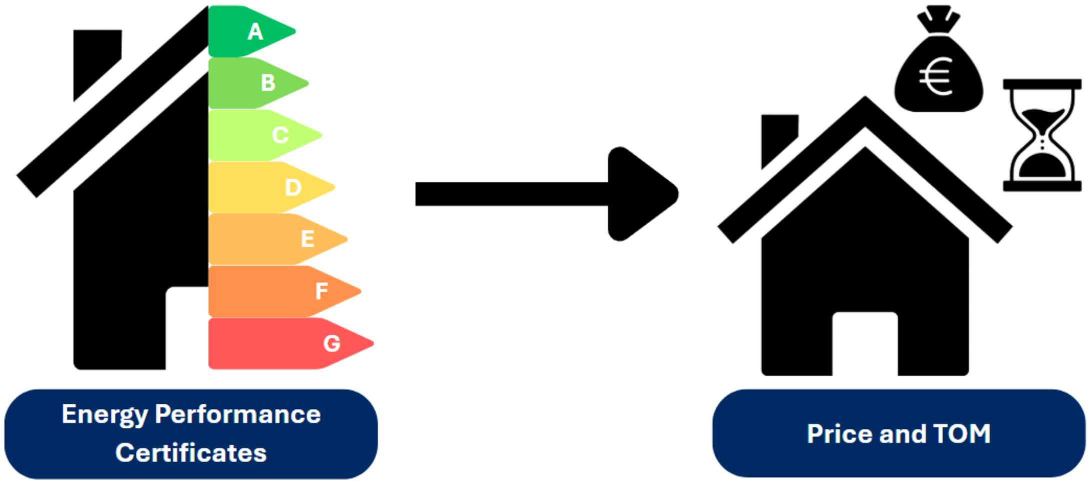

Figure 4.3 Relation between EPCs with Price and TOM

4.2.1. Cross-tabulations

For all cross-tabulations using the NVM dataset, together with EPC data from Springco, the variables are distributed as shown in Appendix I. Cross-tabulations make it possible to see how many times a variable intersects with categories of another variable. In this case transaction price and time on the market related to EPC. This gives an overview of how EPCs are distributed over price categories or time on the market categories. Via over- and underrepresentation, the tabulation can be interpreted, as the percentages are compared to the total percentage of a certain variable. Eventually the results add to the overview in terms of price effects, where certain price effects, tied to the distribution seen in 4.1, say something about social equity because of more or less wealth growth when residing in a certain EPC.

Tabulations were made for EPCs, linked to transaction and original asking price, and duration of sale. The tabulation of transaction price and original asking price with EPCs showed the same pattern. Transaction prices (and per m2) with EPCs are shown in Tables 4.7 & 4.8. All overrepresentations, more than the portion of the total, have been made bold. The cross-tabulation shows a distinct pattern for both the total transaction price and square metre transaction price. Lower transaction prices, entail worse energy labels and vice versa. Except for the highest price category, there a divide is seen, with either very good labels or very bad labels (A-B versus F-G). The underrepresentation that is most remarkable is A in the lowest price category (19.4%), as well as for the lowest category with only 2.3% label A. The largest overrepresentation also occurs for label A in the highest price class, closely followed by labels D and E in the lowest price class (respectively 12.3% and 10.1%-9.8% overrepresentation). Although label A is not the most represented category (21.8% compared to the largest, C with 27.6%), it still shows the biggest difference between over and underrepresentation. This reflects a strong dominance of label A in the most expensive categories and almost an absence in the lowest price categories, a much stronger difference than is seen for other EPCs. However, label E has an even smaller portion (9.4%) and shows a 6.9% difference between the highest overrepresentation in the lowest price category and the highest underrepresentation in the highest price category. Combined, the table shows a clear pattern with high price categories entailing better labels, vice versa.

When further explored, the high price class and bad label category show dwelling characteristics that could explain the distribution. The construction year of these dwellings is for 82.5% before 1945. Most of these dwellings are located in North- or South-Holland provinces (respectively, 29.1% and 21.0%). The typology of these dwellings is mainly detached, semi-detached and terraced, which added up, are responsible for 77.7% of the cases. So, this category mostly entails historical or old family-sized dwellings in urban areas.

Cross-tabulation EPC across Price Categories								
		<€210k	€210k - €332k	€332k - €468k	€468k - €605k	>€605k	Total %	Total N
EPC	A	2.3%	11.0%	**24.3%**	**33.4%**	**34.1%**	21.8%	99,675
	B	6.0%	12.3%	**17.6%**	**18.6%**	**16.1%**	15.1%	69,361
	C	26.0%	**33.6%**	**30.3%**	21.8%	17.0%	27.6%	126,445
	D	**24.4%**	**18.3%**	11.9%	10.0%	10.9%	14.2%	65,105
	E	**19.2%**	**12.1%**	7.0%	6.6%	7.8%	9.4%	43,159
	F	**11.3%**	**7.2%**	5.0%	5.3%	**7.7%**	6.6%	30,064
	G	**10.8%**	**5.5%**	3.8%	4.4%	**6.4%**	5.3%	24,345
Total %		100%	100%	100%	100%	100%	100%	
Total N		30,803	139,192	143,484	72,200	72,475		458,154

Table 4.7 Share of dwellings per energy label category within each price bracket, with overrepresentation made bold, transactions after 2015 with EPC available (NVM 2015-2023; Springco, n.d.)

Cross-tabulation EPC across Price Categories per m^2										
		<€2.5k	€2,5k-€3k	€3k-€3.5k	€3.5k-€4k	€4k-€4.5k	€4,5k-€5k	>€5k	Total %	Total N
EPC	A	6.3%	15.5%	**22.2%**	**27.3%**	**30.0%**	**29.9%**	**25.6%**	21.8%	99,623
	B	9.5%	14.7%	**17.2%**	**18.0%**	**17.1%**	**16.0%**	12.6%	15.1%	69,331
	C	**35.9%**	**33.7%**	**30.1%**	26.2%	22.9%	20.4%	18.3%	27.6%	126,377
	D	**20.2%**	**15.8%**	13.3%	11.8%	11.4%	11.7%	**14.5%**	14.2%	65,069
	E	**12.0%**	**9.8%**	8.2%	7.6%	8.0%	9.1%	**11.7%**	9.4%	43,135
	F	**8.0%**	**6.1%**	5.2%	5.1%	6.0%	**7.2%**	**9.6%**	6.6%	30,039
	G	**8.1%**	4.6%	3.9%	3.9%	4.6%	**5.6%**	**7.8%**	5.3%	24,313
Total %		100%	100%	100%	100%	100%	100%	100%	100%	
Total N		59,134	79,166	91,583	76,841	52,440	33,174	65,549		457,887

Table 4.8 Share of dwellings per energy label category within each price per m^2 bracket, with overrepresentation made bold, transactions after 2015 with EPC available (NVM 2015-2023; Springco, n.d.)

The cross-tabulation between duration of sale and energy label (EPC) does not reveal a consistently linear pattern for the whole period between 2015-2023. Homes with an A label tend to sell the fastest, with A being the only label overrepresented in the less than 25 days category. The most notable over- and underrepresentations are label A in the <25 days category (24.0% vs. 21.8% total) and label A in the >120 days category (19.0% vs. 21.8% total), indicating that highly energy-efficient homes sell quicker. Despite these observations, most over- and underrepresentations are relatively small, often just a few tenths of a percent, making it difficult to identify a clear or uniform trend across all labels. Additionally, the distribution appears irregular because, after the peak of quick sales for label A, the overrepresentation drops for label B to over 50 days, then rises again for labels C-E and drops a little for F-G.

However, there is a clear trend shown in the duration per label per year. The overall duration decreased from an average of 95 days in 2015 to 36 days in 2022. This reflects the tension on the owner-occupied market, here demand is very high. Over the years it is seen that EPC A consistently has the lowest duration in the period between 2016 and 2020. In 2021 this is the case for EPC C, after which A is again the lowest in 2022 and 2023. Over the period of 2015-2023 the mean duration in days is 66, where A has a mean of 61 days and G 75 days. Like the cross-tabulation, B shows a longer duration than worse labels C-E, like what is seen for EPC F (70 days compared to 65). Although A has the shortest duration and G the longest, the results show no clear effect that reflects a shorter duration as the EPC becomes better. The distribution per year did not affect the results discussed in the previous paragraph.

Another comparison is made for cross-tabulations between EPC and time on the market (see Appendix J for both cross-tabulations). Even though no EPCs after 2019 exist in the dataset, a comparison is made between the periods between 2015-2020 and after 2021. Although recent EPCs, based on new methods of certification are missing in the dataset, this could reflect more awareness towards sustainability. The comparison shows that the overrepresentation of A-labelled dwellings in the fastest selling category increased in the more recent period, rising from 22.7% to 29.8%. C shows a more focused distribution in shorter selling periods as well, creating a clearer diagonal in the post-2021 period from fast selling EPCs A to slower selling worse labelled dwellings. However, EPC B remains showing a surprising effect being overrepresented in everything longer than 40 days, with the largest overrepresentation in the longest period. Figure 4.4 shows the general pattern of A selling the fastest and G the slowest with the mean days of time on the market presented.

Based on the cross tabulations, it is seen that the most energy-efficient dwelling cost the most and sell the fastest. This creates less opportunities for low-income households, being less able to afford energy-efficient dwellings, and facing high competition in this high demand housing market.

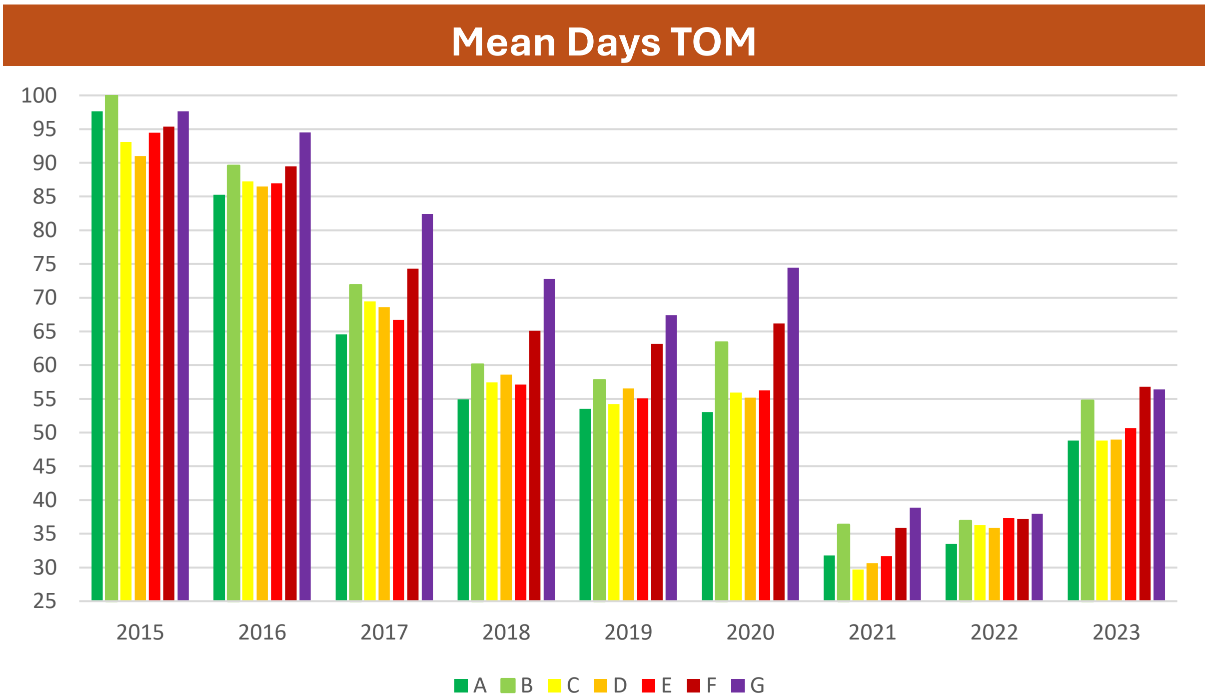

Figure 4.4 Mean Days TOM period 2015-2023 (NVM 2015-2023; Springco, n.d.)

4.2.2. Regression

To move beyond descriptive analyses and gain deeper insight into structural dynamics, a multiple linear regression model was applied (Table 4.9). While cross tabulations show correlations between EPCs, transaction prices and time on the market, they do not control for interactions between multiple variables or account for confounding effects. Linear regression allows for the simultaneous inclusion of predictors, dwelling characteristics, typology and EPCs, enabling a more precise estimation of the individual effects on transaction price.

Dwelling typology variables are used, like usable floor area, construction year and type. Furthermore, urbanisation and the energy labels are added. The model predicts the transaction price based on these variables, with dummies for dwelling typology and energy labels, because no linearity is expected for these variables. The model explains 52.5% of the variance in housing transaction prices based on the included predictors ($R = 0.724$, $R^2 = 0.525$, Adjusted $R^2 = 0.525$). Using these predictors, the outcome variable (the house price) can be predicted relatively well, the standard error is €141,938.08. The total regression is shown in Appendix K.

Remarkable positive predictors in the model are usable floor area, urbanisation, and typologies corner and (semi-) detached. Usable floor area shows for every m^2 added an increased price of €3,095, as well as every step for urbanisation rate becoming more urban adding €32,400 to the transaction price. Construction year shows a discount of €4,629 per category newer, reflecting high valued monumental dwellings in the dataset. Dwelling types are tested with a terraced dwelling as reference, where (semi-) detached show a price premium varying between €60,675 and €135,270. Furthermore, the less favourable energy labels show discounts compared to an EPC A dwelling. The price effects for the EPCs show a pattern of increased discount for C and D compared to B, but then a lower discount for E and F and again an increased discount for G. The average transaction price of EPC A within the dataset in 2023 is €510.520, which translates to a discount of 17.1% for EPC G compared to A. D shows a 17.4% discount, the largest effect, whereas B shows the smallest discount of only 9.8%. E and F show a discount of 14.6% and 13.7%, whereas C shows a discount of 16.6%.

The regression clearly indicates price discounts for labels worse than A, however not as a strong outcome indicated by the low Beta. This reflects the choice of using EPCs as a proxy. There is a high probability that other factors influence price more than EPCs, causing the price effects. These could be recent renovations not only improving the energy label but also aesthetics or the kitchen or bathroom. However, still when used as a tool to measure, the worse labelled dwellings are probably in a worse state and therefore less valuable. This aligns with the earlier findings, for lower-income households being less able to afford energy-efficient housing, due to financial constraints and higher transaction prices. The lowest-income households thereby face lower wealth growth, since most households in this category reside in worse labelled dwellings.

Regression Results Predicting Transaction Price			
Variable	**Unstandardised (B)**	**Beta**	**Interpretation**
(Constant) (Transaction price)	-1,196.111	-	-
Energy Performance Certificates			
EPC B	-€50,099	-0.088	Lower value than EPC A, weak predictor
EPC C	-€84,939	-0.185	Even lower value and stronger effect, strongest predictor
EPC D	-€89,036	-0.149	Continued decrease in value, largest discount compared to A
EPC E	-€74,546	-0.104	Lower value than A, but smaller difference than C and D
EPC F	-€69,868	-0.082	Even smaller difference than E, weakest predictor
EPC G	-€87,535	-0.092	In between price effects of C and D, weak predictor
EPC A = 0	-	-	-
Dwelling Characteristics			
Usable floor area (m^2)	€3,095	0.628	Each extra m^2 increases price
Urbanisation (1 rural – 5 urban)	€32,400	0.205	More urban areas lead to increase in price
Construction year	-€4,629	-0.050	Every step in construction year newer, leads to a discount in transaction price, likely due to monumental dwellings in category 1.
Dwelling Typology			
Appartement < 1945	€99,485	0.095	Strong price premium, could be historic value, however, a weak predictor
Appartement 1945-1970	-€20,687	-0.024	Lower value than terraced, weak predictor
Appartement > 1970	€47,682	0.083	Higher price than terraced dwelling
Terraced (Schakel)	€48,522	0.037	Higher price than terraced but weak predictor
Corner	€22,096	0.036	Higher price than terraced but weak predictor
Semi-detached	€60,675	0.108	Significantly more valuable, stronger predictor than other typologies
Detached	€135,270	0.213	Largest price increase compared to terraced, strong predictor
Terraced (tussen) = 0	-	-	-

Table 4.9 Regression Coefficients Predicting Transaction Price (all significant, $p < .001$, unless stated otherwise, n = 458,605) (NVM transactions 2015-2023; Springco, n.d.)

4.2.3. Wealth Growth

Both the cross-tabulations and the regression showed price effects connected to EPCs. Bad-labelled dwellings are consistently linked to price discounts compared to better-labelled dwellings. These effects can be linked to Table 4.10. The table shows the price effects per EPC over the timespan of 2015 to 2023. Although the percentage gain seems to be relatively close, the absolute gain differs substantially. Dwellings with EPC A appreciated by almost 236,500, whereas those with EPC E gained only around 153,300. This difference shows that, over time, households residing in poorly rated dwellings have built up less housing wealth than those in better labelled dwellings. As section 4.1 showed, these households are typically low-income, young and a single-person household. Consequently, the EPC-related price effects not only influence affordability and market access, but also contribute to disparities in wealth accumulation, leaving lower-income households increasingly disadvantaged.

Price effects 2015-2023				
EPC	**Price 2015**	**Price 2023**	**Gain (%)**	**Absolute gain**
A	€266,270	€502,758	88.8%	€ 236,488
B	€240,027	€414,729	72.8%	€ 174,702
C	€209,454	€367,912	75.7%	€ 158,458
D	€199,650	€366,625	83.6%	€ 166,975
E	€201,917	€355,265	75.9%	€ 153,348
F	€228,666	€391,006	71.0%	€ 162,340
G	€227,442	€416,365	83.1%	€ 188,923

Table 4.10 Price effects per EPC over the period 2015-2023 (NVM transaction 2015-2023; Springco, n.d.)

4.3. Subsidy Allocation

Equitable access to subsidies is the final component examined to evaluate the social equity in the owner-occupied housing market. As previously shown, lower-income households are more likely to reside in lower-labelled dwellings, leading to both increased energy expenses (as a percentage of gross income), decreased living comfort and less wealth growth.

To facilitate improvements, the Dutch government offers three primary financial instruments: the ISDE subsidy, the NWF 0% interest loan, and the National Insulation Programme (NIP) which is distributed locally. This section focuses on the ISDE and NWF, comparing how both schemes are accessed by different income groups, using estimates from the 2023 ISDE and NWF Monitor. The income categories used here are coupled percentiles of the original monitor to align with those applied in earlier sections.

While the number of dwellings that qualify for both schemes is consistent across income groups, substantial differences appear in the number of granted applications, average subsidy amounts, and number of improvements between the ISDE and NWF. Tables 4.11 & 4.12 present the results.

ISDE Allocation across Income Categories					
	Dwellings qualified for ISDE	Granted applications	Dwellings with granted applications (%)	Subsidy per dwelling (€)	Measures per dwelling
1*	684,600	12,300	1.80%	€1,042.50	1.40
2*	730,750	17,550	2.40%	€990.00	1.41
3*	883,050	23,950	2.71%	€1,045.00	1.41
4*	649,900	19,300	2.97%	€1,150.00	1.41
5*	1,375,100	44,800	3.26%	€1,370.00	1.42
Total	4,323,400	117,900	n.a.	n.a.	n.a.

Table 4.11 Overview ISDE efficiency (ISDE/NWF Monitor, 2023)

*Income categories:

1. *<€53,000*
2. *€53,000-€75,250*
3. *€75,250-€103,800*
4. *€103,800-€129,400*
5. *>€129,400*

There is a clear difference in uptake between the two options. Where the ISDE has an uptake between 1.80% and 3.26%, the NWF is only used by 0.15% to 0.23%. However, the highest and lowest uptakes are reversed, for the ISDE the higher the income group, the higher the number of granted subsidies, the NWF shows the lower the income group the higher the amount of granted subsidies. Another strong difference between the two options is the amount in euros per dwelling, the ISDE shows lower amounts per dwelling, whereas the NWF shows almost 8-9 times higher amounts per dwelling. This is how the different options are intended, the subsidies not covering 100% of the costs, with the loan covering 100%. This is also the reason for the different uptakes for the lowest income groups, this group struggles with the upfront costs and thus often need 100% recovery of the cost, thus using the NWF more compared to higher-income groups.

NWF Allocation across Income Categories					
	Dwellings qualified for ISDE	Granted applications	Dwellings with granted applications (%)	Subsidy per dwelling (€)	Measures per dwelling
1*	684,600	1,600	0.23%	€8,807.50	1.35
2*	730,750	1,750	0.24%	€9,853.33	1.41
3*	883,050	1,950	0.22%	€10,526.67	1.43
4*	649,900	1,300	0.20%	€11,450.00	1.43
5*	1,375,100	2,000	0.15%	€12,880.00	1.47
Total	4,323,400	8,600	n.a.	n.a.	n.a.

Table 4.12 Overview NWF efficiency (ISDE/NWF Monitor, 2023)

*Income categories:

1. *<€53,000*
2. *€53,000-€75,250*
3. *€75,250-€103,800*
4. *€103,800-€129,400*
5. *>€129,400*

However, this group also shows loan aversion due to inconsistent government policy, complexity in the application process and the Dutch childcare benefits scandal, these barriers will be discussed in the qualitative part. The amounts of subsidy rise for both options (with a stronger effect for NWF) as the income rises, reflecting a larger loan and initial capital capacity for higher-income groups. The lower uptake could be an effect of this higher initial capital as well, reducing the need for a loan. Higher loans align with higher-income groups residing in larger dwellings, having larger areas to insulate, driving up prices for energy-efficient measures. The higher initial capital could also be tied to the slightly higher number of measures per dwelling for higher-income groups, although the differences are small in both financing options.

The ISDE is more often used by wealthier households, who apply more, get more granted subsidies, and receive higher amounts. The NWF is used more often by lower-income households, who apply more percentage wise, but receive lower amounts of subsidy compared to higher-income households. Although the NWF is targeted more at lower-income households and shows an effect that is indeed reaching these households more often, 0.23% of all qualified dwellings is far too low to say that this is an effective measure to give these households more equitable access to subsidies and taking energy-efficient measures.

4.4. Household Segmentation

Based on the previous sections, the following overview is made per EPC, with the overrepresentations per variable shown when cross-tabulated with the EPC (Table 4.13). This shows an overview of demographic and socio-economic variables across EPCs. Per category, examples of typical households are shown below.

Household Segmentation per Income Category						
Nr.	EPC	Income	Price class based on income	Age	Education	Household composition
1	A-B	> €75k	> €337k	> 35 years	Low and High	Multi-person with(out) children
2	C-D	< €75k	< €337k	< 35 years	Mid	Single person
3	E-G	< €50k or €100k -€125k	< €205k or €468k -€605k	< 35 years	High	Single person

Table 4.13 Segmentation based on EPCs (Data source: WoON 2021)

Category 1 shows the highest income, best label and largest family size. This category typically entails high educated couples both working, possibly having children, or seniors either low or high educated benefitting from wealth accumulation for a longer period of time and a pension.

The second category consists of younger adults under 35, typically single-person households with mid-education, and incomes below €75,000. This could be for instance individuals with already some years of experience, and thus closer to the 35-year mark, leading to higher incomes. This category can be seen as the second-time buyer (doorstromer) or movers already within the housing market.

Lastly, category 3 entails typically first-time buyers (starters). This group has the lowest income, and is therefore limited in free choice of where to reside. Since bad-labelled dwellings are the cheapest, this group most often resides in the worst EPCs (E-G). The high education could suggest students, just graduated, who entered the market for the first time.

In terms of energy costs and comfort, category 3 faces significant disadvantages, highlighting their lack of equitable access to affordable and comfortable housing. This aligns with earlier findings from section 4.1. Additionally, these groups experience limited opportunities for wealth growth through energy-efficient homeownership and face barriers to accessing subsidies, as detailed in sections 4.2 and 4.3.

CHAPTER 5

QUALITATIVE RESULTS

5. QUALITATIVE RESULTS

This section presents the findings of seven expert interviews conducted with professionals from Nibud, Vereniging Eigen Huis, TNO, RVO, two real estate brokers, and a municipality. These interviews focused on the practical workings of EPCs, barriers to energy efficiency investment, and the effectiveness of subsidy systems in reducing or reinforcing social inequity. The qualitative findings complement the quantitative results, validating the results, as well as preventing biased results.

5.1. Inequality in Access to Subsidies and Sustainable Financing

Several interviewees, representing organisations such as Nibud, TNO, RVO, and a municipality, confirmed that uptake of subsidies applications and sustainable financing options is significantly higher among higher-income households. This group generally faces fewer barriers, are often more familiar with bureaucratic processes, have upfront capital for renovations, and are less affected by mortgage limitations. Vereniging Eigen Huis remarked that a lot of subsidies went to households that could already easily afford the measures themselves. TNO noted that this is partly explained by the fact that higher-income households often live in larger homes that require bigger investments to insulate, explaining the differences in amounts per dwelling seen in 4.3. Nibud confirmed that these households frequently do not need to borrow to finance improvements and often stay well below their mortgage limits, allowing them to access additional financing for sustainability upgrades more easily, compared to low-income groups that needed to lend to the maximum mortgage capacity.

NL: "Heel veel geld is gegaan naar mensen die het eigenlijk ook zonder subsidie hadden kunnen doen."
— Vereniging Eigen Huis —

EN: "A lot of money has gone to people who could have done it without subsidies in the first place."
— Vereniging Eigen Huis —

In contrast, lower-income households face several overlapping barriers. First, they often lack the capital required to pre-finance renovations needed to apply for schemes like ISDE (Nibud, Vereniging Eigen Huis, Municipality, RVO and TNO). Second, they are discouraged by BKR registration when using loans from the NWF, fearing the long-term implications of credit listings (Vereniging Eigen Huis). Third, there is widespread distrust of government financial tools, rooted in past policy failures like the childcare benefits scandal (Vereniging Eigen Huis and RVO). According to RVO, this distrust is so strong that letters from the municipality are often thrown away without being read. These factors contribute to a strong aversion to loans, even when these are offered at favourable terms, such as the 0% interest loan (NWF). TNO emphasised too that low-income groups are generally loan-averse, and uncertainty around receiving subsidies adds further hesitance to commit to apply for ISDE or NWF. Nibud added that the psychological barrier of taking on debt, especially a mortgage to the max, remains high, even when monthly energy savings would outweigh new loan payments.

NL: "Je moet wel die hobbel over om dat bedrag op tafel te leggen, om die investering te kunnen doen. En daar zit voor heel veel mensen natuurlijk wel een soort drempel in, omdat ze niet willen lenen of niet kunnen."
— Nibud —

EN: "You need to get over that hurdle of putting the money on the table to make the investment. And for many people, that's a real obstacle, either because they don't want to borrow, or simply can't."
— Nibud —

Moreover, many low-income households live in apartment complexes governed by homeowner associations (VvEs). In such settings, sustainability upgrades depend on collective decision-making. If financially vulnerable residents oppose renovations, the entire projects may be halted. According to Vereniging Eigen Huis the upgrades may lower energy bills, the increase in service costs that is often charged after the renovations, can result in higher monthly payments, neutralising or reversing financial gains from the renovation. RVO raised the concern that some residents are even forced to leave their homes when the VvE is initiating a renovation, probably due to financial constraints. Vereniging Eigen Huis noted that many of these residents live in the poorest-performing buildings and struggle with already high energy bills. They explained that while subsidies and VvE-specific loans exist, the resulting rise in service costs makes participation unaffordable for some households. They advocated for financial backstops to protect these households and prevent them from blocking essential upgrades. Existing loan options for VvEs are less attractive compared to those available for single-family homeowners. Interviewees proposed extending zero-interest financing options to VvEs and establishing financial safeguards for low-income residents who cannot bear the additional costs.

5.2. Actors and the Reliability of EPCs

In the process of taking energy-efficient measures, several actors are present became evident during the interviews. It all starts with the homeseller and -buyer who have to come to an agreement, facilitated by the real estate broker. A mortgage advisor and lender help the homebuyer with the mortgage (Vereniging Eigen Huis). However, the lender, as well as the municipality and government, have an interest in the most recent EPCs, or at least one that reflects the current state of the dwelling (as stated by the municipality). According to the participating municipality, many registered EPCs are outdated or estimated, especially for homes not recently sold, and this significantly weakens the reliability of housing stock data.

Despite being well-positioned to inform buyers about sustainability-related financing, most mortgage advisors refrain from doing so according to the interview participants. Across several interviews, mortgage advisors were mentioned as key actors in informing new homebuyers about the financing options to take energy-efficient measures. There is no incentive to do so, while in this way, homebuyers often leave viable options on the table due to not having all the necessary information. So, homebuyers do have an interest here in a recent EPC, since this influences the mortgage capacity. However, buyers are not always completely informed or do not have the priority on sustainability. Vereniging Eigen Huis repeatedly emphasised that advisors are not fulfilling their role in guiding consumers and should take responsibility for explaining subsidies, municipal loans, and all financing options available.

NL: "Die adviseur hoort ook alles te vertellen, die hoort ook te vertellen wat de gemeentelijke leningen zijn, welke subsidies er zijn, zodat ze dan integraal dat hele plaatje neer kunnen leggen."
— Vereniging Eigen Huis —

EN: "The advisor should explain everything, including municipal loans and available subsidies, so they can present the full picture in an integrated way."
— Vereniging Eigen Huis —

The urban real estate broker stated that it could also already begin with the real estate broker taking responsibility for informing homebuyers about their options. Real estate brokers walk around in the dwelling and have more information about what can be done in terms of renovating, and what is maybe already been done, but not indicated due to an outdated EPC. So, this could mean that the real estate broker already gives the indication, where the mortgage advisor only should agree or disagree, and does not need to give all the information themselves. This aligns with Vereniging Eigen Huis, who stated that the responsibilities should be more evenly distributed to unburden homeowners. The rural real estate broker confirmed this approach and added that awareness of EPC ratings among buyers is growing, but that features like kitchen quality still often outweigh sustainability factors in decision-making.

NL: "Ik zie dat nog niet echt structureel bij die mensen van, ik ga dan liever minder wonen in een A, dan beter wonen in een C. Ze denken toch eerder prachtige keuken of sanitair."
— Rural real estate broker —

EN : "I don't yet see people consistently saying, I'd rather live in a smaller home with an A label than in a better one with a C. They still look at things like a beautiful kitchen or nice bathroom."
— Rural Real Estate Broker —

Many energy labels in circulation are outdated (indicative from 2015) and fail to reflect improvements made since, according to the municipality. Homeowners often avoid updating their labels since there is no incentive, if there is no sale (RVO). Consequently, municipalities and banks operate with distorted data, undermining policy targeting and risk profiling (municipality). The municipality wants to target the worst dwellings, but when households have already renovated after the last EPC was given, on paper it is still a bad dwelling, but in reality, it is not. Therefore, the municipality wants the most recent EPCs. The municipality acknowledged that homeowners avoid updating their labels due to fear of a higher WOZ-value and increased property tax, although this effect could be marginal and therefore refrain from doing so.

NL: "Wat ik heel opvallend vind is dat wij als gemeente niet precies weten wat het energie-label van een woning is [...] Als mensen in een woning zijn blijven wonen hebben we daar alleen het geschatte label van, dat niet overeenkomt met de werkelijke staat van de woning."
— Municipality —

EN: "What I find remarkable is that, as a municipality, we don't know the actual energy label of a home [...] If people have stayed in a house for a long time, we only have the estimated label, which often doesn't reflect the home's actual condition."
— Municipality —

Some banks are offering a free EPC renewal, to get a better insight into the state of their portfolio. However, since there is no incentive for a homeowner to update the energy label, it is hard to actually gain these insights. The urban real estate broker observed that even when EPCs are available, outdated ratings can significantly misrepresent the real condition of a home. Buyers, especially in the mid-market segment, are becoming more conscious of label implications but remain confused about what they truly indicate.

Concerns were also raised about the credibility of EPC ratings. Although assessors follow the NTA8800 standard, the margins allowed for interpretation can result in strategic manipulation to achieve a slightly better rating. While a B-rated property is unlikely to perform as poorly as an F-rated one, such marginal shifts can have implications, especially in the rental market, where better EPCs allow landlords to charge more rent. However, for this research about the owner-occupied market, the effects are limited. TNO and RVO both raised concerns about label manipulation, and RVO noted that recent media reports about EPC’s have damaged trust in the system. The urban real estate broker also stated that it is not a closed system, since registered EPC’s now both exist from before and after 2021 (when the new methodology was introduced).

To illustrate the complex web of actors and responsibilities, Table 5.1 shows dependencies, incentives and barriers per actor. Important to note is that the stakeholders highly dependent on renewed EPCs, are not the ones in the position to apply for a new EPC. Furthermore, there are a lot of stakeholders, all with their own responsibilities. This creates fragmentation within the process of renewing EPC and taking energy-efficient measures.

Actors related to EPCs			
Stakeholder	**Dependencies**	**Incentives**	**Barriers**
Homebuyer	Mortgage advisor, real estate broker, seller, access to correct EPC info, interest in most recent EPC due to mortgage capacity (dependent on being informed correctly by advisor or broker)	Lower energy bills, extra mortgage (106%), €10k bonus for A-B label	Limited knowledge, complexity of subsidies, outdated EPCs (probably already better)
Homeseller	Energy advisor for EPC, buyer interest	Higher property value with better EPC	EPC cost vs. low fine, little motivation to renovate or get an updated EPC before sale
Real Estate Broker	Seller's EPC, buyer preferences	Obligated to use EPCs in advertisements	Not required to advise on energy efficiency
Mortgage Advisor	Bank products, regulatory knowledge, buyer awareness	Client satisfaction, selling more comprehensive products	Not obliged to inform about all green options or subsidies, time pressure

Bank/ Lender	EPC data (during transaction only), mortgage advisors	Green portfolio (CSRD compliance), lower risk loans on efficient homes	EPCs not updated without sale, which gives blind spots in portfolio
Municipality	EPC data, cooperation from owners and banks	Meet climate goals, reduce emissions, improve housing stock	EPCs outdated, leading to poor targeting of worst homes, limited enforcement power
Government	Market actors for compliance, data collection	National climate targets, EU regulation compliance (EPBD, CSRD), housing quality	Fragmented policy, low awareness among public, limited enforcement of EPC regulations
Energy Advisor	Homeowners requesting EPCs	Business opportunities through mandatory certificates	Only relevant during transactions, due to low incentives for homeowners
Installer of energy-efficient measures	Homeowners requesting energy-efficient measures	Business opportunities, because subsidies lowers the threshold to renovate	Households withholding from renovating due to financial constraints

Table 5.1 Key actors involved in the EPC system, interdependencies, and factors influencing their engagement with energy performance labels in the Dutch housing market.

5.3. Administrative and Procedural Bottlenecks

Several interviewees noted that the procedures around ISDE and other schemes are unnecessarily complex and discourage participation. Requirements such as digital applications, pre-financing, and specific documentation often overwhelm applicants, particularly those with limited digital or literacy skills. As a result, vulnerable groups are left out despite being the primary targets of many policy initiatives.

NL: "Met de hele toeslagenaffaire werkt dat [waarschuwingen dat mensen de aanvraag correct in moeten vullen, of anders de subsidie terug moeten betalen] echt niet hoor, dan denken mensen ook van handjes eraf, ik doe niks meer, want ik vind het doodeng."
— Vereniging Eigen Huis —

EN: "With the whole childcare benefit scandal in mind, that kind of warning [fill it in correctly or pay the subsidy back] really doesn't work anymore. People just back off and say, I'm not touching this, it's terrifying."
— Vereniging Eigen Huis —

Vereniging Eigen Huis stated that many applicants are unaware of detailed application requirements and often fail to provide correct evidence due to lack of upfront guidance. RVO added that many people simply stop engaging when they see bureaucratic language or municipal logos on letters.

A related challenge is the fragmentation of responsibilities across institutions. For instance, due to legal restrictions, mortgage advisors are not allowed to assist applicants in acquiring loans from the NWF or ISDE subsidy. This leaves applicants to navigate disconnected systems and procedures without guidance. A lack of coordination between housing, financial, and municipal actors widens this gap. RVO mentioned that this administrative fragmentation is particularly burdensome for households already dealing with financial stress, who are also less likely to proactively seek help due to shame or mistrust.

Interviewees agreed that unburdening ("ontzorgen"), offering full-process support in an integrated way, is essential. Effective support would include personal guidance, easy-to-use digital tools, and one-stop-shops where homeowners can access advice, subsidies, and financing options in one place. RVO referred to the upcoming national roll-out of 'energiehuizen', a Dutch version of the one-stop-shop mandated by EU regulations, as a key tool to simplify this process. However, RVO cautioned that current efforts to establish these centres are inconsistent and often underfunded.

NL: "Echt ontzorgen, vereenvoudigen zijn de sleutelwoorden."
— Vereniging Eigen Huis —

EN: "Truly unburdening and simplifying, that's the key."
— Vereniging Eigen Huis —

Another administrative bottleneck, not for applying subsidies, but for renewing an EPC is the fine for not having a valid certificate at the time of transaction. This fine is considered to be too low to serve as an effective enforcement mechanism, according to a rural real estate broker. In some cases, it is even more cost-effective to simply pay the fine, especially when a dwelling has many square metres, making the cost of obtaining an energy label higher than the penalty. Instead of increasing the fine amount as punishment it is better to stimulate in another way according to the urban real estate broker. However, real estate brokers are required to present the EPC of a property in sale advertisements and get fined as well for missing EPCs. Since no valid indicative labels have been issued since 2015, and given this obligation, in theory, it should no longer be possible to complete a transaction without a valid label.

5.4. The Vicious Cycle of Outdated Labels

Municipalities and financial institutions depend on updated energy labels for a range of operational, regulatory, and strategic purposes. EPC data is used to determine which households should be targeted for renovation support, to assess risk in mortgage portfolios, and to report on sustainability progress in line with European regulations. However, homeowners have little to no incentive to renew their EPCs unless there is an intend to sell the dwelling. This creates a systemic mismatch where institutions require updated information, while homeowners receive no direct benefits from providing it. Gemeente Westland highlighted that many older labels are based on estimates rather than actual inspections, and homeowners who have made energy improvements rarely update their labels unless prompted by a sale.

NL: "Waarom zou ik 500 euro uitgeven aan een label waar ik niks aan heb?"
— RVO —

EN: "Why should I spend €500 on a label that offers me nothing?"
— RVO —

The result is a data feedback loop that disadvantages everyone involved. Outdated EPCs skew the ability of municipalities to identify and target the least energy-efficient dwellings, delaying much-needed improvements. Financial institutions are left with inaccurate data on the state of their portfolios, undermining efforts to report on or improve the energy efficiency of their mortgage books, potentially costing them millions. Homebuyers are disadvantaged when a more recent EPC would be better than the current registered one, due to lower mortgage capacities for worse EPCs. Moreover, the fear of a higher WOZ valuation, and thereby increased property taxes, discourages voluntary updates, especially for those who have improved their homes informally and are not planning to move. RVO further explained that many simply do not see the value in spending money to update a label they perceive as offering no return.

NL: "De verbetermaatregelen worden niet actief gemeld aan de gemeente omdat ze bang zijn dat daardoor ook de WOZ-waarde omhoog gaat. En ze hebben er dan geen belang bij tot het moment dat de woning verkoop klaar wordt gemaakt?"
— Municipality —

EN: "Homeowners don't report improvement measures to the municipality because they're afraid it'll raise the WOZ value. So, they only have an interest in doing so when they're preparing the home for sale."
— Municipality —

5.5. Proposed Reforms and Support Strategies

The qualitative findings link closely to the three core dimensions also examined in the quantitative analysis, energy costs and comfort, wealth growth, and subsidy allocation. Among these, subsidy allocation emerges as the most actionable policy lever. By improving the way subsidies are allocated and accessed, particularly for low-income households, a wide range of social benefits can be unlocked. These include reduced energy costs, increased comfort, and potentially enhanced housing wealth through EPC-linked price premiums. While widespread upgrades could eventually lower price premium effects market-wide, in the short term they offer opportunities for levelling the field. The urban real estate broker and Nibud both pointed out that lower-income households tend to purchase the least efficient homes and often remain stuck in these segments due to financial and structural barriers. Targeted financial tools could help these households renovating dwellings to better EPCs.

NL: "Het energielabel bepaalt mede de prijs. Dus op het moment dat jij als koopstarter of als persoon met een niet zo hoog inkomen op zoek bent in de woningmarkt in Rotterdam, dan kun je waarschijnlijk niet gaan voor het huis wat net helemaal verbouwd en goed geïsoleerd is. [...] En als je dan zo'n label F of G hebt, die we overigens wel steeds minder zien, dan zijn die huizen gewoon goedkoper."
— Urban real estate broker —

EN: "The energy label partly determines the price. So, if you're a first-time buyer or someone with a modest income looking for a home in Rotterdam, you probably can't go for the one that's recently renovated and well insulated. [...] If you end up with an F or G label, which we thankfully see less often, those homes are simply cheaper."
— Urban Real Estate Broker —

A recurring theme across all interviews is the principle of unburdening, a comprehensive, user-friendly, integrated approach to support. This involves not only simplifying the subsidy application but also integrating financial advice for energy-efficiency improvements. Energy coaches bundled advice-and-loan services, and personalised guidance were suggested as effective tools to lower the entry barriers. TNO advocated for integrating subsidy offers directly into the advisory process, as most people are not looking for subsidies per se but rather want to improve their homes and need support in understanding their options.

Special attention must be given to upfront accessibility. Many of the low-income households cannot afford to pre-finance sustainability measures. Upfront subsidies or loans, free of BKR registration, could remove a major barrier for these groups. Vereniging Eigen Huis emphasised that subsidies should be issued beforehand, not retroactively, to address the liquidity gap among these households.

NL: "Kijk je naar subsidies waarin wij altijd al gezegd hebben, juist voor de groep die zelf het geld niet heeft, doe alsjeblieft de subsidie vooraf geven en niet achteraf, want mensen kunnen het niet zelf voorfinancieren."
— RVO —

EN: "When it comes to subsidies, we've always said: for the people who don't have the money themselves, please issue the subsidy in advance, not afterwards. They simply can't pre-finance it."
— RVO —

The issue of trust also surfaced repeatedly. To restore confidence among low-income households by past government failures, new interventions may need to be embedded in existing networks of trust. Health professionals, for example, could serve as intermediaries, particularly when poor housing quality directly affects wellbeing. By targeting households with health vulnerabilities, such as cold, mould, or poor air quality, relevant energy-efficiency information could be conveyed in a credible and personal way. Although, with this approach it is very important the credibility of health-care workers is ensured. Additionally, this would also need extra effort of this sector, while it is already under high time and labour pressure. RVO reported pilot efforts to involve general practitioners in outreach, especially in households with chronic health issues, based on a successful model used in the United Kingdom. This approach is rooted in the idea of "borrowed trust," where a known and trusted figure introduces unfamiliar support systems, reaching an unreachable group for the government or municipality.

Interviewees also highlighted the effectiveness of policy triggers. Requiring that at least two sustainability measures be taken in exchange for receiving subsidy funding could increase impact while discouraging opportunistic use. This would align well with common renovation behaviours, as most homeowners implement energy upgrades during broader home improvements such as a new kitchen or bathroom. TNO evaluated a similar measure in the past and found that the two-measure requirement significantly increased energy savings and improved outcomes. Despite these positive results, the regulation has since been removed.

NL: "Om subsidie te geven aan isolatiemaatregelen als je meer dan één maatregel neemt, dus dat je minimaal twee maatregelen moet nemen. [...] En wij hebben toen gezegd, ja, als je dat gaat subsidiëren (1 maatregel), dan ben je heel veel free-riders aan het subsidiëren."
— TNO —

EN: "To provide subsidies for insulation measures only when more than one measure is taken — so that you must take at least two measures. [...] And at the time, we said, yes, if you start subsidising single measures, then you're essentially subsidising a lot of free riders."
— TNO —

Finally, as a synthesis of all interviews, to break the cycle of outdated labels, an incentive for homeowners is needed, without plans to sell the dwelling, there is no need for a new EPC. Incentives should come from those with interest in updated EPCs, like the municipality and banks. Financial benefits like scaling a homeowner in a lower tax scale although the EPC increased and thus the WOZ-value, or interest discounts could be one of the ways to do so. Another way to incentivise households to renew the EPC, is to link it to subsidies. When a renovation is completed, and subsidy is granted, a new EPC is registered, allowing municipalities to get more insights in the current state of dwellings. Obligating mortgage lenders to renew the EPC at the time of transaction could also be an opportunity. In this way it is prevented that homebuyers get a lower mortgage than it should be due to a worse (outdated) EPC. Further directions to solutions will be discussed in the discussion section.

5.6. Synthesis of Qualitative Results

Linking these qualitative results to the three dimensions of social equity for this research, energy costs, wealth growth and access to subsidies, this reflects a disadvantagous position for low-income households in access to energy efficiency in housing. These households are overrepresented in poorly labelled dwellings, resulting in high energy costs relative to the income. Reaching this group is hard due to distrust in the government, causing a lack of information about available subsidy schemes, witholding this group of using subsidies to renovate. Interviewees suggested using "borrowed trust" of the healthcare sector to reach this group.

The access to subsidies is even lower for this group due to the complexity of the procedure, not being able to cover upfront costs and a lack of tailored guidance. Moreover, low-income households are often unable to invest in energy efficiency measures, due to the need for upfront capital and loan aversion due to the childcare benefit affaire. Because this groups mostly reside in worse EPCs, the wealth growth is lower compared to higher-incomce groups. As such, the lower access to subsidies or lower ability to renovate leads to more inequity on the housing market, leaving low-income households behind on wealth growth as well as bearing a higher burden then others because of the higher energy costs relative to income.

In addition to these barriers, fragmented responsibilities among actors, such as real estate brokers, mortgage advisors, lenders, and municipalities, result in homeowners not being aware of their options and procedures. Interviewees emphasised the need for integrated "one-stop-shop" solutions to support and unburden these households in a more integrated way.

Meanwhile, homeowners have little to no incentive to renew an EPC unless a sale of the dwelling is planned. This creates a problem for municipalities, mortgage lenders and banks. Without up-to-date EPC data, municipalities are unable to effectively target the worst-performing dwellings, and banks reporting most probably a worse portfolio than what the actual state is. The latter is important for compliance with sustainability reporting standards and accurate risk assessment. Homebuyers, too, are negatively impacted when outdated EPCs undervalue the actual state of a dwelling, lowering mortgage capacity.

Overcoming these challenges are important to create more equitable access to energy efficiency in housing. Directions for reforms entail upfront subsidies, BKR registration free loans, as well as 0% loans for VvE's. EPC renewal incentives are needed to break the cycle, an integrated approach can help to unburden homeowners and simplify the process, and the healthcare sector can be used to inform the unreachable households due to distrust in the government.

The qualitative results are summarised and shown in Table 5.2. An important difference between stakeholders that benefit from a certain reform and actors that are needed to integrate the reform is made.

Overview of qualitative results				
Problems	**Consequences**	**Proposed reforms**	**Beneficiaries**	**Needed to integrate**
		Incentivise		
Little to no incentive to renew EPC	Missing updated EPCs	Financial benefit tied to EPC renewal	Municipalities, banks	Municipalities, banks, homeowners
Missing updated EPCs	Less efficient subsidy targeting	Linking subsidies to EPC renewal, and lowering OZB tax	Municipalities, homeowners, banks	Municipality, government, EPC certifiers
Missing updated EPCs	Less efficient portfolio reporting and risk assessment	Lowering mortgage interest rates for label jump with renewed EPC	Banks, homeowners, municipalities	Banks, EPC certifiers
Missing updated EPCs	Lower mortgage capacity	Obligation to renew outdated EPCs when applying for a mortgage	Homebuyers, banks, municipalities	Banks, EPC certifiers
VvE's face financial feasibility issues	Energy cost reduction offset by rising service costs	0% NWF loan for VvEs	VvEs, appertement owners	Government
		Inform		
Distrust towards government and lack of information	Lack of renovations for worst labelled dwellings	Use of borrowed trust (e.g. health sector, sports club, social workers)	Homeowners, municipality	Municipality, Health sector, other social sectors
Non-efficient targeting	Targeted dwellings not always as bad as reported			

Integrate				
Complex application procedure	Households not able to apply	Unburdening and simplify processes	Homeowners	Municipalities, government, real estate brokers, banks, installers
Fragmented responsibilities	Homeowners not aware of options and procedures	One-stop-shop approach	Homeowners	Municipalities, government, energy coaches, real estate brokers, banks, mortgage advisors, installers
Upfront capital needed for energy-efficiency measures	Low-income households not able to invest	Upfront subsidy without BKR registration	Homeowners	Government, municipalities

Table 5.2 Problems, consequences, proposed reforms, and stakeholders (based on qualitative results and synthesis of all results)

CHAPTER 6

DISCUSSION

6. DISCUSSION

This research used a mixed methods approach using the WoON 2021 survey as well as NVM transaction data (2015-2023) together with Springco EPCs data and ISDE/NWF subsidy data for the quantitative part. Interviews were conducted for the qualitative part with experts in the real estate sector. All quantitative data is secondary data, adjusted as explained in chapter 3 to be most representative for this research. Therefore, when this research would be repeated, the outcomes should be the same, creating the validity of this research. With the repeatability, and structured and transparent approach, the accuracy of the findings is increased, improving the internal validity. Repeatability also creates external validity, since other researchers could recreate the research to other contexts.

The goal of the research was to give insight into the impact of demographic and socio-economic backgrounds on access to energy efficiency in housing. Three pillars are used to measure this, energy costs relative to income, wealth growth and access to subsidies. These pillars combined are seen as the level of social equity on the current Dutch owner-occupied housing market with EPCs as a tool to measure this. This chapter interprets the key findings, discusses the alignment with literature, outlined policy implications, and addresses the limitations and recommendations for future research.

6.1. Interpretation of Key Findings

Based on the outcomes of the data analyses using the WoON 2021, income is seen as the strongest predictor of EPCs in both cross-tabulations and ordinal regression. This result aligns with the expectations that high-income groups would reside in energy-efficient dwellings. More expensive dwellings are more efficient as well, further strengthening this result. This aligns with the price premiums results of various literature sources, however there is still debate about whether the EPCs cause the effects or other housing specifications. Therefore, EPCs are used as a proxy in this research, ensuring these can be used as a measurement for both demographic and socio-economic effect on them as the price and time on the market of the EPCs.

Surprisingly, low-educated household are overrepresented in A-B labelled dwellings, when only recently households are examined. This is not in line with the assumption that income and education would be strongly linked to each other. While income shows a clear pattern of higher-income is more chance of residing in an energy-efficient dwelling, education shows that low-educated households are more likely to reside in an energy-efficient dwelling than high-educated households. A possible explanation for this is the fact that only recent movers are examined, also entailing older households, benefiting of wealth accumulation and not necessarily high educated. For this it is not the income, but the accumulated wealth that made it possible to reside in an energy-efficient dwelling. The cross-tabulation of age and EPCs showed that there is a large overrepresentation of > 65 years households in EPCs A-B, strengthening this result.

Single person households are less likely to reside in an energy efficient dwelling, even when income and age are controlled for. This aligns with the expectations and literature. An explanation could be that these households reside in other typologies, due to the smaller household size, which are less energy-efficient, like appartements. It could also be that these households are younger than families with children and had less time to accumulate wealth.

All results are in line with the patterns seen in the most recent version of the WoON (2024). However, in general there are less E-G dwellings reported, reflecting a more sustainable housing stock.

The residential mobility also showed this disparity in the owner-occupied market. The cross-tabulation of current EPC and previous presented a clear pattern of A-B to A-B movers staying in this side of the market, while E-G owners often are stuck in the worse labelled side of the market. In this way the market shows a diverging trend, where low-income households are left behind in terms of access to energy efficiency in housing.

The ISDE and NWF monitor showed that low-income households bear a higher financial burden for their energy costs than high-income households, answering the first subquestion. The lower-income households reside in worse labelled dwellings, however, do not use the most gas and electricity in absolute numbers. This could be because of the scenario that lower-income households live in smaller dwellings, needing less energy and gas. However, in terms of energy costs relative to income, this group spends a higher share to energy costs than the higher-income households. This can also be explained by the fact that gas and electricity usages do not alter more than €750 for gas and €250 for electricity, while income groups vary by thousands of euros.

Subsequently, the next research questions showed the price effects results aligned well with existing literature, and showed differences in price effects per EPC over the period 2015-2023. However, the price premiums found are significantly higher than the ones in literature. This indicates another approach, possibly missing other factors influencing price, like location or region. This could be of influence, as interviewees already stated that every region has its own market dynamics. The pattern is still clearly the same, higher transaction prices correlate with better EPCs, and EPC A appreciated more than lower EPCs percentage wise and absolute. Together with the conclusion that low-income households bear a disproportionate amount of energy costs relative to income, it creates the situation that this group is also in a disadvantageous position in terms of wealth growth compared to high-income households. Not only at the time of sale, but also over time due to varying price effects over time per EPC.

Time on the market did not show clear patterns throughout the 2015-2023 period. However, notable differences emerge when comparing the period 2015-2020 with the years following 2021, possibly reflecting a growing awareness for sustainability in the housing market. Dwellings with EPCs A and C have recently been selling faster, while label B remains overrepresented in the longest time on the market category. This aligns with findings by Aydin et al. (2019). This may indicate that B-labels, particularly when predicted rather than certified through inspection, suffer from less consistent quality or market perception, weakening the signalling power. Another explanation could be the idea of buying a lower priced EPC C, reserving financial resources for energy-efficient measures and upgrading the dwelling to EPC A or B once bought for a more favourable costs than buying a more expensive EPC B dwelling.

The last subquestion showed the allocation of subsidies showed results in line with what was expected. Although the NWF seemed better targeted, it is underused due to complexity, lack of information or awareness, trust issues and loan aversion of low-income households. The fact that it is stimulated to take on the loan and pay it back with the ISDE that is granted afterwards, reflects the procedural complexity, especially for illiterate individuals or not digitally clever.

According to the interviewees, the low-income household group is hard to reach, due to the trust issues and a lack of insights into current EPCs of dwellings. The information spread is necessary for this group, as well as unburdening, so that renovation and subsidy procedures are approached in an integrated manner, using the expertise of real estate professionals involved. Subsidies could be a policy lever, that if used efficiently, could close the gap in access to energy efficiency in housing. However, to grant the subsidies efficiently, recent EPCs are needed to target the worst-labelled dwellings. These subsidies should than also be pre-financed and applied for in a one-stop-shop process, unburdening the homeowners even more. Currently, there is little to no incentive to renew the EPC for a homeowner, when there is no intention of selling the dwelling. Directions to incentivise this are presented in the next section, however, it should be noted that the hard-to-reach income group, is also hard to inform and convince about these incentives.

6.2. Policy Directions

As shown in the overview of the qualitative results, there are several policy directions, to improve subsidy efficiency and indirectly reducing energy costs and increasing wealth growth.

The problem of little to no incentive to renew the EPC to target subsidies more efficiently, report on portfolios and assess risk more accurately and to ensure the right mortgage capacity is used, can be solved in multiple ways. First, the EPCs could be linked to when a subsidy is granted. However, this would cost municipalities or governments a lot of money extra relative to the subsidy amount, as well as it would if it were on the homeowners' own costs. Another way for the municipality to incentivise homeowners is to place the owners in a lower tax scale, giving a financial incentive. This costs the municipality financial resources, furthermore, the effects of a higher WOZ-value and therefore higher taxes is relatively small, so this measure could be not in proportion to the extra tax.

Mortgage lenders and banks can also incentivise homeowners by lowering interest rates or giving other financial incentives, when an EPC is renewed and a "label jump" is made. This would cost the banks financial resources, but these could be neutralised by the gain in better EPCs in the portfolio, lowering risks.

Another way is to renew outdated EPCs, when a renovation took place after the registration date of the EPC, before a transaction, on the costs of the homebuyer. This ensures that the homebuyer is given the right information about the mortgage capacity, and the costs are relatively small on a total transaction for a dwelling. The mortgage lender would benefit as well, since the portfolio is updated for every new mortgage, if in the past a label jump is made.

Low-income households struggle to cover upfront costs, withholding this group from using the ISDE, and are loan averse, therefore hesitant to taking on the NWF loan. To overcome this there should be a subsidy, without BKR registration that is provided upfront based on a quotation and controlled retroactively through invoices. Amounts of subsidy can be like the ISDE, preventing extra costs for the government. The subsidy can be granted "upfront" by discounting the subsidy on the invoice of the installer. However, this still has the issue of a complex process, that could withhold these households from using the subsidy scheme.

However, to prevent "free riders", this subsidy could also be targeted only towards households living in energy poverty. Making two or more energy-efficient measures obligatory like it was a few years ago, could indeed improve the amount of energy improvements taken, but could also frighten low-income households needing to invest more than is needed for just one measure. It could be that it should be obligatory for the existing ISDE, to prevent "free riders", and that it is not a requirement for the upfront subsidy.

In line with this change in subsidy lowering the interest rate on VvE's NWF loans, to ensure that also households living in apartment can benefit from energy-efficient renovations could be a direction for policy change. For the households that are not able to cover extra service costs due to the renovation, there should be a safety net provided by the government.

When improving subsidy or loan schemes, it is good to keep in mind that it is still the responsibility of the homeowner or buyer to act. There could be such great incentives and efficient information spread, but there is still the dependency on the individuals or VvE's to decide to take energy-efficient measures and to make use of the financial options.

If nothing is changed to the policies, low-income households stay behind in the access to energy-efficiency in housing, diverging the gap in the owner-occupied housing market, exacerbating affordability issues. Furthermore, if homeowners are not incentivised to renew the EPC, municipalities, mortgage lenders and banks remain facing challenges due to outdated EPCs, keeping the circle of less efficient subsidy targeting alive.

The directions of policy reform are all about incentivising, informing and integrating. Not all as separate directions, but together as a whole. Incentivising leads to more targeted information spread and supports an integrated process, making the hard-to-reach households not only more visible but also more able to participate in the energy transition. These three I's have a lot of potential to improve equitable access to energy efficiency in housing.

6.3. Limitations

This section shows the limitations of the research, and how these are mitigated. The research adds to the existing body of literature on equitable access to energy efficiency in the housing market. By using EPCs as a proxy, earlier findings regarding price effects and time on the market are confirmed. Furthermore, by combining the three pillars of energy costs, wealth growth and access to subsidies, a new perspective is created to look at the energy transition and policies influencing social equity.

However, it is important to note that this research is based on several assumptions and focuses only on these three dimensions of social equity. Social equity in housing is broader than energy costs, wealth growth and access to subsidies. Market conditions (over the years as well as per region) and buyers' motives are not taken into account for this research. Furthermore, regional policies and the height of energy savings per label jump are not considered.
In terms of methodology, the effects over time could have been interesting, to see whether sustainability became more prominent in recent years, possibly influencing the equitable access to energy efficiency more and more. Missing EPCs were estimated based on the construction year, which could be misleading, as renovations and other variables influencing the energy efficiency of a dwelling are not considered. In 2015, when EPCs became mandatory for selling a dwelling, the construction year was also used together with dwelling type and gross floor area to determine the EPC. This research uses the construction year of known EPCs to predict the missing values, which is possibly more accurate than the original methodology in 2015.

Due to high price premiums, but weak effects, it is very likely that other factors influence pricing more than the EPC, like a recent renovation with a new kitchen or bathroom. This is also a limitation of the datasets, since not all variables that are influencing price are measurable or in the dataset, as well as that this research focused no creating an overview of the Dutch owner-occupied housing market, while this market strongly varies across regions. Since only recently moved households are examined, it is possible that the patterns do not reflect the current EPCs of households. Buying a dwelling is a "natural moment" to renovate, therefore has a high chance of becoming more energy-efficient after the transaction. By only examining the EPC before the transaction, this possibility is not considered.

As for the datasets, the WoON 2021 is self-reported, this may have led to reporting errors and misclassification of housing characteristics. It is also not the most recent version, although it is expected that the new version shows the same patterns. Using income as a variable to see the relation with EPCs also ignored already existing wealth or informal financial support. However, using only recently moved households, part of this limitation is mitigated. In the NVM transaction dataset, only the transaction that could be coupled with an EPC, registered before the transaction date, were used. This led to a decrease in cases, possibly biasing the data. The energy costs are also assumed based on the income categories and related EPC, this is not the most accurate, but given the available data and the size of the datasets the general patterns are sufficient for this research.

For the qualitative part, only one municipality was interviewed, limiting generalisability of local policy insights, since municipalities can vary in policies a lot. This is partly mitigated by also interviewing the RVO and asking whether municipalities vary in policies targeting households for NIP subsidies. However, given this mitigation, the findings still reflect a limited municipal perspective. While different experts are interviewed, also on the experiences with practice, partly giving insights into how homeowners perceive subsidy policies, no homeowners were interviewed. This did not fit the scope of this research, neither would it have given extra useful insights for this research, since it is about creating an overview of the current market state and policies influencing this.

Despite these limitations, the combination of quantitative data analyses with qualitative interviews provides new findings for understanding equity implications in the Dutch housing market. The mixed-methods approach strengthens the credibility of the results by enabling triangulation, thereby cross-verifying insights from different types of data.

6.4. Suggestions for Further Research

Now that this research has provided an overview of the current state of equitable access to energy efficiency in the Dutch housing market, suggestions to build upon this research are presented.

One of the main barriers shown are the upfront investment costs, lack of information and awareness, and the tendency of households to wait for a natural moment to renovate form barriers to improving energy efficiency. Future research into these subjects could give insights that can start the debate on how to create more awareness about sustainability and lower thresholds to invest in energy-efficiency. Researching renovation behaviour after purchase aligns with these suggestions as well, creating insights into whether indeed energy-efficiency is often improved after transaction. This could also lead to involvement of homeowners.

These suggestions could also be interesting if examined per region, reflecting varying market conditions and policies. This can be done by researching local price effects per EPC or using the WoON for examining demographic and socio-economic effects per region. Policies across municipalities can also give insights into different approaches, varying from active to more passive. Further examining whether the policy directions in this research are feasible could lead to concrete policies improving efficiency of subsidy allocation. The role and integration of different stakeholders in these policies as well as stakeholder's dependency on updated EPCs could also be further investigated, to align interests and come up with integrated solutions unburdening homeowners and ensuring equitable access to energy efficiency in housing.

CHAPTER 7

CONCLUSION

7. CONCLUSION

This thesis examined the influence of demographic and socio-economic status on the equitable access to energy efficiency in housing. Using a mixed-method approach, both quantitative data analysis and qualitative interview were used to measure the influence in terms of energy costs relative to income, wealth growth and access to subsidies. But first an overview had to be made reflecting the current state of the Dutch housing market, relating demographic and socio-economic statuses to EPCs. In this way, the results per EPC could be connected to certain household characteristics like income. Based on all quantitative findings, the interviews gave insights into the validity of the results as well as the barriers for households to renovate and renew EPCs, and directions for policy reforms. By combining the results, the main research question can be answered, which will be presented in this chapter.

7.1. Demographic and Socio-Economic Status and EPCs

The first subquestion was needed to let the other findings make sense. An overview of demographic and socio-economic backgrounds across EPCs was necessary, to conclude something about the social equity pillars of this research. The variables examined are income, education, age, and household size, for recently moved households stemming from the WoON 2021. The subquestion is as follows:

How are demographic and socio-economic characteristics distributed across EPC categories in the Dutch owner-occupied market?

The results showed clear signs of no equitable access to energy-efficient EPCs. Low-income households, single-person households, and young households showed significant lower access to better EPCs in the cross-tabulations. Low-educated households showed overrepresentations for the best labelled dwellings. This could be explained by the factor of wealth growth, since a large portion of this low-educated population is of older age, therefore enabled to profit from long-term wealth growth.

The regression confirmed these findings, although age was not a strong predictor anymore, implying that once controlled for the other variables the effect of age diminishes. Income is the strongest indicator, predicting the probability of residing in an energy-efficient dwelling.

The residential mobility reflected unequal access to energy efficient dwellings too, as movers from A-B to A-B showed the highest overrepresentation. The cross-tabulation showed a clear pattern from E-G as current and previous to A-B as current and previous. As current E-G owners only showed an overrepresentation for having owned an E-G dwelling previously, together with an underrepresentation for A-B owners for having owned an E-G dwelling previously reflects a threshold entering better labelled dwellings. However, once into the better labelled dwellings market, it seems to be easier to remain there, reflected by the high overrepresentation of current A-B owners for previously having owned an A-B rated dwelling.

Demographic and socio-economic characteristics are distributed across EPC categories on the Dutch owner-occupied market in a way where the best EPC-rated dwellings are often occupied by households that are older, or with higher incomes, or larger household sizes, or those who have previously owned an A-B rated dwelling. Low-income, single-person, and younger households are more often found in worse-rated dwellings, reflecting the inequality in access. The findings demonstrate that access to energy-efficient dwellings is not evenly distributed.

7.2. Energy Costs Relative to Income

This subquestion examined the financial burden of energy costs for different income groups and how this is connected to the EPC distribution identified in the first subquestion. Using the ISDE and NWF 2023 monitor, gas and electricity consumption per income category was examined, to answer the second subquestion:

How do energy costs relative to income vary across income groups in the Dutch owner-occupied housing market?

The results showed a clear pattern, while lower-income households are not the largest energy (gas and electricity) consumers in absolute terms, this group spends a significantly larger portion of income on energy compared to higher-income households. Although the EPCs connected to the income groups would indicate otherwise, the income categories with the most energy-efficient dwellings showed the highest absolute energy consumption. This may be due to larger homes or other energy consuming housing characteristics or behaviour. Still, energy costs relative to income vary greatly, burdening lower-income households with disproportionately high expenses, while higher-income groups consume more but spend a smaller share of their income on energy.

7.3. Wealth Growth

For this subquestion, price effects and time on the market per EPCs are examined to measure equal wealth growth benefits. These market effects are linked back to the socio-economic distribution to determine whether specific groups benefit disproportionately from housing wealth accumulation.

How do price and time on the market effects of EPCs in the Dutch owner-occupied housing market affect equitable wealth growth?

The results showed that better EPC-rated dwellings sell faster and at significantly higher prices, even when controlling for size, urbanisation, and typology. The price effects show a discount for G of 17.1% compared to A. EPCs C and D are close to that with discounts of 16.6% and 17.4% (largest discount) respectively. Even label B shows a 9.8% lower transaction price. Surprisingly, EPCs E and F perform slightly better than expected, with discounts of 14.6% and 13.7%. Although these findings are significant, the results were weak, reflecting other specifications being more of influence of transaction price, like a favourable kitchen or bathroom.

The price effects over time reveal another effect influencing wealth growth. EPC A showed the highest growth in price both percentagewise as absolute. So, not only at the time if sale are their disparities in price per EPC, but also in appreciation. This affects the wealth growth over time, leaving households residing in bad labelled dwellings behind compared to the households residing in better labelled dwellings. This divide is not primarily getting bigger based on percentages, but due to absolute gains, where EPC A gained almost €236,500, whereas E only gained €153,300.

Connecting this back to earlier conclusions the disparities become even clearer, groups with the least access to A-B dwellings, are also the households missing out on capital gains associated with energy efficiency. Moreover, shorter sale times for better rated EPCs increase competition among buyers, making it even harder to access energy-efficient dwellings with limited financial resources. Lower-income households are less able to act quickly or offer competitive bids, creating unequal access to energy-efficient dwellings. The price premiums and liquidity advantages of better-labelled dwellings benefit those already in a stronger financial position, while disadvantaged groups face barriers to compete in this housing market segment with energy-efficient dwellings.

7.4. Access to Subsidies

The last subquestion combines quantitative data analysis based on the ISDE/ NWF 2023 monitor with qualitative interviews. It investigates whether subsidies for energy-efficient measures are efficiently reaching the households that need these the most. The monitor is used to examine uptake and set the context for the targeting, while targeting and overcoming barriers were discussed during the interviews to give a combined answer to the question:

How efficient are current subsidy schemes (ISDE/ NWF) in terms of uptake, targeting and overcoming barriers?

The results based on the monitor showed that subsidy usage is not evenly distributed for both ISDE and NWF. Households with higher income are more likely to apply for ISDE, while households with lower incomes often lack the resources, time, or procedural understanding to apply. Interviewees confirmed that the complexity of the application process, lack of awareness and the need for upfront investments create barriers for households that could benefit the most from the financial instruments. As a result, higher-income households make more use of the ISDE, and while the NWF shows a higher uptake for lower-income households, the uptake is far too low to really make a difference. This leads to lower-income households staying behind, while higher-income households benefit from lower energy costs and more wealth growth due to the energy-efficient measures.

Interviewees also stated a mismatch between interest of municipalities and mortgage lenders or bank and homeowners. Currently homeowners are not incentivised to renew EPCs, while municipalities and mortgage lenders are dependent on renewed EPCs for targeted subsidy allocation, reporting about the real estate portfolio and accurate risk assessment.

To overcome these barriers, synthesising the qualitative results, several directions for policy reforms are created following the logic of incentivise, inform, and integrate. Incentivising EPC renewal is needed to ensure effective subsidy targeting, granting right mortgage capacity, improve sustainability reporting and risk assessment. To inform low-income households, outreach should leverage the borrowed trust of familiar community actors, like healthcare provider, sports clubs, or community centres, to overcome distrust in the government and increase awareness. To integrate efforts and lower practical barriers, upfront subsidies should be made to remove the need for pre-financing, and the application process should be simplified and centralised. This will reduce fragmentation and the administrative burden, ensuring more equitable access to energy-efficiency.

The current subsidy schemes, although intended well, do benefit higher-income households disproportionately, reflecting unequitable access to subsidies. Targeting can be more efficient, since currently municipalities act on outdated EPCs. This results in a larger gap between households renovating using subsidy, reducing energy costs, and improving wealth growth and those not able to renovate. However, even with better targeted subsidies, and more equitable access, it is still the responsibility of the individuals to make use of this equitable access to create a more balanced situation on the Dutch owner-occupied housing market.

7.5. Demographic/ Socio-Economic Status and Access to Energy Efficiency in Housing

With all the subquestions answered, the main research question can be answered, bringing together all results to assess how the demographic and socio-economic status influences access to energy-efficiency, thereby answering the question:

How does demographic and socio-economic status influence the access to energy efficiency in the Dutch owner-occupied housing market in terms of energy costs, wealth growth and access to subsidies?

The results consistently showed that households with lower incomes, smaller household sizes, and younger ages are disadvantaged in accessing energy efficient dwellings. These groups are more likely to reside in worse EPC-rated dwellings, face higher relative energy costs, and miss out on the wealth growth associated with price premiums. At the same time, higher-income households or wealthier households are better positioned to benefit from subsidies, leading to reduced energy costs and more wealth growth, diverging the equitable access to energy efficiency gap. So, the demographic and socio-economic status heavily influences access to energy efficiency in the Dutch owner-occupied market, creating a divide between households benefitting from higher access to subsidies and all related benefits, and households with lower access, staying behind with high energy costs relative to income and reduced wealth growth.

However, the findings also point out policy directions for change. To create more equitable access to energy efficiency in housing, incentivising EPC renewal is the first step. In this way, households that need help the most can be targeted more easily, especially when parallel to the targeting from the municipality, borrowed trust is used to reach the unreachable for the municipality due to distrust. Subsidy policies must actively lower the financial and procedural thresholds withholding these households from participating, through providing upfront subsides and ensuring an easy and integrated application process.

NL: "Echt ontzorgen, vereenvoudigen zijn de sleutelwoorden."
— Vereniging Eigen Huis —

EN: "Truly unburdening and simplifying, that's the key."
— Vereniging Eigen Huis —

This quote captures what is urgently needed, unburdening and simplifying. It is now the responsibility of the government, municipalities, real estate brokers, mortgage advisors, lenders and even installers to align their efforts and ensure equitable access to energy efficiency in housing.

Equitable access to energy efficiency starts with equitable access to subsidies. Therefore, recognising that not all households begin from the same financial or informational position is important. Those who need subsidies the most, are currently the least likely to benefit from them. Yet subsidies are a catalyst to enable energy-efficient renovation, which in turn reduce energy costs and increase wealth growth. True equity therefore requires proactive, targeted support to ensure that these benefits are not limited to those who already have the means to access them.

To work towards a more equitable access to energy efficiency in housing, the focus should be on the three I's, incentivising, informing and integrating.

CHAPTER 8

BIBLIOGRAPHY

8. BIBLIOGRAPHY

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CHAPTER 9

APPENDIX

9. APPENDIX

A. Search Query

EPC
("Energy Performance Certificates" OR "EPC" OR "Energy labelling" OR "Energy ratings for homes")

Time frame: 2015-2024
Subject areas: Engineering & Environmental Science
Keyword: Buildings
Country/ territory: EU, focus on more Netherlands
Sources: (Chegut et al., 2016b; Economidou et al., 2020; Visscher et al., 2016)

EPC and housing market dynamics
(("Energy Performance Certificates" OR "EPC" OR "Energy labelling" OR "Energy efficiency certificates") AND ("Housing market dynamics" OR "Market liquidity" OR "Time on market" OR "Real estate transactions" OR "Property value trends" OR "Regional housing market segmentation"))

Time frame: 2015-2024
Subject areas: Engineering & Environmental Science
Keywords: Housing, Residential Building, Residential Sectors, Building, Policy Recommendations, Policy Making, Policy Implementation, Low Income Population, Europe, Energy Efficiency, Energy Poverty
Country/ territory: EU
Sources: (Aydin et al., 2019; Fregonara & Rubino, 2021; Fuerst et al., 2016)

Social inequality and housing market dynamics
(("Social inequality" OR "Energy poverty" OR "Income inequality" OR "Housing affordability" OR "Economic disparities" OR "Access to energy efficiency improvements") AND ("Housing market dynamics" OR "Market liquidity" OR "Time on market" OR "Real estate transactions" OR "Property value trends" OR "Regional housing market segmentation"))

Time frame: 2015-2024
Subject areas: Engineering & Environmental Science
Keywords: Housing, Residential Building, Residential Sectors, Building, Policy Recommendations, Policy Making, Policy Implementation, Low Income Population, Europe, Energy Efficiency, Energy Poverty
Country/ territory: EU
Sources: (Hochstenbach & Aalbers, 2024)

Social inequality and policies

(("Social inequality" OR "Energy poverty" OR "Income inequality" OR "Housing affordability" OR "Economic disparities" OR "Access to energy efficiency improvements") AND ("Sustainability subsidies" OR "Government incentives for retrofitting" OR "Green energy subsidies" OR "Energy efficiency programs" OR "Public funding for sustainable housing"))

Time frame: 2015-2024
Subject areas: Engineering & Environmental Science
Keywords: Housing, Residential Building, Residential Sectors, Building, Policy Recommendations, Policy Making, Policy Implementation, Low Income Population, Europe, Energy Efficiency, Energy Poverty
Country/ territory: EU
Sources: (Bertoldi et al., 2021)

Theoretical Frameworks and EPC

(("Behavioural economics") AND ("Energy Performance Certificates" OR "EPC" OR "Energy labelling" OR "Building energy efficiency"))

Time frame: 2015-2024
Subject areas: Engineering & Environmental Science
Country/ territory: EU
Sources: (Ebrahimigharehbaghi et al., 2019)

B. Interview protocol

Preparatory Steps
To ensure smooth and effective interviews, the following logistical aspects are arranged:

- Selection of Interviewee: Participants are selected based on their expertise related to the housing market, sustainability policy, subsidies, financing, or buyer behaviour.
- Duration and Planning: Interviews are scheduled for 30-45 minutes, allowing in-depth discussion with built-in flexibility.
- Location: Interviews take place in a quiet, distraction-free setting, either in person or via a secure online platform (e.g., Microsoft Teams).
- Materials Prepared:
    - Informed consent form for recording and data usage.
    - Reliable recording device and note-taking materials.
    - Interview guide tailored to the interviewee's area of expertise.
    - TNO, RVO, Municipality about subsidy allocation
    - Nibud and Vereniging Eigen Huis about financing options
    - Real estate brokers about buyers decision-making
    - Interviews are conducted in Dutch, for better mutual understanding.

Introduction (Opening Script)
"Dank u wel voor de deelname aan mijn onderzoek via dit interview. Eerst wat over mijzelf, Dylan Schroevers, master student aan de TU Delft, waarbij ik de master Management in the Built Environment volg. Dit interview is onderdeel van mijn onderzoek naar de relatie tussen demografische en socio-economische achtergrond en toegang tot duurzaamheid in huisvesting binnen de koopwoningmarkt.

This is a semi-structured interview, meaning I have a set of guiding questions, but please feel free to elaborate wherever you feel it is important. I may also ask follow-up questions to explore certain topics more deeply."

Consent Request:
"Voordat we beginnen, mag ik bevestigen dat u akkoord gaat met wat er in het informed consent formulier staat en dus akkoord bent met de opname van dit interview? De opnames worden gebruikt voor analyse en blijven vertrouwelijk."

Interview Questions (Thematic Sections)
A. Background and Role

- Could you briefly introduce yourself and explain your role within [organisation]?
- How are you involved with policies or practices related to energy labels, housing finance, or sustainability?

B. Policy and Incentives

- What are the main policy goals behind tools such as the 106% mortgage rule, ISDE subsidies, or the Heat Fund?
- How do you assess the effectiveness of such instruments in encouraging home sustainability?

- Are certain demographic or income groups underrepresented among those making use of these tools?

C. Buyer Behavior and Energy Labels

- To what extent do buyers consider EPC ratings when making a purchase decision?
- Are there certain buyer segments (e.g., first-time buyers, investors) that are more sensitive to energy performance?
- Have you observed any price or time-on-market differences between homes with different EPC ratings?

D. Equity and Accessibility

- Research shows that lower-income households often live in homes with poorer energy labels. Do you recognise this pattern?
- What are the barriers these households face in accessing subsidies or loans for sustainability improvements?
- How could access to sustainable housing be improved for lower-income groups?

E. Subsidy Use and Implementation

- Are there clear trends in the uptake of subsidies like ISDE or local programs such as the National Insulation Programme (NIP)?
- How are eligible homeowners informed about these opportunities?
- Are there challenges in implementation or communication that could be addressed?

F. Future Developments and Recommendations

- What adjustments in policy or financing would you recommend to better align sustainability and social equity goals?
- Do you foresee energy performance playing an even greater role in the housing market in the future?
- What role should organisations like [RVO, municipalities, Nibud, brokers] play in supporting this transition?

<u>Transitions Between Sections</u>
Transitions between topics are made smooth using brief summaries and clear segues. For example:

"Bedankt voor de relevante nieuwe inzichten over [onderwerp X], interessant om te zien dat u X op deze manier ervaart, wat anders is [of in lijn] is met mijn resultaten. Ik zou graag over willen gaan naar [onderwerp Y], om te zien of dat ook nieuwe inzichten op kan leveren. "

Closing the Interview
"Bedankt voor uw tijd en moeite om aan dit interview en het onderzoek bij te dragen. Ik heb al mijn vragen gesteld die ik wilde stellen, zijn er bij u nog dingen te binnen geschoten gedurende het interview die u graag zou willen bespreken?"

Next steps:
"Ik zal het interview hierna transcriberen, de transcriptie zal ik toesturen zodat u hier nog op- of aanmerkingen op kunt maken. Daarna gebruik ik de transcripties om te analyseren en quotes te gebruiken om resultaten verder te ondersteunen. Als u het interessant vindt, kan ik de resultaten met u delen zodra de scriptie is afgerond."

Final thanks:
"Nogmaals bedankt en we houden contact!"

Post-Interview Procedures

- Supplement notes immediately.
- Save and secure the audio recording.
- Transcribe and anonymise the interview.
- Share transcription with interviewee for feedback.
- Compare results with other interviews and quantitative results.
- Provide results to the participant if requested.

C. Signed informed consent forms

(As signed by all participants)

Opening Statement

You are being invited to participate in a research study titled "Balancing Energy Efficiency and Social Equity." This study is being conducted by Dylan Schroevers from TU Delft and an intern at Fakton Consultancy.

The purpose of this research study is to analyse the effects of energy labels on social equity through quantitative data and to validate these findings with practical experiences. The study will take approximately 30 minutes to complete. Your input will help contextualise the quantitative research findings, ensuring they align with real-world experiences. During the study, we will ask you to discuss the results, compare them to your professional or personal insights, and explore potential solutions if discrepancies arise.

As with any online activity, the risk of a data breach is always possible. We will minimise risks by ensuring that all collected data will be fully anonymised. Responses will be stored securely on TU Delft's research servers and will only be accessible to the research team. The anonymised data will be used exclusively for academic purposes and will not be shared with third parties outside the research team.

Open Data Policy: The anonymised results of this study may be made available in an open-access repository to promote transparency and further academic research. However, no individual responses will be identifiable in any published dataset.

Your participation in this study is entirely voluntary, and you may withdraw at any time. You are also free to skip any questions you prefer not to answer. Since the data collection is fully anonymised, once you submit your responses, they cannot be traced back to you or removed.

For any questions regarding this research, please contact:
Dylan Schroevers
TU Delft | Fakton Consultancy
Email: **[e-mail]**

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [*DD/MM/YYYY*], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves a one-on-one interview that will be audio-recorded and later transcribed into text. These transcripts will be anonymized, and the original recordings will be deleted after transcription.	☐	☐
5. I understand that the study will end in June 2025.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study involves minimal risks related to sharing professional or personal experiences about housing market dynamics and energy labels. These risks will be mitigated by anonymizing responses and securing the data.	☐	☐
7. I understand that this study will collect personally identifiable information (PII), including my name, professional background, and role in the housing sector. However, all identifying information will be removed before analysis and publication to protect my privacy.	☐	☐
8. I understand that my data will be protected through the following measures: anonymisation of responses, secure storage with access limited to the research team on the TU Delft OneDrive, and destruction of identifiable data after the study ends.	☐	☐
9. I understand that personal information collected about me, such as my name and professional details, will not be shared beyond the study team.	☐	☐
10. I understand that the (identifiable) personal data I provide will be destroyed when the study ends.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
11. I understand that after the research study, the de-identified information I provide will be used for the publication of the graduation thesis. The study findings may also inform policy discussions on energy efficiency and social equity.	☐	☐
12. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
13. I give permission for the de-identified transcripts of my interview to be archived in TU Delft's secure research repository so they can be used for future research and learning.	☐	☐
14. I understand that access to this repository will be restricted to academic researchers and will not be open to the public.	☐	☐

Signatures

________________________________ ______________________ _______________
Name of participant [printed] Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Dylan Schroevers 05-03-2025

_____________________________ ______________________ __________
Name of researcher Signature Date

Study contact details for further information:

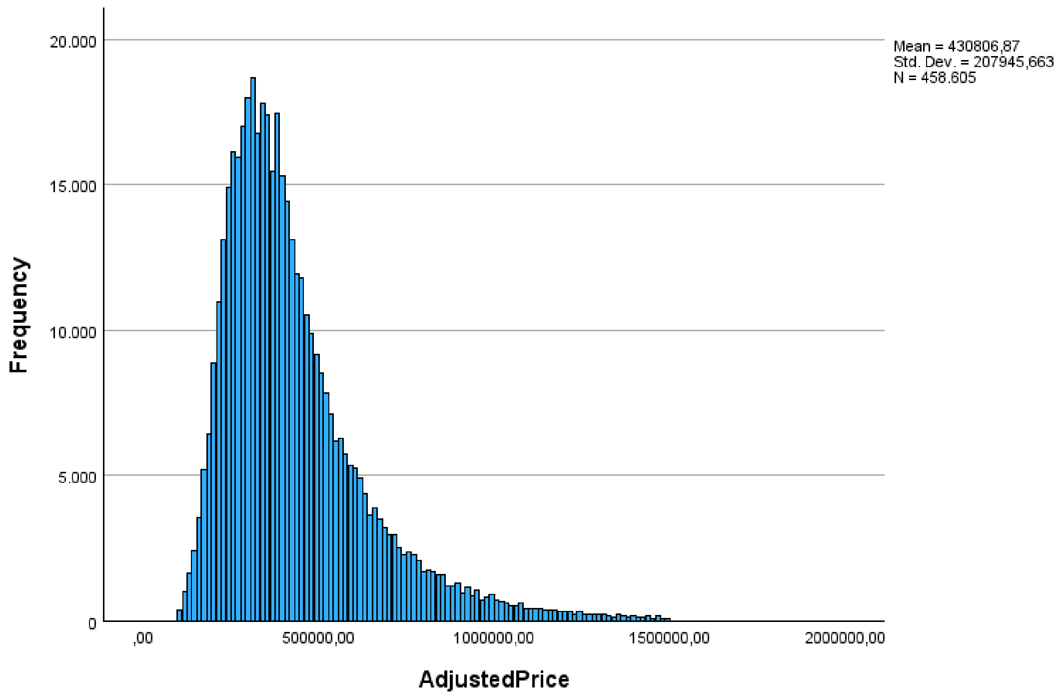
Dylan Schroevers

D. Histograms after filtering

Graph

Notes

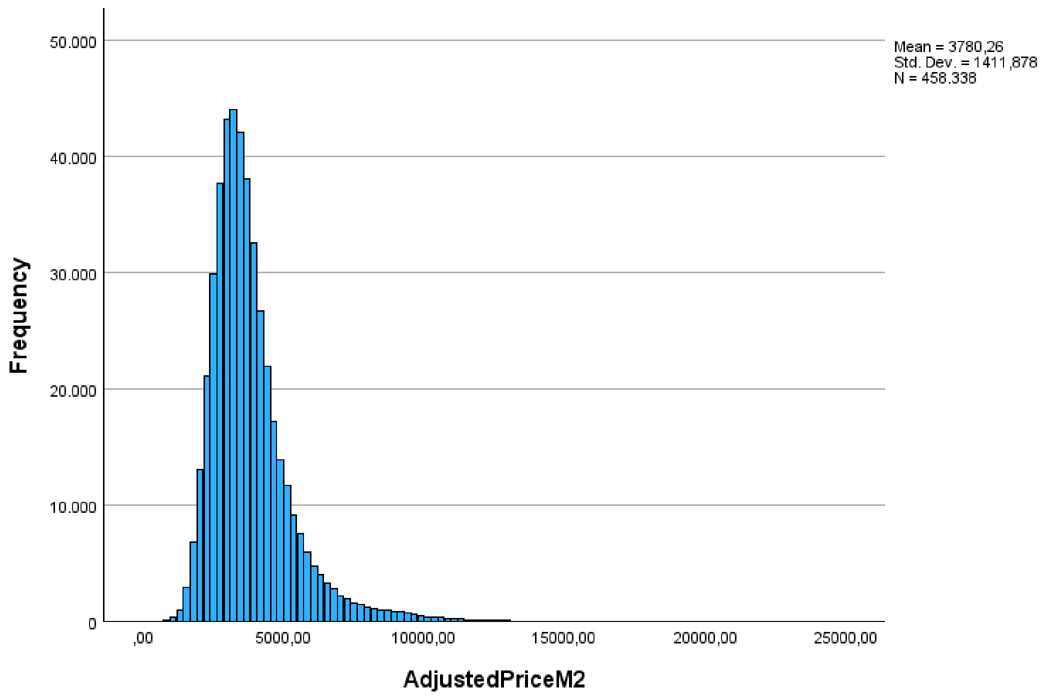
Output Created		06-MAY-2025 10:21:57
Comments		
Input	Data	C:\Users\Dylan Schroevers\OneDrive - Delft University of Technology\00 Graduation Laboratory\Aangeleverde data\NVM alle gelinkte cases.sav
	Active Dataset	DataSet1
	Filter	VOLLEDIG FILTER (alle voorwaarden)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	458605
Syntax		GRAPH /HISTOGRAM=AdjustedPrice.
Resources	Processor Time	00:00:09,09
	Elapsed Time	00:00:03,46



Graph

Notes

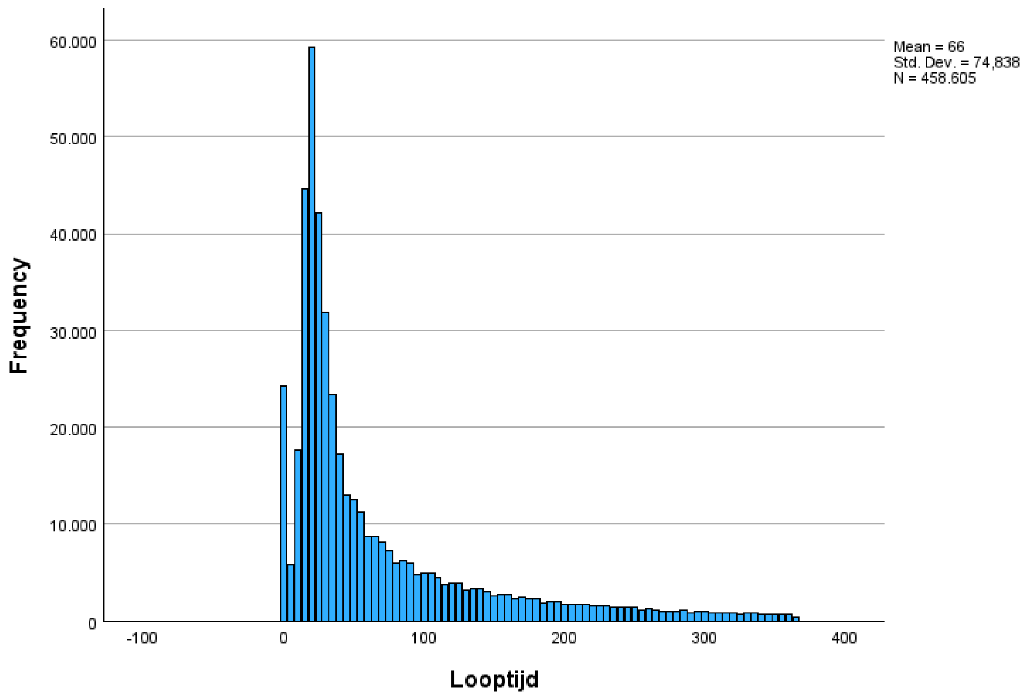
Output Created		06-MAY-2025 10:22:01
Comments		
Input	Data	C:\Users\Dylan Schroevers\OneDrive - Delft University of Technology\00 Graduation Laboratory\Aangeleverde data\NVM alle gelinkte cases.sav
	Active Dataset	DataSet1
	Filter	VOLLEDIG FILTER (alle voorwaarden)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	458605
Syntax		GRAPH /HISTOGRAM=AdjustedPriceM2.
Resources	Processor Time	00:00:06,86
	Elapsed Time	00:00:06,67



Graph

Notes

Output Created		06-MAY-2025 10:22:07
Comments		
Input	Data	C:\Users\Dylan Schroevers\OneDrive - Delft University of Technology\00 Graduation Laboratory\Aangeleverde data\NVM alle gelinkte cases.sav
	Active Dataset	DataSet1
	Filter	VOLLEDIG FILTER (alle voorwaarden)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	458605
Syntax		GRAPH /HISTOGRAM=Looptijd.
Resources	Processor Time	00:00:02,22
	Elapsed Time	00:00:01,74



E. Data Management Plan

A Data Management Plan created using DMPonline

Title: Graduation thesis: Assessing the Effectiveness of Government Subsidies on Sustainability in the Dutch Housing Market

Creator: Dylan Schroevers

Principal Investigator: Dylan Schroevers

Affiliation: Delft University of Technology

Template: TU Delft Data Management Plan template (2021)

Project abstract:
Abstract DMP related:

Research is about the impact of Energy Performance Certificates on market dynamics (price and time on market), with quantitative analysis based on databases of NVM, WoOn 2021, RVO and graduation organisation (Fakton). With data of the WoOn 2021 on demographics it is tried to investigate whether there is a segmentation in the Dutch owner-occupied housing market based on EPCs/ energy labels. Then the allocation of subsidies is examined to see whether these influences this segmentation or not with data of RVO/NVM/WoOn. The last step is to look at policies and create policy recommendations which are discussed with an expert panel with relevant actors in the real estate sector and policymakers.

ID: 165086

Start date: 10-02-2025

End date: 30-06-2025

Last modified: 22-01-2025

Graduation thesis: Assessing the Effectiveness of Government Subsidies on Sustainability in the Dutch Housing Market

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

The data and DMP for this project have been discussed with my supervisor, Harry Boumeester. My faculty Data Steward, Janine Strandberg, reviewed this DMP on 13-01-2025.

2. Date of consultation with support staff.

13-01-2025

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
NVM database regarding anonymous transactions, data used: specifications of dwelling, transaction price, time on the market and energy label (EPC)	.csv	Accessible via TU Delft, dataset of NVM, non-public, made available by data delivery agreement between Brainbay and TU Delft	To understand EPC effect on price and time on markets	TU Delft OneDrive	Master student, Dylan Schroevers and supervisor, Harry Boumeester
WoOn 2021 database regarding anonymous survey data, data used: specifications of dwelling, demographic	.csv	Accessible with institutional account (TU Delft) via DANS.	To segment the market based on demographics and energy labels	TU Delft OneDrive	Same as above

information like income and education level and energy label (EPC)					
RVO database regarding distribution of ISDE (Investerings subsidie duurzame energie) subsidy	.xlsx	Publicly available	To examine the effectiveness of sustainability subsidies, testing whether this influences the market segmentation	TU Delft OneDrive	Same as above
Fakton (graduation organisation) database regarding information of energy labels on postal code level and typology of dwellings.	.xlsx	Re-used data of dataset of graduation organisation, original source is RVO database, accessed via EP-online by Fakton.	Linkage of information with transaction data of NVM, to examine price effects of EPCs.	TU Delft OneDrive	Same as above
Personally Identifiable Information (PII): participants' name, email, work address, company name, mobile number	.pdf, .xlsx	Contact information for participants taking part in interviews or expert panel, received from professional network. Informed consent forms are signed digitally and contain participants' name + email.	For administrative purposes: obtaining informed consent and communicating with participants	SURF drive	Same as above
Audio-recordings of	.mp3	Expert panel with	Capturing the opinions on	External recording	Same as above

expert panel with policymakers and real estate experts		policymakers and real estate experts conducted on-site. Audio-recordings are made on an external device, before being moved to OneDrive. Recordings are deleted after transcription	current policies and creating new policy recommendations/ reacting to policy recommendations	device (temporary storage) + SURF drive	
Anonymous transcriptions of expert panel	.txt	Anonymous transcriptions created manually based on audio-recordings. Participants are asked to review the transcriptions of their interview before the transcript is finalised	Privacy-preserving data on opinions on policies and policy recommendations	TU Delft OneDrive	Same as above
Atlas.ti dataset	Atlas.ti project bundle	Transcriptions will be coded using Atlas.ti	Capturing opinions on policies and policy recommendation, capturing sentiments and examining arising themes	TU Delft OneDrive	Same as above

4. How much data storage will you require during the project lifetime?

250 GB - 5 TB
NVM Dataset (transaction data)
RVO Datasets (Energy label and subsidy allocation)
WoOn Dataset (Demographics of households)

Expert panel recordings, transcriptions and Atlas.ti bundle

II. Documentation and data quality

5. What documentation will accompany data?

Other - explain below
Methodology of data collection
The dataset will not be shared in a data repository, but the methodology of data collection will be explained in the MSc thesis, which
is made available in the TU Delft Education repository.

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

SURFdrive
Another storage system - please explain below, including provided security measures
OneDrive
External recording device: Used as a temporary storage location for recorded on-site interviews. Interviews will be deleted from device as soon as they are moved to OneDrive.
Informed consent forms are stored on SURF drive, to prevent the risk of re-identification.

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

Yes
Researcher is aware of HREC approval, however, involvement of human subjects is the last phase of the research, and this qualitative part is depend on earlier findins.

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, first ask your Faculty Data Steward ***for advice. You can also check with the*** privacy website ***. If you would like to contact the privacy team: privacy-tud@tudelft.nl, please bring your DMP.***

Yes
The research data collected in the project will be anonymised, but processing of personal data is required for conducting the research project.
Third-party data from NVM and WoOn 2021 will be received already anonymised.

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward ***for advice.***

Yes, confidential data received from commercial, or other external partners
Dataset of NVM, is not open to public. NVM and WoOn data is accessed via the TU Delft (or institutional credentials for logging in), RVO dataset via a license of the graduation organisation on EP-online.

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager ***when answering this question. If this is not the case, you can use the example below.***

The student conducts the research independently, and is the owner of the qualitative research. The anonymised interviews underlying the graduation report will be included in the MSc thesis appendix, with the thesis being made publicly accessible in the TU Delft Education repository. Third-party data from NVM, WoOn and RVO is available under restricted access, and cannot be distributed without express permission from the rights holder.

10. Which personal data will you process? Tick all that apply

Data collected in Informed Consent form (names and email addresses)
Signed consent forms
Gender, date of birth and/or age
Email addresses and/or other addresses for digital communication
Telephone numbers
Names and addresses
Personally Identifiable Information (PII): interviewee name, work address, company name, email address, and mobile phone number are processed for administrative reasons (to obtain informed consent and communicate with participants).

Personally Identifiable Research Data (PIRD): Personal research data processed for interview participants:
Audio-recordings
Professional opinion on policy-making, energy markets, housing markets, statistics, real estate
Occupation: policy maker, real estate agent, employee of CBS/Municipality/Government/Energy market organisation
Years of experience: e.g., under 1, 1-4, 5-10, more than 10
Participant data for interviewees is anonymised when recordings are transcribed.

The re-used data from NVM, WoOn and RVO is received in anonymised form.

11. Please list the categories of data subjects

Interview participants are professionals on the topic of sustainability subsidies in the Netherlands.

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

No

15. What is the legal ground for personal data processing?

Informed consent
The HREC informed consent guide and template will be used to create the informed consent forms for the interviewees (template 2 in the HREC guide).

16. Please describe the informed consent procedure you will follow:

All interview participants will be asked for their written consent for taking part in the study and for data processing before the start of the interview. Interviewees will also be allowed to review the anonymous transcriptions from their interviews before they are finalised and used for analysis.

17. Where will you store the signed consent forms?

Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).
If two or more of the options listed below apply, you will have to complete the DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.
If you have any additional comments, please add them in the box below.

None of the above applies

22. What will happen with personal research data after the end of the research project?

Anonymised or aggregated data will be shared with others
Personal research data will be destroyed after the end of the research project
The anonymised research data consists of anonymised interview transcripts, and anonymised coded datasets.
These data will be used in the body of the thesis and included the appendix, but will not be shared in a data repository.
Audio-recordings of interviews are destroyed after completion of anonymised interview transcriptions. All other personal research data will be destroyed at the latest 1 month after the end of the project.
Third-party data from NVM and CBS is available under restricted access, and cannot be distributed without express permission from the
rights holder.

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

Not all non-personal data can be publicly shared - please explain below which data and why cannot be publicly shared
Datasets of NVM, WoOn and RVO are not publicly available.

29. How will you share research data (and code), including the one mentioned in question 22?

All anonymised or aggregated data, and/or all other non-personal data will be uploaded to 4TU.ResearchData with public access
Anonymised data collected during the project will be included in the body and appendix of the MSc thesis, made available in the TU Delft Educational repository.

30. How much of your data will be shared in a research data repository?

< 100 GB

31. When will the data (or code) be shared?

At the end of the research project
The thesis is made available in the TU Delft Education repository at the end of the graduation project. Research data are only shared within the thesis.

32. Under what licence will be the data/code released?

Other - Please explain
Research data are only shared within the MSc thesis, which is automatically placed under copyright in the Education repository.

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below
Internship with Fakton.

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

Thesis supervisor, Harry Boumeester of Management in the Built Environment [e-mail]

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

Research data are only shared within the MSc thesis: no additional resources are required.

F. HREC approval

Date 02-May-2025
Correspondence hrec@tudelft.nl

Human Research Ethics
Committee TU Delft
(http://hrec.tudelft.nl)

Visiting address
Jaffalaan 5 (building 31)
2628 BX Delft

Postal address
P.O. Box 5015 2600 GA Delft
The Netherlands

Ethics Approval Application: Balancing Energy Efficiency and Social Equity
Applicant: Schroevers, Dylan

Dear Dylan Schroevers,

It is a pleasure to inform you that your application mentioned above has been approved.

Thanks very much for your submission to the HREC which has been approved.

In addition to any specific conditions or notes, the HREC provides the following standard advice to all applicants:
• In light of recent tax changes, we advise that you confirm any proposed remuneration of research subjects with your faculty contract manager before going ahead.
• Please make sure when you carry out your research that you confirm contemporary covid protocols with your faculty HSE advisor, and that ongoing covid risks and precautions are flagged in the informed consent - with particular attention to this where there are physically vulnerable (eg: elderly or with underlying conditions) participants involved.
• Our default advice is not to publish transcripts or transcript summaries, but to retain these privately for specific purposes/checking; and if they are to be made public then only if fully anonymised and the transcript/summary itself approved by participants for specific purpose.
• Where there are collaborating (including funding) partners, appropriate formal agreements including clarity on responsibilities, including data ownership, responsibilities and access, should be in place and that relevant aspects of such agreements (such as access to raw or other data) are clear in the Informed Consent.

Good luck with your research!

Sincerely,

Dr. C. Shelley-Egan
Chair HREC
Faculty of Technology, Policy and Management

G. Frequencies WoON 2021

Frequencies of EPC, Income, Demographics, and Socio-economic Variables				
Variable	**Weighted cases**	**Percent**	**Unweighted cases**	**Percent**
EPC				
A-B	244,058	44.6%	1,297	45.1%
C-D	175,918	32.2%	916	32.3%
E-G	127,025	23.2%	643	22.7%
Total	**546,991**	**100%**	**2,838**	**100.0%**
Income				
<€50k	125,878	23.0%	599	21.1%
€50k -€75k	140,964	25.8%	737	26.0%
€75k -€100k	128,561	23.5%	692	24.4%
€100k -€125k	75,550	13.8%	391	13.8%
>€125k	76,037	13.9%	419	14.8%
Total	**546,991**	**100%**	**2,838**	**100.0%**
Household composition				
Single person	114,284	20.9%	520	18,3%
Multi-person without underage children	238,733	43.6%	1,357	47.8%
Multi-person with underage children	193,974	35.5%	961	33.9%
Total	**546,991**	**100.0%**	**2,838**	**100.0%**
Education				
Low	60,732	11.1%	309	10.9%
Mid	195,671	35.8%	984	34.7%
High	290,587	53.1%	1,545	54.4%
Total	**546,991**	**100.0%**	**2,838**	**100.0%**
Age				
<35 years	198,808	36.3%	987	34.8%
35-64 years	296,085	54.1%	1,514	53.3%
65>	52,098	9.5%	337	11.9%
Total	**546,991**	**100.0%**	**2,838**	**100.0%**

H. Ordinal regression

Unweighted

Case Processing Summary

		N	Marginal Percentage
EPC	E-G	643	22,7%
	C-D	916	32,3%
	A-B	1279	45,1%
Income	<€50.000	599	21,1%
	€50.000-€75.000	737	26,0%
	€75.000-€100.000	692	24,4%
	€100.000-€125.000	391	13,8%
	>€125.000	419	14,8%
Age	< 35 years	987	34,8%
	35 - 64 years	1514	53,3%
	> 65 years	337	11,9%
Household composition	Single person	520	18,3%
	Multi-person without underage children	1357	47,8%
	Multi-person with underage children	961	33,9%
Valid		2838	100,0%
Missing		0	
Total		2838	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	543,139			
Final	415,734	127,405	8	<,001

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	121,384	72	<,001
Deviance	118,621	72	<,001

Link function: Logit.

Pseudo R-Square

Cox and Snell	,044
Nagelkerke	,050
McFadden	,021

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Threshold	[EPC = 1,00]	-2,472	,172	205,554	1	<,001	-2,810	-2,134
	[EPC = 2,00]	-,996	,167	35,539	1	<,001	-1,323	-,668
Location	[Income=1]	-,379	,133	8,050	1	,005	-,640	-,117
	[Income=2]	-,260	,118	4,845	1	,028	-,492	-,029
	[Income=3]	,021	,119	,031	1	,861	-,212	,254
	[Income=4]	,053	,134	,156	1	,692	-,209	,315
	[Income=5]	0[a]	.	.	0	.	.	.
	[Age=1]	-1,172	,128	83,932	1	<,001	-1,423	-,921
	[Age=2]	-,888	,130	46,746	1	<,001	-1,143	-,634
	[Age=3]	0[a]	.	.	0	.	.	.
	[Household_composition=1]	-,398	,115	11,931	1	<,001	-,625	-,172
	[Household_composition=2]	-,218	,085	6,574	1	,010	-,385	-,051
	[Household_composition=3]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Weighted

Case Processing Summary

		N	Marginal Percentage
energielabfinal_recode	E-G	127024,60	23,2%
	C-D	175918,34	32,2%
	A-B	244048,14	44,6%
Income	<€50.000	125878,06	23,0%
	€50.000-€75.000	140964,33	25,8%
	€75.000-€100.000	128560,90	23,5%
	€100.000-€125.000	75550,31	13,8%
	>€125.000	76037,48	13,9%
Age	< 35 years	198808,03	36,3%
	35 - 64 years	296085,05	54,1%
	> 65 years	52098,00	9,5%
Household composition	Single person	114283,66	20,9%
	Multi-person without underage children	238733,40	43,6%
	Multi-person with underage children	193974,02	35,5%
Valid		546991,08	100,0%
Missing		,00	
Total		546991,08	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	52439,387			
Final	28039,418	24399,970	8	<,001

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	28902,515	72	<,001
Deviance	27358,895	72	<,001

Link function: Logit.

Pseudo R-Square

Cox and Snell	,044
Nagelkerke	,050
McFadden	,021

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[energielabfinal_recode = 1,00]	-2,466	,013	35189,772	1	<,001	-2,492	-2,440
	[energielabfinal_recode = 2,00]	-1,004	,013	6166,683	1	<,001	-1,029	-,979
Location	[Income=1]	-,465	,010	2332,599	1	<,001	-,484	-,446
	[Income=2]	-,288	,009	1099,345	1	<,001	-,305	-,271
	[Income=3]	,077	,009	75,562	1	<,001	,059	,094
	[Income=4]	,067	,010	47,323	1	<,001	,048	,087
	[Income=5]	0[a]	.	.	0	.	.	.
	[Age=1]	-1,144	,010	13006,996	1	<,001	-1,164	-1,124
	[Age=2]	-,926	,010	8277,454	1	<,001	-,946	-,906
	[Age=3]	0[a]	.	.	0	.	.	.
	[Household_composition=1]	-,339	,008	1809,152	1	<,001	-,354	-,323
	[Household_composition=2]	-,179	,006	859,838	1	<,001	-,191	-,167
	[Household_composition=3]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

I. Frequencies NVM transactions (2015-2023)

Frequencies of EPC, Price Categories (per m^2), Time on Market (TOM)		
Variable	**Number of cases**	**Percent**
EPC		
A	99,832	21.8%
B	69,423	15.1%
C	126,487	27.6%
D	65,156	14.2%
E	43,203	9.4%
F	30,116	6.6%
G	24,388	5.3%
Total	**458,605**	**100.0%**
Price categories		
<€210k	30,727	6.7%
€210k -€332k	139,192	30.4%
€332k -€468k	143,484	31.3%
€468k -€605k	72,200	15.7%
>€605k	73,002	15.9%
Total	**458,605**	**100.0%**
Price categories per m^2		
<€2500	59,064	12.9%
€2500-€3000	79,171	17.3%
€3000-€350	91,590	20.0%
€3500-€4000	76,858	16.8%
€4000-€4500	52,461	11.4%
€4500-€5000	33,215	7.2%
>€5000	65,979	14.4%
Total	**458,338**	**99.9%**
Time on Market		
<25 days	176,940	38.6%
26-30 days	38,819	8.5%
31-45 days	58,619	12.8%
46-60 days	33,754	7.4%
61-90 days	43,378	9.5%
91-120 days	28,153	6.1%
>120 days	78,942	17.2%
Total	**458,605**	**100.0%**

J. Cross-tabulations time on market (2021-2023 | 2015-2020)

Time on the Market 2015-2020

Days		<25	26-30	31-35	36-40	41-45	45-60	61-90	91-120	>120	Total %	Total N
E	A	**22.7%**	**21.0%**	20.5%	20.0%	19.7%	20.2%	20.5%	19.7%	18.7%	20.9%	83,079
P	B	15.4%	14.8%	15.0%	15.6%	15.3%	15.2%	**15.9%**	**16.5%**	**16.8%**	15.7%	62,325
C	C	28.2%	**28.6%**	**28.4%**	28.2%	**28.4%**	**29.0%**	28.3%	**28.7%**	27.8%	28.3%	112,354
	D	13.9%	**14.2%**	**14.6%**	**14.5%**	**14.5%**	**14.2%**	**14.1%**	13.7%	13.8%	14.0%	55,734
	E	9.3%	**9.7%**	**9.6%**	**9.6%**	**9.6%**	9.2%	9.1%	9.0%	9.0%	9.3%	36,899
	F	6.0%	6.5%	6.5%	**6.8%**	**7.0%**	**6.7%**	**6.8%**	**6.8%**	**7.2%**	6.5%	25,987
	G	4.5%	5.1%	5.3%	5.3%	**5.5%**	**5.6%**	**5.4%**	**5.5%**	**6.6%**	5.3%	21,075
Total %		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Total N		144,094	31,629	21,931	15,037	13,671	30,138	39,627	25,992	75,334		397,453

Time on the Market 2021-2023

Days		<25	26-30	31-35	36-40	41-45	45-60	61-90	91-120	>120	Total %	Total N
EPC	A	**29.8%**	24.5%	23.1%	23.1%	22.9%	25.4%	25.6%	25.7%	25.7%	27.4%	16,753
	B	11.1%	11.6%	11.4%	11.5%	**12.1%**	**12.4%**	**12.3%**	**12.8%**	**13.7%**	11.6%	7,098
	C	**23.4%**	**24.2%**	**24.1%**	**22.8%**	**23.5%**	21.4%	22.2%	21.8%	21.0%	23.1%	14,133
	D	15.0%	**17.3%**	**15.9%**	**16.5%**	15.2%	**15.9%**	15.3%	14.5%	14.0%	15.4%	9,422
	E	9.8%	10.1%	**10.9%**	**11.4%**	**13.2%**	**11.0%**	**11.3%**	**11.2%**	9.9%	10.3%	6,304
	F	6.0%	6.8%	**7.9%**	**8.4%**	**7.3%**	**8.0%**	**7.6%**	**7.3%**	**8.3%**	6.8%	4,129
	G	4.8%	5.4%	**6.6%**	**6.4%**	**5.9%**	**5.9%**	**5.6%**	**6.8%**	**7.4%**	5.4%	3,313
Total %		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Total N		32,846	7,190	3,864	2,191	1,925	3,616	3,751	2,161	3,608		61,152

K. Linear regression transaction price

Regression

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	EL_G, RevURBAN, NVM_4_Hoekwoning, NVM_3_Schakelwoning, EL_F, EL_E, EL_B, NVM_8_App_voor1945, NVM_5_TweeOnderEenKap, EL_D, GebruiksoppervlakteWoonfunctie, NVM_9_App_1945_1970, NVM_10_App_na1970, EL_C, NVM_6_Vrijstaand[b]	.	Enter

a. Dependent Variable: AdjustedPrice

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,719[a]	,517	,517	144558,79910

a. Predictors: (Constant), EL_G, RevURBAN, NVM_4_Hoekwoning, NVM_3_Schakelwoning, EL_F, EL_E, EL_B, NVM_8_App_voor1945, NVM_5_TweeOnderEenKap, EL_D, GebruiksoppervlakteWoonfunctie, NVM_9_App_1945_1970, NVM_10_App_na1970, EL_C, NVM_6_Vrijstaand

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1,025E+16	15	6,831E+14	32689,206	<,001[b]
	Residual	9,583E+15	458577	20897246398		
	Total	1,983E+16	458592			

a. Dependent Variable: AdjustedPrice

b. Predictors: (Constant), EL_G, RevURBAN, NVM_4_Hoekwoning, NVM_3_Schakelwoning, EL_F, EL_E, EL_B, NVM_8_App_voor1945, NVM_5_TweeOnderEenKap, EL_D, GebruiksoppervlakteWoonfunctie, NVM_9_App_1945_1970, NVM_10_App_na1970, EL_C, NVM_6_Vrijstaand

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-36796,317	1187,088		-30,997	<,001
	GebruiksoppervlakteWoonfunctie	3101,528	6,502	,626	477,028	<,001
	RevURBAN	33579,432	200,687	,211	167,322	<,001
	NVM_10_App_na1970	42347,506	721,887	,073	58,662	<,001
	NVM_3_Schakelwoning	47051,059	1420,414	,035	33,125	<,001
	NVM_4_Hoekwoning	21171,035	710,669	,034	29,790	<,001
	NVM_5_TweeOnderEenKap	61412,239	699,264	,108	87,824	<,001
	NVM_6_Vrijstaand	135736,857	870,903	,212	155,858	<,001
	NVM_8_App_voor1945	111329,281	1136,225	,111	97,982	<,001
	NVM_9_App_1945_1970	-22435,563	986,492	-,027	-22,743	<,001
	EL_B	-43050,050	718,019	-,074	-59,957	<,001
	EL_C	-72007,394	623,754	-,155	-115,442	<,001
	EL_D	-70565,319	762,764	-,118	-92,513	<,001
	EL_E	-53494,559	874,141	-,075	-61,197	<,001
	EL_F	-46600,715	984,305	-,056	-47,344	<,001
	EL_G	-64156,312	1073,727	-,069	-59,751	<,001

a. Dependent Variable: AdjustedPrice

L. Reflection

If the approach worked?

In short, yes, although not from the beginning. My approach was a mixed-methods design, combining quantitative analysis using SPSS with qualitative interviews with real estate professionals. In retrospect, this was the right approach for the focus of this research, to uncover both measurable inequities in access to energy efficiency (through EPCs) and the underlying mechanisms behind them. However, the effectiveness of this approach only became clear once I had properly prepared the datasets and refined my subquestions. Preparing all datasets first, to then in three weeks do all the analysis worked really well. While preparing it felt like I did not make any progress, that of course changed when I started doing all the analyses. Because this is an descriptive research, the results almost filled themselves, with cross-tabulations and description on what where notable findings in the tables.

When I started, I wanted to do everything at once and find all the answers in the first week. Although I had a solid research plan, I underestimated the amount of datasets, what was in the datasets (a lot of variables) and the time it would take to prepare data and run regressions correctly. Once I slowed down, cleaned the data, and approached each step with care, I noticed that the analysis became much easier and more insightful.

How and why did it work?

The combination of quantitative and qualitative methods allowed me to triangulate results, which strengthened the reliability and depth of my findings. I learned SPSS from scratch, and grew confident using techniques like cross-tabulations, Chi-square tests, and both linear and ordinal regressions. While interpreting the statistical outputs, especially elements like unstandardised B, Beta coefficients, Wald, and df, was initially confusing, I learned to assess significance and effect strength more critically over time with the help of my mentors. The qualitative interviews were important to validate the patterns I found and to understand the 'why' behind them.

Working at Fakton's office significantly helped my focus. It removed daily distractions, especially those from BOSS, where I serve as treasurer, and gave me structure. In weeks where I combined morning sports with full research days, my focus and productivity noticeably increased. I didn't expect physical routine to have such a mental impact, but it became a thing that worked for me.

I also learned that I genuinely enjoy working with data. This wasn't new, my earlier enjoyed with Excel could have predicted this, but diving into SPSS confirmed that quantitative research suits me. At the same time, the interviews were energising. I love speaking with people and was surprised by how engaged the interviewees were. They asked for the final report and even led to invitations to present to the municipality and RVO. These moments gave meaning to my research beyond academic obligations.

Reflection on feedback and its implementation

Feedback from both TU Delft mentors and Fakton was meaningful. Early feedback centered on narrowing the scope, especially around the social equity definition. I translated this into a clearer structure based on three dimensions: energy costs, wealth growth, and access to subsidies. This not only gave the research a strong red thread but helped structure subquestions and chapters coherently.

Statistical feedback helped me refine regression models and interpret results more robustly. For instance, I changed how cross-tabulations were structured, shifting from row percentages to column percentages (variable adding up to 100% instead of EPC), which made the output clearer. I also learned to rethink variable selections and better understand how different socio-economic variables interact.

One particularly helpful session involved a long discussion about the conceptual model. Eventually, we concluded that the underlying mechanism was in fact quite simple, which helped me distil the narrative.

My mentor at Fakton encouraged me to look at recommendations from a consultancy perspective, making them actionable, specific, and well considered. This led to the integration of policy levers like tax reduction for EPC updates and better subsidy application procedures. He also supported the use of a mortgage capacity calculator, which was the base for the income groups and price classes.

How I learned from my own work
Through trial and error, I learned to let go of perfectionism and trust the process. I also discovered that the hardest part is not doing the work, but translating what's in your head into a structured story. That's why I appreciated feedback that urged me to read my own work as if I were a stranger to the topic, the "taking the reader by the hand" writing is a thing that I struggled with.

Another important insight was the benefit of staying close to a central concept, in my case, social equity. Anchoring everything around this made it easier to connect insights across methods, chapters, and disciplines.

Relation to MSc Programme and Track
The topic fits with the Management in the Built Environment (MBE) track, as it connects sustainability, affordability, and housing market dynamics. It also reflects the MSc AUBS's focus on the Built Environment and (social) inclusivity.

Research and Design Interaction
The quantitative data defined the problem space, while the qualitative interviews gave shape to the potential solutions. The research defined the 'what' and the design-oriented part the 'how'. Although this was a more descriptive-oriented research, it still provided useful directions for policy reforms.

Value of My Approach
My mixed-methods approach worked well. Quantitative methods identified disparities, qualitative methods explained them. This enabled me to generate insights with both statistical rigour and societal relevance.

Academic and Societal Value
Academically, this thesis contributes to the debate on energy transition and inequity. Societally, it proposes actionable strategies to prevent the energy transition from reinforcing inequity.
Ethically, the work raises awareness of how policy design, even when well-intentioned, can exacerbate disparities if not carefully targeted.

Transferability

The methods and results can be applied in other municipalities or countries facing similar challenges. The structure, combining data analysis with stakeholder perspectives, is generic enough to be reused, especially for policies combining sustainability with affordability.

Self-developed reflection questions

1. How can I ensure that my future work always translates data into action?

This thesis taught me that insights are only valuable if they're picked up by decision-makers. I want to keep working on bridging research or expertise with real-world application. This is a very practical thing a consultant does in day-to-day work.

2. What makes a research project meaningful to me personally?

Meaning arises when others are genuinely interested in your results. I learned that working with stakeholders, not just about them, adds value, depth, and satisfaction to the work. Another thing is that at first the research proposal was only focused on the descriptive part. However, once the results started to become clear, I felt the need to create direction to improve the situation. This made it more meaningful for me.