# BALANCING ENERGY EFFICIENCY AND SOCIAL EQUITY

## ASSESSING THE EFFECTS OF ENERGY EFFICIENCY IN HOMES ON SOCIAL EQUALITY IN THE DUTCH OWNER-OCCUPIED HOUSING MARKET


| | |
|---|---|
| Author | D. Schroevers |
| Date | 26 June 2025 |
| Student Number | 5913195 |
| University | Delft University of Technology |
| Faculty | Architecture and the Build Environment |
| Master Track | Management in the Built Environment |
| Graduation Theme | Housing Crisis |
| Graduation Company | Fakton B.V. |


TU Delft

# BALANCING ENERGY EFFICIENCY AND SOCIAL EQUITY

## ASSESSING THE EFFECTS OF ENERGY EFFICIENCY IN HOMES ON SOCIAL EQUITY IN THE DUTCH OWNER-OCCUPIED HOUSING MARKET

*Version: P2 Report*
*Date: 26/06/2025*


**Student**

| | |
|---|---|
| Name | D. (Dylan) Schroevers |
| Student Number | 5913195 |

**University**

| | |
|---|---|
| University | Delft University of Technology |
| Faculty | Architecture and the Build Environment |
| Master Track | Management in the Built Environment |
| Course | AR3MBE100 Graduation Laboratory |
| Theme | 5 Housing Crisis |

**University Supervisors**

| | |
|---|---|
| First Mentor | Dr. H.J.F.M. (Harry) Boumeester |
| Department | Housing Systems |
| | |
| Second Mentor | Dr. Ir. M.U.J. (Michaël) Peeters |
| Department | Real Estate Management |

**Graduation company**

| | |
|---|---|
| Company | Fakton B.V. |
| Address | Beursplein 37, 3011 AA, Rotterdam |
| Company supervisor | Ir. M. (Martijn) Nawroth |

# ABSTRACT

In the built environment, sustainability becomes more and more important. However, due to affordability issues on multiple levels, it is hard to find a balance between social equity and sustainability objectives. This report functions as the research proposal to examine this balance. By analysing transactions, existing literature on price premiums and impact on the time on the market due to Energy Performance Certificates (EPCs) is examined. This creates the foundation to uncover a possible segmentation of high- and low-labelled dwellings based on demographic and geographic variables, all related to the impact of EPCs. Besides, it is insightful to see whether homeowners move between different energy labels, therefore interacting with both possible markets. With datasets providing information about this quantitative part, conclusions can be made. To validate these conclusions, a qualitative approach is used to discuss the findings with an expert panel or by interviews, including policymakers, real estate agents and experts. During this discussion, it is important to get insights about the allocation of subsidies, to share quantitative findings and to create policy recommendations. With all these insights, this proposal suggests that one of the end products will be policy recommendations to create a balance between social equity and sustainability.

# KEYWORDS

Dutch housing market, energy labels, government subsidies, market liquidity, segmentation, social equity, sustainability

TU Delft FAKTON

# LIST OF FIGURES



# LIST OF TABLES

# TABLE OF CONTENTS

# 1. INTRODUCTION

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 persons face great difficulties in finding affordable housing (NOS, 2021). 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 (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%. However, this support, the Temporary Emergency Fund Energy (Tijdelijk Noodfonds Energie) has not been reopened and has stopped on the 1st of January 2025 (Eigenhuis, 2024). This could lead to a rise in households living in energy poverty. Overall, the current situation creates overlapping affordability and energy-cost burdens for low-income groups.

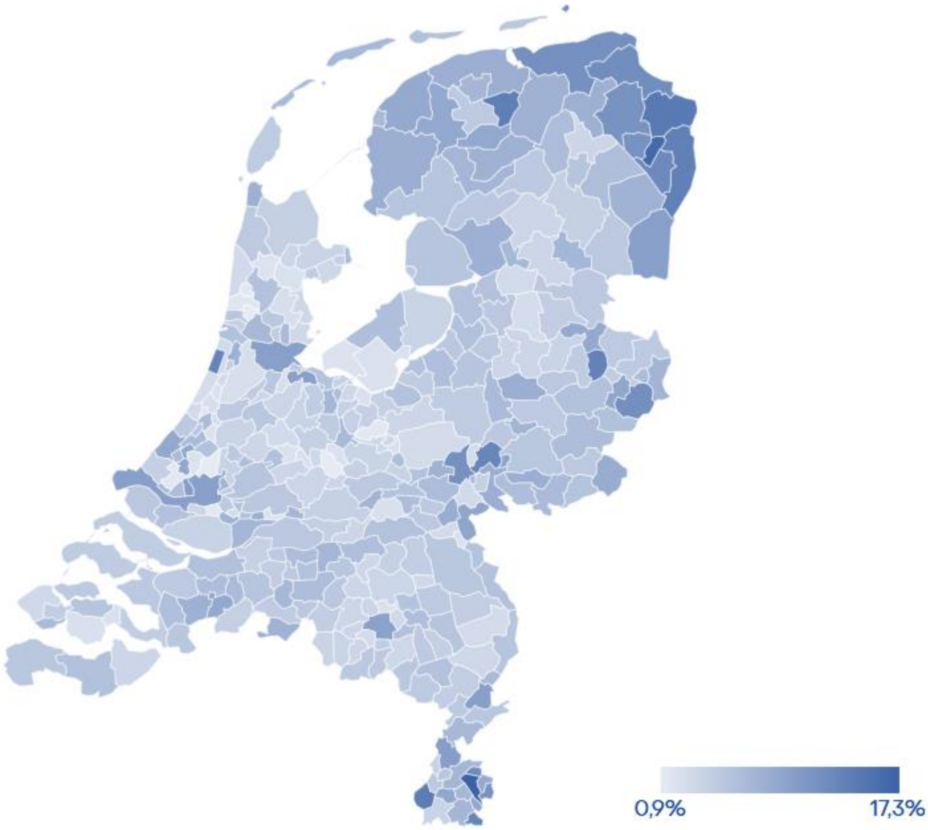


*Figure 1 Energy Poverty in the Netherlands (TNO, 2024)*

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 net zero-targets and energy costs. The introduction of the Energy Performance Certificates (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 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 *National Warmtefonds* (NWF), by the Dutch government (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 high-labelled 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 high 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 high 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 is 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 is 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 of TNO (2024) on the instructions of the Ministry of BZK, shows that the ISDE subsidy is mostly granted to households living in dwellings with energy label C in absolute figures. In total, all labels below label B were granted more subsidies than 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 appliances, 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, 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. Other studies have also shown that existing renovation subsidies can exacerbate regressive distributional impacts, as they are more accessible to higher-income households (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 mobility within the housing market 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 2). The figure shows how the dwellings, based on EPCs level, 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 wall, glass and floor insulation, having a smaller impact on energy efficiency.

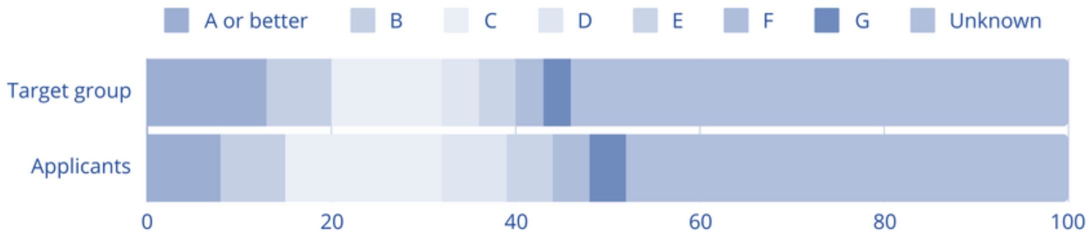

*Figure 2 Distribution of total EPCs versus Applicants per EPCs level (TNO & CBS, 2024)*

Although numerous studies explore the impact of energy labels on housing prices (Aydin et al., 2020; Brounen et al., 2009; Brounen & Kok, 2010; Gerassimenko et al., 2024; Murphy, 2013; Stangenberg et al., 2020), less is known about their combined influence on market dynamics together with subsidies, or EPCs and sustainability subsidies as a driver of social inequality. While individual aspects of housing market dynamics have been researched, few studies have examined them together to assess whether EPCs contribute to social inequality. This study uniquely addresses market segmentation, investigating if this social inequality is large enough to show two distinct markets, one for properties with higher EPC ratings and another for those with lower ratings. To achieve this, the research will analyse data from home buyer transactions and demographic data. Additionally, questions remain regarding the efficiency of subsidies, are these reaching the households most in need, or are high-income households disproportionately benefitting, thereby worsening social inequality? This research seeks to capture the broader impact of energy labels on housing market dynamics and offer actionable policy recommendations to create a more balanced Dutch housing market.

This research addresses a critical gap in understanding how energy efficiency, with both EPCs and subsidies, affects owner-occupied housing market dynamics and social inequity within the Dutch context. Furthermore, the existing insider/ outsider theory that already applies to the buy versus rent sectors, will be examined to determine whether this also applies for high- versus low-labelled dwellings. Now, certain target groups are having issues accessing the owner-occupied market and are stuck in the rental sector (outsiders), where households that are once into the owner-occupied market often stay there (insiders). The question then is, does the same principle apply for target groups within certain energy labels or within low- versus high-labelled dwellings. By analysing the impact of energy labels on housing prices, time on the market, segmentation and homeowners' residential mobility, the study contributes valuable insights into energy-efficient measures in relation to social equity in real estate. It explores whether sustainability policies inadvertently reinforce socio-economic divides, which is consistent with broader theories of wealth distribution and informs more equitable policy development. By quantifying EPC-induced market segmentation and assessing the effectiveness of subsidies by examining the distribution, the research provides evidence-based recommendations for designing incentives that promote both energy efficiency and social equity.

The remainder of the research proposal will be structured beginning with the theoretical background, research questions, methodology, outputs, study targets, the research plan and a reflection.

# 2. THEORETICAL BACKGROUND

The growing focus on enhancing building energy performance to mitigate climate change and reinforce energy security has positioned Energy Performance Certificates (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, insider-outsider divides, 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. By integrating these perspectives, the review establishes a foundation for research investigating how EPCs, as key instruments of environmental policy, interact with market dynamics and social structures.

**Evolution of the Energy Performance Certificates (EPC)**

The Energy Performance Certificate (EPC) 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 groundbreaking for their time, often struggled with low uptake and inconsistencies in implementation (Figure 3). The figure shows a remarkable 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).

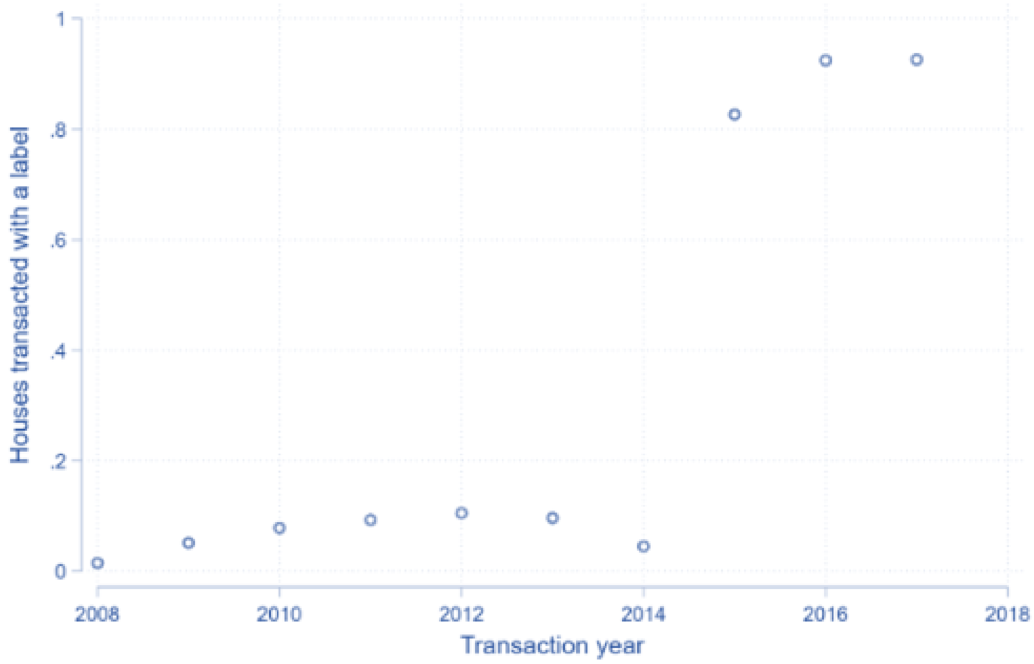


*Figure 3 Adoption rate of energy labels in the Netherlands (Stangenberg et al., 2020)*

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).

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 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).

**Price Premiums for EPCs**

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 higher 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 variable outcomes across contexts (Fregonara & Rubino, 2021).

An overview of discussed literature about EPCs effects on price is shown, see Table 1.

| Author(s) | Year | Context | Pos./Neg./Mix. | Findings | Nuances |
|---|---|---|---|---|---|
| Brounen & Kok | 2011 | Netherlands | Positive (1) | A-labelled homes sold at a 12.1% premium compared to similar homes with G-label. | Here EPC was only a tool to prevent information asymmetry. Adoption rates declined due to negative media coverage (study data is up until 2009, so in the voluntary situation). |

| | | | | | |
|---|---|---|---|---|---|
| Hyland et al. | 2012 | Ireland | Positive (2) | A-rated homes had a 9.3% sales premium; F/G homes were discounted by 10.6%. | Premiums and discounts were stronger in weak markets and rural areas. Energy effects were higher for smaller homes. |
| Cerin et al. | 2014 | Sweden | Positive (3) | Older and lower-priced homes showed price premiums for energy efficiency. | Premiums depended on energy performance benchmarking. Premiums were highest for homes with a low square meter price and homes built before 1960. |
| Fuerst et al. | 2015 | England | Positive (4) | A/B-labelled homes showed significant price premiums, strongest for flats. | Detached homes exhibited weaker effects. EPCs provided transparency in urban markets, leading to less selection bias compared to Brounen & Kok (2010) and Hyland et al. (2012), so that the result could be interpreted with more certainty. |
| Chegut et al. | 2016 | Netherlands | Positive (5) | Affordable A-labelled homes sold for 6.3% more than C-labelled ones. | Strongest premiums in urban areas. Retrofitting affordable housing yielded measurable returns, not especially in higher rents due to regulations, but in higher transaction price. |
| Fuerst et al. | 2016 | Finland | Positive (6) | Top energy-efficient homes had a 3.3% price premium. | Energy-efficient homes acted as a signal for environmentally conscious buyers, amplified in cold climates. Because there heating leads to higher energy consumption, potential gain via e.g. insulation has a great effect. |
| Fregonara et al. | 2017 | Italy | Mixed (1) | EPCs explained only 6–8% of price variation, other factors were more important. Limited to no effect on price. | EPC effects disappeared when controlling for building characteristics like building period, location, size and quality, limited awareness of EPC benefits. |

| | | | | | |
|---|---|---|---|---|---|
| Olaussen et al. | 2018 | Norway | Negative (1) | EPCs had no significant effect on transaction prices. | Buyers prioritised property attributes like location and size over energy efficiency. EPC premiums were likely influenced by omitted variables such as how recently it was renovated, or different amenities of the building. |
| Aydin et al. | 2019 | Netherlands | Positive (7) | EPC-labelled homes sold 7–12% faster. | Higher-quality EPCs (e.g., on-site inspections) reduced TOM significantly, and simplified models of labelling after being made mandatory were less effective. |
| Stangenberg et al. | 2020 | Netherlands | Mixed (2) | Pre-existing (before EPCs) premiums due to energy efficiency itself reduced the added value of EPCs. | Voluntary EPCs (2008-2014) had limited impact, mandatory schemes (from 2015 onwards) added little new information in already functioning markets. New labelling is also based on less specifications and have are more vulnerable to fraud. |
| Aydin et al. | 2020 | Netherlands | Mixed (3) | A 10% energy efficiency increase resulted in a 2.2% price premium. | Energy efficiency was capitalised effectively, but EPCs themselves were not necessary for valuation, energy efficiency itself suffices. |
| Olaussen et al. | 2021 | Norway | Negative (2) | EPCs did not influence asking prices. | Buyers relied on real estate agents for energy performance information, reducing the relevance of EPCs in this market. Pricing based on energy efficiency, not on EPC. |
| Fregonara et al. | 2021 | Italy | Positive (8) | EPCs do influence pricing, most influence on bad to less bad rated dwellings. | Lower ratings (e.g., G to F) yielded greater returns percentage wise. Top-tier labels showed limited additional value (A compared to B or C). No linear relation. |
| Gerassimenko et al. | 2024 | Belgium (Flanders) | Positive (9) | A-labelled homes showed a 42% premium, F-labelled homes had a 13% discount. | Sales markets responded more strongly than rentals, the highest returns came from improving F to A labels. |

*Table 1 Overview of literature on EPCs effect on price (own work)*

**Time on Market and Energy Efficiency**

Time on the market (TOM) analyses offer an 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. 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 lower-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.

**Insider versus Outsider Issue**

The current housing system is characterised by a growing divide between those who occupy secure market positions, often referred to as 'insiders', and those who are systematically disadvantaged or excluded, known as 'outsiders'. Empirical evidence from the Netherlands demonstrates that disadvantage in labour markets, frequently manifested as insecure employment or unemployment, gives rise to challenges in accessing stable and affordable housing, as well as in accumulating housing wealth (Arundel & Lennartz, 2020; Boelhouwer, 2020; Hochstenbach & Aalbers, 2024). Arundel & Lennartz (2020) reveal that being a labour market outsider greatly increases the likelihood of also holding an outsider position in the owner-occupied housing market, including reduced prospects for home equity formation and wealth accumulation. A large portion of the cause is the fact that without a job, a person cannot get a mortgage, making it almost impossible to buy a house. Groups such as women, single parents, and lower-educated individuals are more frequently found among housing outsiders, reflecting broader socio-economic inequalities. But also younger house-buyers face the trade-off between accepting high sales, and thus high debts and mortgage risks, or extended stays in the rental sector, reflecting the result that younger populations find themselves in the outsider group (Arundel & Lennartz, 2020). Furthermore, rising housing demand and escalating prices intensify these divides, making it harder for outsiders to secure favourable positions (Boelhouwer, 2020). Housing wealth inequalities expand as those already holding assets benefit disproportionately from appreciation, reinforced by policies and market conditions that favour established owners and higher-income households (Hochstenbach & Aalbers, 2024). This wealth-driven market dynamic produces a self-reinforcing cycle that excludes newcomers due to the high threshold to enter the owner-occupied market as is shown in Figure 4.

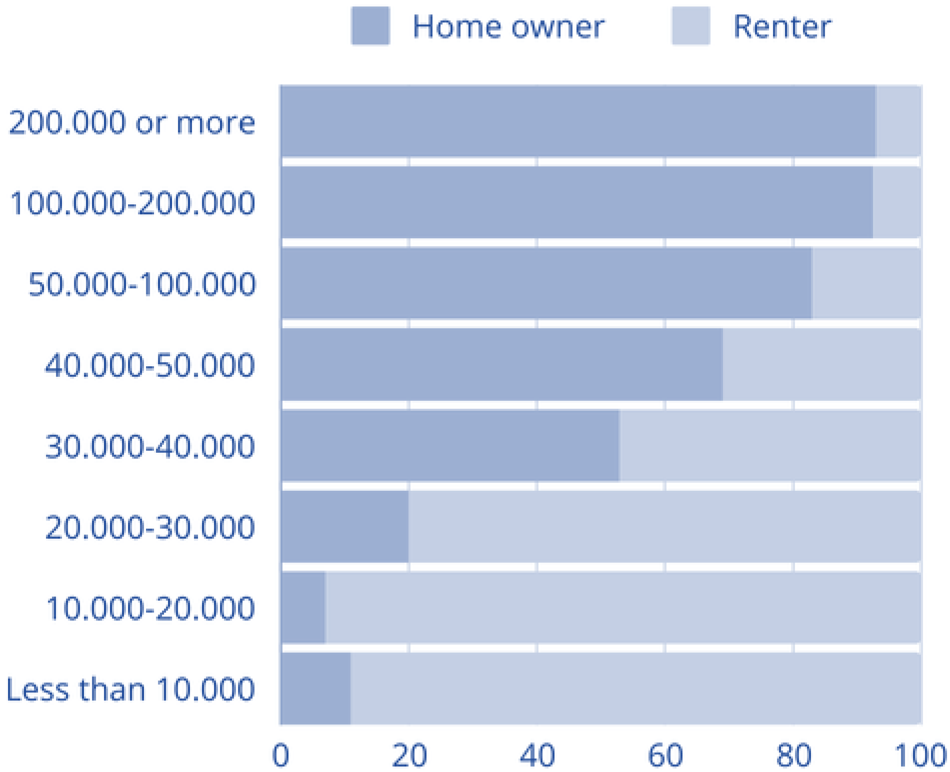

*Figure 4 Homeowners versus renters per income group (TNO & CBS, 2024)*

**Social Inequality and Energy Efficiency**

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 pronounced 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 higher 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 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 energy label C in absolute figures (TNO &

CBS, 2024). In total, all labels below label B were granted more subsidies than B or above. Another result is that the subsidies are granted to mostly high-income households, as the lowest six decile groups did 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).

To give context to how big the groups are and what type of housing and age, Figure 5 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.

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.

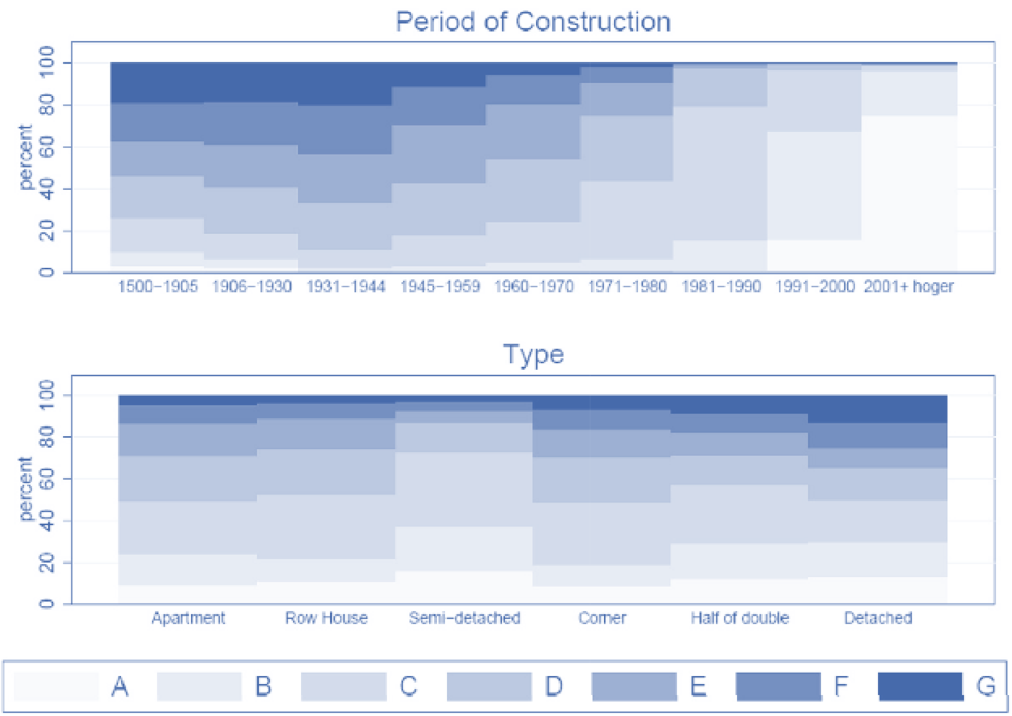


*Figure 5 Distribution of labels per construction year and housing type (Aydin et al., 2019)*

**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 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.

**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). To give an idea of the Dutch budget for 2024, the ISDE has a total budget of 600 million, with 374.8 million already claimed by private homeowners in November 2024 (RVO, 2024). The budget continues to exist up until 2030, but with this much already claimed, the budget will probably be totally 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 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 Loan-to-Value. This ratio can become 106% instead of the usual 100% when energy-saving measures are taken during renovation (Westerlaak, n.d.).

Tax incentives have also been deployed in several European countries to reward building envelope upgrades, efficient heating, or renewable installations (Bertoldi et al., 2021). Yet taxation schemes can yield unintended outcomes, performance-based property taxes may discourage improvements, because better energy-performing properties pay higher taxes. Energy efficiency obligations and on-bill financing (OBF) integrate repayment with utility bills. The costs of energy efficient measures are then linked to the bills, whereby each month the households pay a part of the total investment back. There is the condition that the total bill, so the energy usage plus amortisation of energy efficiency measures, may not exceed the original energy bill price before the measures. In doing so, this approach helps reducing upfront costs but raising concerns over administrative complexity and risks of default/ non-payments (Bertoldi et al., 2021). Fernández et al. (2024) propose “green imputed rent” taxation to channel untaxed housing income into efficiency, potentially mitigating regressive biases. What is basically described here is that there should be a tax related to the energy efficiency of homes, stimulating homeowners to invest in energy efficient measures. However, this is focused on the rental sector, since in the owner-occupied sector there are no untaxed housing incomes.

**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. Soaring 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. They advocate rethinking regulatory systems, including stronger enforcement, performance-based incentives, and integrated financial, informational, and technical assistance. Occupant engagement is vital, 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.

The existing body of literature on EPCs, market dynamics, and social inequality reveals a complex and multifaceted landscape where environmental policies intersect with economic incentives, entrenched market structures, and longstanding social divides. Energy Performance Certificates (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, education, and labour market security 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.

# 3. RESEARCH QUESTIONS AND CONCEPTUAL MODEL

## 3.1. Research Questions

As described in the introduction, there are several concepts that this research will entail. From the sustainability perspective, there are the Energy Performance Certificates, together with sustainability subsidies, such as the ISDE. Then from a social perspective, there is the social equity, that this energy efficiency in housing is potentially influencing. To create a relevant context for these concepts to examine, the Dutch owner-occupied housing market is chosen. This creates the opportunity to evaluate transaction data, leading to results on the price effects, time on the market and market segmentation due to EPCs. Furthermore, with data on demographics and previous homes of households, the residential mobility can be examined, showing relevant insights to investigate whether the market segmentation is rigid or fluid. This interaction is further explored by examining the allocation of subsidies, potentially favouring higher income groups, as is expected due to the findings in the literature. Lastly, current policies are discussed, and policy recommendations are examined with an expert panel or by interviews, to investigate whether it is possible to create a better balance between social equity and energy efficiency in homes. This would mean that the distribution would be fairer and that still the worst energy labels, since low-income households live there the most, would be upgraded, making the most impact on the sustainability goals. To capture all these concepts, the following main research question is designed: **How can a balance between social equity and energy efficiency in homes be promoted in the Dutch owner-occupied housing market?**

To answer this main research question, the following subquestions need to be answered:

1. How do Energy Performance Certificates (EPCs) influence pricing and time on the market?
2. Can the housing market be segmented by demographic and geographic factors related to EPCs?
3. How are sustainability subsidies allocated, and how do they affect social equity?
4. Which policy approaches could promote a balance between energy efficiency and social equity?

By answering all these questions, an overview is created of the effects of EPCs on the owner-occupied housing market, with the result of a confirmation or decline of the hypothesis that EPCs and sustainability subsidies drive social inequity. This fills the research gap (Figure 6), by combining the different effects of EPCs on market dynamics, and market segmentation, with subsidies. These are all researched separately but not combined in relation to the social impact.

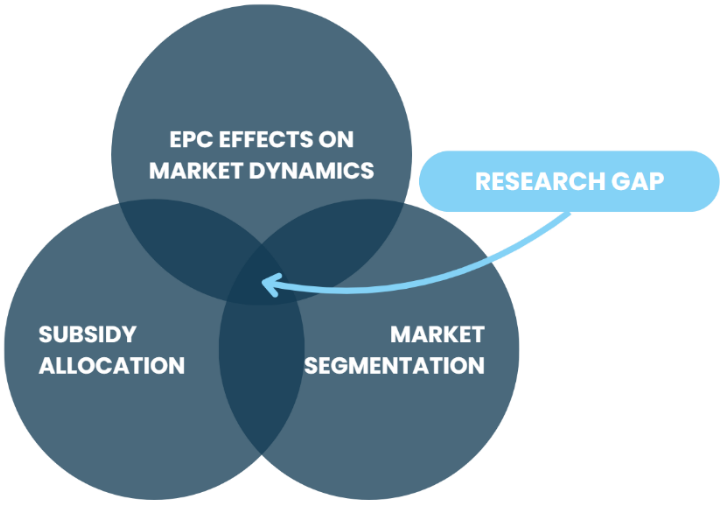


*Figure 6 Research gap (own work)*

## 3.2. Conceptual Model

The logic of this research is shown in the conceptual model in Figure 7. The two main concepts are social equity and energy efficiency in homes. The first concept can be defined as the fair distribution of benefits arising from energy efficiency across different socio-economic groups. This fairness in equity relates to the opportunity to have the same outcome. The difference between this and equality is visualised in Figure 8. Indicators for this concept are energy costs, as a proportion of household income, availability of capital for sustainability (based on income), wealth growth due to owning and keeping a house, and access to subsidies to support energy-efficient measures. Furthermore, demographic information is used to categorise social classes, based on income, education level and age.

Energy efficiency in homes refers to the extent to which homes achieve optimal energy performance, for this research only the financial and societal impact is measured, not the environmental impact. Indicators for this concept are the Energy Performance Certificates (EPCs), energy costs, investments in sustainability measures and wealth growth due to owning an energy-efficient dwelling.

The relation between these two concepts is influenced by housing market dynamics, as a mediating factor. This factor explains how energy efficiency in homes influences housing-related social equity. Aspects of this concept include price effects of EPCs, time on the market, transaction volumes per EPC, and segmentation by energy efficiency label. This will be studied by using NVM transaction data, linked to open-source data of the RVO ensuring that all transactions have an energy label of the time of transaction linked to the transaction. Then, this mediating factor is influenced by subsidy allocation. This is conceptualised as a policy lever that can either exacerbate or mitigate the relationship between energy efficiency in housing and social equity. Effective subsidy design and distribution could address affordability barriers, enabling lower-income households to invest in energy-efficient measures and participate in the benefits of sustainable housing. On the other hand, unequal subsidy allocation risks deepening social inequities. By examining subsidy distribution data, misalignments are identified where possible, to see how the subsidies influence this relation.

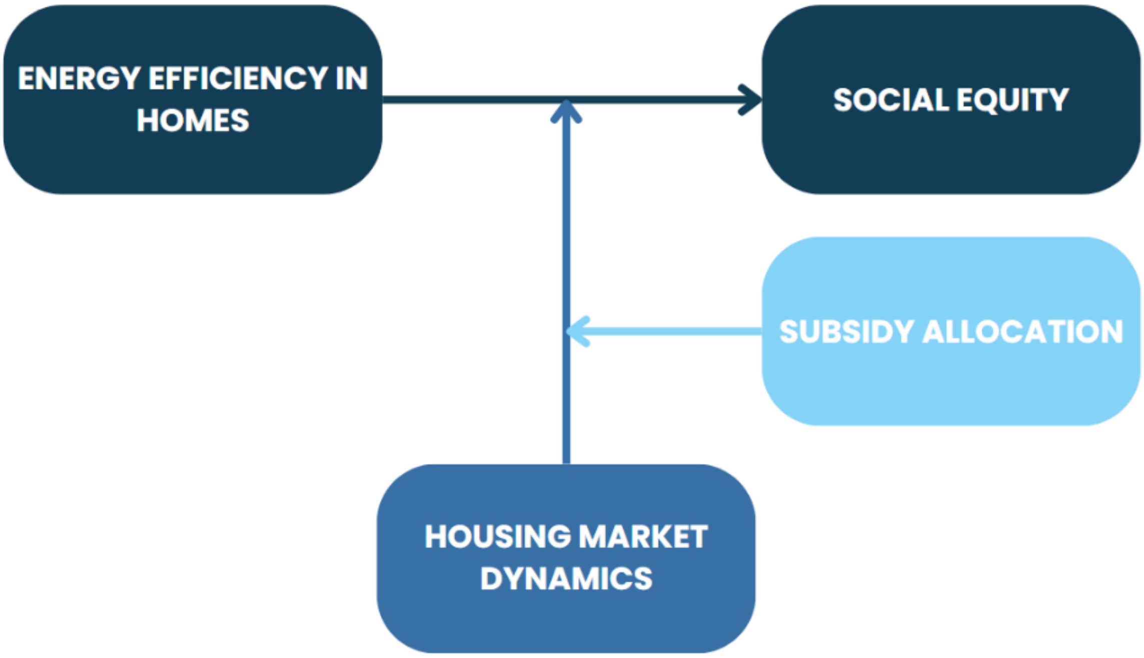


*Figure 7 Conceptual model (own work)*

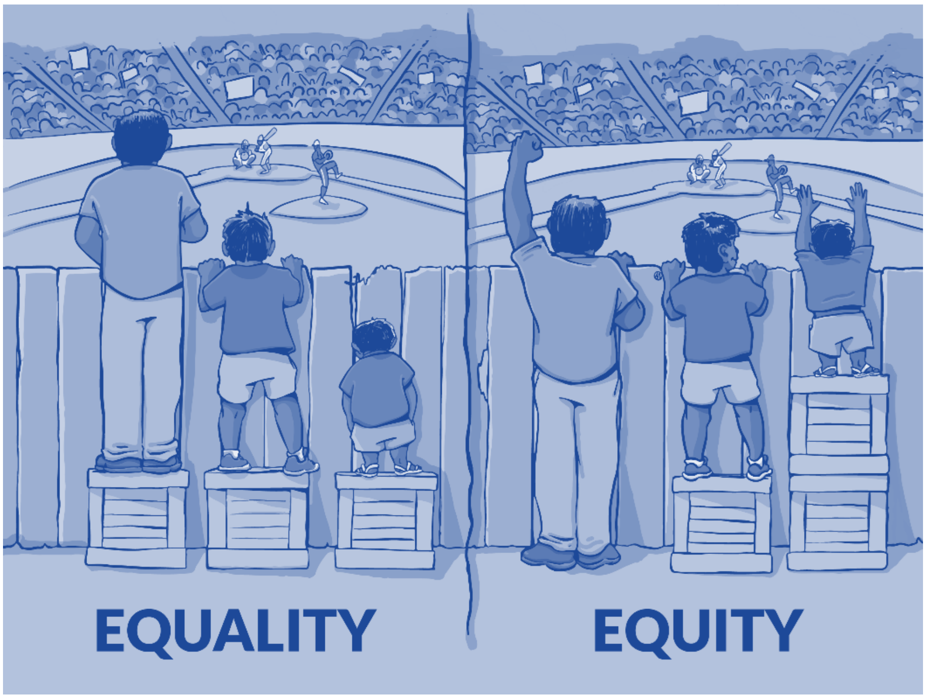


*Figure 8 Difference equality and equity (IISC, 2016)*

This approach is intended to create a better understanding of the limited studied relation between energy efficiency in homes and social equity. Because there are limited studies, this research will be explorative and descriptive in the analysis.

# 4. RESEARCH METHODS

## 4.1. Type of Study

In this research, a mixed-method design will be used to address the research inquiries. This involves both quantitative and qualitative research methodologies. The research is both exploratory and explanatory, using quantitative methods such as descriptive analyses and cross-tabulations to examine large datasets from the Dutch owner-occupied housing market. Qualitative methods include an expert panel discussion or interviews to interpret quantitative findings and formulate policy recommendations.

## 4.2. Methods and Techniques

### 4.2.1. Literature search strategy

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". Besides, 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.

#### 4.2.1.2. Search Databases

- 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:

| | **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 2 Searching scheme*

#### 4.2.1.2. Literature review structure

To create a solid foundation for the research, the following structure is used, for which literature is searched using the search query.

- Evolution of the Energy Performance Certificates (EPC)
- Price premiums for EPCs
- Time on the market and energy efficiency
- Insider versus outsider issue
- Social inequality and energy efficiency
- Barriers to energy-efficient renovations
- Financial instruments for energy renovation
- Policies and governance in energy efficiency

#### 4.2.1.3. Search query

Using Table 2, multiple search queries were conducted, resulting in literature that are used for the literature review. The exact search queries are presented in Appendix 1.

#### 4.2.1.4. Filters and Inclusion/Exclusion Criteria

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 is 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).

## 4.3. Data Analysis

### 4.3.1. Quantitative research instruments

**Phase 1: Impact of EPCs on pricing and TOM**

The goal of the first phase is to investigate the effect of EPCs on housing prices and time on the market on a national level. A descriptive analysis will be conducted using the NVM (Dutch Association of Real Estate Agents) transaction database in combination with datasets of Fakton (with a base document of the RVO), including the energy labelling.

**Datasets**

- **NVM transaction data (2013–2023):** Includes transaction prices, listing durations, and property characteristics.
- **RVO energy label data:** Will be linked to NVM transactions to ensure, to ensure that the transactions have energy labels linked to them, to examine price effects and TOM.

**Data Types**

| | |
|---|---|
| EPC Rating: | Ordinal |
| Price per Square Meter: | Ratio |
| Time on Market: | Ratio |

**Analysis**

The data will be analysed in a descriptive way. This entails visualisations on average price per m2 and TOM per EPC rating, but also box plots for price and TOM by EPC.

**Phase 2: Segmentation of the housing market by EPCs**

With this phase, a better understanding of the owner-occupied market on a national level, based on energy efficiency, is created. This will examine whether energy efficiency in housing creates two segments, high- versus low-labelled homes, based on demographics. Therefore, it will be determined if there are distinct target groups within a side of this segmentation. Furthermore, to assess whether this segmentation is rigid or fluid, residential mobility is examined. This will be done by comparing energy labels from current dwellings to previous dwellings, for households that moved in the timeframe of the data. Analysing this will set the context for the later subquestion about subsidy allocation, potentially affecting this segmentation.

**Datasets**

**WoOn dataset:**

- Random survey providing detailed demographic information (income, education, age).
- Includes questions about recent moves and previous dwellings, requiring assumptions to assess residential mobility.

**Analysis**

First, a descriptive analysis will be executed to summarise the segmentation patterns. Second, a cross-tabulation and Chi-square test will be performed to explore relationships between EPCs, and demographics. This approach analyses the associations between EPC categories and various demographics. The results will be visualised using bar charts showing EPC distributions across these factors. The WoOn is a random survey, with a limited sample size. Because some information is not available in this dataset, assumptions must be made on for instance the residential mobility. This entails using the specifications of the previous dwelling of recently moved households. Then, the RVO dataset can be used to see whether an assumption for the energy label can be made based on the specifications in that dataset.

**Phase 3: Allocation of sustainability subsidies and social equity**

With this phase it is examined how sustainability subsidies are distributed and their effects on social equity within the housing market.

**Datasets**

- RVO dataset on subsidy distribution: Contains data on subsidies per energy label, income group, education level, and other demographics.
- Data integration with findings from Phases 1 and 2 to create new conclusions about the distribution of subsidies and the effects on social equity

**Data types**

| | |
|---|---|
| Subsidy amounts: | Ratio |
| Demographics: | Ordinal |

**Analysis**

The data will be analysed descriptively. The descriptive part will analyse subsidy distribution by income and education levels and will be visualised using stacked bar charts (or similar) of subsidies across income and education groups. Data about this distribution is publicly available via the ISDE Monitor of the RVO.

The analysis will focus on:

- **Beneficiary Profile:** Income groups, education levels, ethnic backgrounds, age and household size and the relation to the market segmentation.
- **Subsidy Allocation:** Amounts received, types of energy improvements funded in relation to the market segmentation.

#### 4.3.2. Qualitative research instruments

**Sub-question 4: Policy exploration and recommendation for balancing social equity and energy efficiency**

Following the quantitative analyses, an expert panel or interviews will be convened, including policymakers involved in the ISDE programme and experienced real estate professionals. The latter can be employees of organisations like the municipality, government, CBS, NVM or a real estate broker, and active in the energy sector. The panel will engage in structured discussions to interpret the findings and explore policy implications. However, the data and findings will define whether an expert panel or interviews are more beneficial.

To facilitate productive dialogue, a clear agenda will be established, highlighting key outcomes from the quantitative analyses. Topics will include the current impact of EPCs and subsidies on market dynamics, social equity considerations, and potential strategies for enhancing the effectiveness of subsidy programmes. Thematic analysis will be employed to synthesise insights from the discussions, using Atlas.ti software to code and categorise the qualitative data.

## 4.4. Data Collection

**Quantitative Data**
**Datasets**

- **NVM transaction data (2015–2023):** Includes transaction prices, listing durations, and property characteristics. This data set is provided on a yearly basis by the NVM to the TU Delft. This is done via a Data Delivery Agreement with Brainbay and the TU Delft.
- **Ministry of RVO energy label data:** 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 graduation organisation already has an improved dataset instead of the raw dataset using EP-online, which can be accessed via their PowerBI dashboard. However, the researcher is in contact with the RVO, to see whether a stance of every first of January can be provided from the period 2015-2023, since Fakton can only access the latest datasets.
- **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 (https://ssh.datastations.nl/dataset.xhtml?persistentId=doi:10.17026/dans-xaa-mrra).
- **RVO/CBS dataset on subsidy distribution:** Contains data on subsidies per energy label, income group, education level, and other demographics (CBS table: https://www.cbs.nl/nl-nl/maatwerk/2024/02/monitor-isde-nwf-2023-i | RVO Report: https://www.rijksoverheid.nl/documenten/rapporten/2024/02/01/monitor-isde).

Data will be imported into SPSS for statistical analyses and QGIS for spatial visualisation.

**Qualitative Data:**

- Expert panel discussions or interview: Audio recordings and transcripts of sessions with policymakers and real estate experts.

Data will be managed and analysed using Atlas.ti to facilitate thematic coding.

## 4.5. Data Management Plan and Ethics

The Data Management Plan is made using DMPonline. The plan is attached as Appendix 2. The HREC checklist and informed consent forms are yet to be worked out, since human participants are only involved during the last phase, and the subjects that will be discussed are dependent on the outcomes of previous phases.

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.

#### 4.5.1. Potential harm

Involved in this research are quantitative data and qualitative interviews. The interviews will be with aforementioned employees of organisations like the municipality, government, CBS, NVM or a real estate broker, and active in the energy sector. 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).

#### 4.5.2. 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 an explorative research, most of the findings will be averages on a national level.

#### 4.5.3. 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 explorative 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.

# 5. RESEARCH OUTPUT

## 5.1. Goals and Objectives

The goal is to confirm or reject the hypothesis that EPCs drive social inequality. This hypothesis comes from the idea that homeowners who can afford the initial costs of sustainable renovation benefit from subsidies, lower monthly energy costs and a higher housing value, contradictory homeowners who cannot afford the initial costs, cannot become more energy efficient, and thus have more monthly energy costs and a lower housing value. To conclude whether this hypothesis is true or not, it is important to have a clear understanding of the housing dynamics as earlier mentioned, because it matters if indeed there are now two housing market dynamics, high and low energy labelled. The objective is to see whether subsidies benefit the right people, or whether there is an unbalanced situation, where subsidies can play a role in balancing social equity with environmental goals. This aligns with the overall sustainability goals because upgrading lower-labelled dwellings has a higher impact than upgrading energy labels A or B.

## 5.2. Deliverables

**Primary Outputs**: P5 report with all the findings, detailed price effect, TOM and segmentation reports of housing market dynamics with EPCs isolated, analysis on social inequality implications, and a policy brief on subsidy effectiveness to balance social equity and energy efficiency in housing.
**Supporting Outputs**: Visualisations of market segmentation, buyer profiles related to EPCs, and subsidy reach across different income levels.

## 5.3. Dissemination

The results will be presented physically in June and a final report will be published on the TU Delft repository, together with the presentation. The audience can be anyone within the field of the Built Environment, but the findings would be most relevant to policymakers (both governmental as municipal), real estate agents, and other researchers investigating housing market dynamics, EPCs and/ or social equity.

# 6. PERSONAL STUDY TARGETS

One of the personal study targets is to get a better understanding of market dynamics and the influence of a certain variable, in this case, EPCs. Besides, by looking at subsidies it is also tried to learn from these policies, how these are created and used and how effective these are. Another goal is to learn to work with large datasets and software like SPSS.  Undertaking an internship at Fakton provides the opportunity to integrate both a top-down and bottom-up approach. The company embodies a top-down perspective, while the guidance from tutors offers a more bottom-up approach. Other study targets involve being able to make conclusions based on descriptive analysis, but also based on findings using software like Atlas.ti. Study targets defined by the supervisors are:

- Designing of an empirical study;
- Performing quantitative analyses on existing databases;
- Designing of an in-dept interview protocol and conducting same interviews;
- Designing of a focus group interview protocol and conducting a focus group meeting;
- Reporting the research outcomes in a scientifical manner;
- Acquiring more insight in the daily practice of a consultancy office/company.

With the stated research methods and a graduation company in place, these study targets can be achieved.

# 7. RESEARCH PLAN

The research plan entails five phases: preparation, data cleaning and integration, quantitative analysis, qualitative research, and reporting and submission. An overview of the research plan is added as Appendix 3.

**Phase 1 Preparation (Weeks 1-2)**

The first phase is about potentially rewriting some parts of P2 based on the feedback and data availability. Simultaneously, access to datasets such as the NVM transaction data, RVO energy label data, and CBS demographic and mobility data will be secured, while tools like SPSS, QGIS, and Atlas.ti will be installed and tested. This phase is also used to get familiar with new tools like SPSS. The second week will focus on developing cleaning protocols for the datasets and initiating preliminary cleaning for smaller datasets, such as WoON and subsidy data.

**Phase 2 Data cleaning and integration (Weeks 3-4)**

This phase includes cleaning NVM transaction data, RVO energy label data, WoOn data on demographics, and RVO dataset on subsidy allocation, to address missing values, standardise variables, and remove inconsistencies. Once cleaned, the datasets that need to be linked, will be integrated. This involves the NVM transaction data with the RVO energy label data, and WoOn data with the RVO energy label data.

**Phase 3 Quantitative analysis (Weeks 5-8)**

The quantitative analysis phase is divided into three stages, each addressing a subquestion. This phase can start as soon as phase 2 is completed. In Week 5, the first stage will investigate the impact of EPCs on price and time on market (TOM) using descriptive analysis and visualisations. The second stage, conducted in Week 6, will focus on market segmentation, employing cross-tabulations and Chi-square tests to examine the relationship between EPC categories and demographic factors. Lastly, the third stage in Week 7 will analyse the distribution of sustainability subsidies across demographic groups, producing descriptive analysis and visual insights to understand the allocation patterns.

**Phase 4 Qualitative research (Weeks 6-12)**

While quantitative analysis is underway, the recruitment of participants for qualitative research will begin in Week 6. This involves identifying and inviting policymakers, real estate professionals, and energy sector experts for interviews or panel discussions. By Week 8, structured discussions will be conducted to gather insights into policy implications and potential recommendations. Thematic analysis will follow from Week 9 to Week 12, involving transcription, coding, and synthesis of the qualitative data using Atlas.ti.

**Phase 5 Reporting and submission (weeks 5-14)**

Report drafting will commence in Week 5 and proceed concurrently with data analysis and qualitative research. Each section of the report, including the methodology, quantitative findings, and qualitative insights, will be written progressively as results become available.

# 8. REFLECTION

During the summer recess, I dedicated time to investigating potential graduation themes with a view to orientate my research focus. The theme of valuation was of particular interest to me, as it aligns closely with my interests in development and my interest in courses such as building economics. Following the introductory session of the valuation graduation laboratory, I was particularly intrigued by a case study that illustrated the approach to renovation obligations and the challenges facing low-income households in Belgium. This example excited me to consider the theme of sustainability in a more general sense, and its impact on market dynamics. To provide a more concrete framework, the focus will be on Energy Performance Certificates (EPCs) as a specific measure of sustainability. This decision allows an examination of not only the influence of EPCs on market dynamics, but also the social implications they may carry, particularly concerning inequality. In order to conduct a detailed investigation of these aspects and to fill a research gap, I have incorporated the role of subsidies into my research. The objective is to determine whether subsidies inadvertently create further segmentation in the market and potentially worsen social disparities, or whether they serve as effective and equitable policy instruments.

In terms of the research process, there were initially some logistical delays. Securing a first supervisor took longer than anticipated, and during this interim period, preliminary discussions had already been initiated with several companies. Fortunately, by the time the first supervisory meeting took place, the research direction had been significantly refined. The companies were able to perceive the commitment to this topic and recognised a broader connection between sustainability goals and pressing societal concerns. Within the process I have a very free role, it is up to me to contact the supervisors when I think is necessary. This makes it that I can do the graduation at my own pace which works for me.

Looking back at the timeline until now, I think there was a bit of a rough and chaotic start because of some issues trying to find a first mentor. However, since I had already been thinking about potential subjects, the idea of research the impact of something sustainable on housing market dynamics did not change much over time. Sure, it became more specific, but the general idea stayed the same. After the P1 presentation I felt more comfortable and on-track then in the weeks before. With the feedback on my draft report and from the supervisory meetings incorporated, I had the feeling that the proposal really began to take shape and more important became concrete and feasible.

# 9. REFERENCES


Arundel, R., & Lennartz, C. (2020). Housing market dualization: Linking insider–outsider divides in employment and housing outcomes. *Housing Studies*, *35*(8), 1390–1414. https://doi.org/10.1080/02673037.2019.1667960

Aydin, E., Brounen, D., & Kok, N. (2020). The capitalization of energy efficiency: Evidence from the housing market. *Journal of Urban Economics*, *117*, 103243. https://doi.org/10.1016/j.jue.2020.103243

Aydin, E., Correa, S. B., & Brounen, D. (2019). Energy performance certification and time on the market. *Journal of Environmental Economics and Management*, *98*, 102270. https://doi.org/10.1016/j.jeem.2019.102270

Bertoldi, P., Economidou, M., Palermo, V., Boza-Kiss, B., & Todeschi, V. (2021). How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU. *Wiley Interdisciplinary Reviews: Energy and Environment*, *10*(1). Scopus. https://doi.org/10.1002/wene.384

Boelhouwer, P. (2020). The housing market in The Netherlands as a driver for social inequalities: Proposals for reform. *International Journal of Housing Policy*, *20*(3), 447–456. https://doi.org/10.1080/19491247.2019.1663056

Brounen, D., & Kok, N. (2010). On the Economics of Energy Labels in the Housing Market. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1611988

Brounen, D., Kok, N., & Menne, J. (2009). *Energy Performance Certification in the Housing Market Implementation and Valuation in the European Union*. https://www.semanticscholar.org/paper/Energy-Performance-Certification-in-the-Housing-and-Brounen-Kok/747216b5ae62c0553d815e44120a866b92ffcd13

Capital Value. (n.d.). *3. Owner-occupier and rental housing market*. Retrieved 4 January 2025, from https://en.research.capitalvalue.nl/pages/koop-en-huurwoningmarkt

Carroll, J., Denny, E., Lyons, R. C., & Petrov, I. (2024). Better energy cost information changes household property investment decisions: Evidence from a nationwide experiment. *Energy Economics*, *139*, 107909. https://doi.org/10.1016/j.eneco.2024.107909

Centraal Bureau voor de Statistiek. (2024, July 2). *Compensatie en energiebesparing remden energiearmoede* [Webpagina]. Centraal Bureau voor de Statistiek. https://www.cbs.nl/nl-nl/nieuws/2024/27/compensatie-en-energiebesparing-remden-energiearmoede

Cerin, P., Hassel, L. G., & Semenova, N. (2014). Energy Performance and Housing Prices: Does higher dwelling energy performance contribute to price premiums? *Sustainable Development*, *22*(6), 404–419. https://doi.org/10.1002/sd.1566

Chegut, A., Eichholtz, P., & Holtermans, R. (2016a). Energy efficiency and economic value in affordable housing. *Energy Policy*, *97*, 39–49. https://doi.org/10.1016/j.enpol.2016.06.043

Chegut, A., Eichholtz, P., & Holtermans, R. (2016b). Energy efficiency and economic value in affordable housing. *Energy Policy*, *97*, 39–49. https://doi.org/10.1016/j.enpol.2016.06.043

Dröes, M., & Van Der Straten, Y. (2024). Home Improvement, Wealth Inequality, and the Energy-Efficiency Paradox. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4805017

Ebrahimigharehbaghi, S. (2022). Understanding the decision-making process in homeowner energy retrofits: From behavioral and transaction cost perspectives. *A+BE | Architecture and the Built Environment*, *06*, Article 06. https://doi.org/10.7480/abe.2022.06.6573

Ebrahimigharehbaghi, S., Qian, Q. K., Meijer, F. M., & Visscher, H. J. (2019). Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making? *Energy Policy*, *129*, 546–561. https://doi.org/10.1016/j.enpol.2019.02.046

Economidou, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., & Castellazzi, L. (2020). Review of 50 years of EU energy efficiency policies for buildings. *Energy and Buildings*, *225*, 110322. https://doi.org/10.1016/j.enbuild.2020.110322

Eigenhuis. (2024). *Energie compensatie 2025*. https://www.eigenhuis.nl/verduurzamen/energierekening/compensatie-stijgende-energielasten

European Commission. (n.d.). *Energy Performance of Buildings Directive*. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

Fernández, A., Haffner, M., & Elsinga, M. (2024). Subsidies or green taxes? Evaluating the distributional effects of housing renovation policies among Dutch households. *Journal of Housing and the Built Environment*, *39*(3), 1161–1188. https://doi.org/10.1007/s10901-024-10118-5

Fregonara, E., Rolando, D., & Semeraro, P. (2017). Energy performance certificates in the Turin real estate market. *Journal of European Real Estate Research*, *10*(2), 149–169. https://doi.org/10.1108/JERER-05-2016-0022

Fregonara, E., & Rubino, I. (2021). Buildings' energy performance, green attributes and real estate prices: Methodological perspectives from the European literature. *Aestimum*, *79*, 43–73. https://doi.org/10.36253/aestim-10785

Fuerst, F., McAllister, P., Nanda, A., & Wyatt, P. (2015). Does energy efficiency matter to home-buyers? An investigation of EPC ratings and transaction prices in England. *Energy Economics*, *48*, 145–156. https://doi.org/10.1016/j.eneco.2014.12.012

Fuerst, F., Oikarinen, E., & Harjunen, O. (2016). Green signalling effects in the market for energy-efficient residential buildings. *Applied Energy*, *180*, 560–571. https://doi.org/10.1016/j.apenergy.2016.07.076

Gerassimenko, A., Defau, L., & De Moor, L. (2024). The impact of energy certificates on sales and rental prices: A comparative analysis. *International Journal of Housing Markets and Analysis*, *17*(5), 1267–1281. https://doi.org/10.1108/IJHMA-03-2023-0041

Hochstenbach, C., & Aalbers, M. B. (2024). The uncoupling of house prices and mortgage debt: Towards wealth-driven housing market dynamics. *International Journal of Housing Policy*, *24*(4), 642–670. https://doi.org/10.1080/19491247.2023.2170542

Hyland, M., Lyons, R. C., & Lyons, S. (2012). *The value of domestic building energy efficiency – evidence from Ireland*.

IISC. (2016, January 14). *Illustrating Equality VS Equity*. Interaction Institute for Social Change. https://interactioninstitute.org/illustrating-equality-vs-equity/

Janssen-Jansen, L. B., & Schilder, F. P. W. (2015). How healthy and sustainable is the Dutch housing mix? Measuring and comparing the theoretical housing market balance of

Dutch regional housing markets. *Urban, Planning and Transport Research*, *3*(1), 88–108. https://doi.org/10.1080/21650020.2015.1054565

Kaufmann, M., Veenman, S., Haarbosch, S., & Jansen, E. (2023). How policy instruments reproduce energy vulnerability—A qualitative study of Dutch household energy efficiency measures. *Energy Research & Social Science*, *103*, 103206. https://doi.org/10.1016/j.erss.2023.103206

Lankreijer-Kos, M. (2024). *Huizenprijzen: Ontwikkeling en verwachting | Independer*. https://www.independer.nl/hypotheek/info/huizenprijzen

Lihtmaa, L., Hess, D. B., & Leetmaa, K. (2018). Intersection of the global climate agenda with regional development: Unequal distribution of energy efficiency-based renovation subsidies for apartment buildings. *Energy Policy*, *119*, 327–338. https://doi.org/10.1016/j.enpol.2018.04.013

Magwood, C. (2020, August 4). *Design practice: Buildings as a Climate Change Solution – SABMag*. https://sabmagazine.com/design-practice-buildings-as-a-climate-change-solution/

Murphy, L. (2013). *The influence of the Energy Performance Certificate: The Dutch case—ScienceDirect*. https://www-sciencedirect-com.tudelft.idm.oclc.org/science/article/pii/S0301421513011841

NOS. (2021, September 11). *Jongeren over woningcrisis: 'Zo veel geld héb ik gewoon niet'*. NOS. https://nos.nl/op3/collectie/13877/artikel/2397348-jongeren-over-woningcrisis-zo-veel-geld-heb-ik-gewoon-niet

NVM. (2024). *Marktinformatie*. https://www.nvm.nl/wonen/marktinformatie/

Oirschot, R. van. (2016, March 30). *NHG-grens niet verlaagd in 2016*. NBG. https://nbg.nl/nieuws/nhg-grens-niet-verlaagd-2016/

Olaussen, J. O., Oust, A., & Solstad, J. T. (2021). Real Estate Price Formation: Energy Performance Certificates and the Role of Real Estate Agents. *Journal of Sustainable Real Estate*, *13*(1), 1–11. https://doi.org/10.1080/19498276.2021.2006875

Olaussen, J. O., Oust, Are, Tore Solstad, Jan, & Kristiansen, Lena. (2018). Energy performance certificates: The role of the energy price. *25th Annual European Real Estate Society Conference*. 25th Annual European Real Estate Society Conference. https://doi.org/10.15396/eres2018_50

Quoquab, F., Sivadasan, R., & Mohammad, J. (2022). "Do they mean what they say?" Measuring greenwash in the sustainable property development sector. *Asia Pacific Journal of Marketing and Logistics*, *34*(4), 778–799. https://doi.org/10.1108/APJML-12-2020-0919

Rijksoverheid. (2024, October 22). *Bovengrens NHG stijgt naar € 450.000, afsluitpremie verlaagd naar 0,4%—Nieuwsbericht—Rijksoverheid.nl* [Nieuwsbericht]. Ministerie van Algemene Zaken. https://doi.org/10/22/bovengrens-nhg-stijgt-naar-%E2%82%AC-450.000-euro-afsluitpremie-verlaagd-naar-04

RVO. (2017). *ISDE: Subsidie voor verduurzaming van uw woning*. RVO.nl. https://www.rvo.nl/subsidies-financiering/isde/woningeigenaren

RVO. (2024). *ISDE: Stand van zaken budget*. RVO.nl. https://www.rvo.nl/subsidies-financiering/isde/budget

Stangenberg, L., Wickeren, S. V., & Zhang, L. (2020, May 1). *The information value of energy labels: Evidence from the Dutch residential housing market*.

https://www.semanticscholar.org/paper/The-information-value-of-energy-labels%3A-Evidence-Zhang-Stangenberg/d96426f104b748c11e43d1ddaad12a6aac560442
TNO. (2024). *TNO Energiearmoede kaart Nederland*. https://energiearmoede.tno.nl/
TNO & CBS. (2024, February 1). *Monitor ISDE 2023*.
Visscher, H., Meijer, F., Majcen, D., & Itard, L. (2016). *Improved governance for energy efficiency in housing*. https://www.tandfonline.com/doi/full/10.1080/09613218.2016.1180808
Westerlaak, M. van. (n.d.). *Verduurzaming particuliere markt*. Adfiz.Nl. Retrieved 5 January 2025, from https://www.adfiz.nl/dossiers/verduurzaming/verduurzaming-particuliere-markt/
Woonnu. (2022). *Woonnu: De hypotheek die duurzaam wonen beloont*. Woonnu. https://woonnu.nl/blog/maximale-hypotheek-berekenen-wat-verandert-er-in-2024/
York, M. (2024, August 16). *Should landlords sell up or splash the cash to meet Labour's new eco rules?* https://www.thetimes.com/life-style/property-home/article/should-landlords-sell-up-or-splash-the-cash-to-meet-labours-new-energy-rules-s0jvnfkkq

# 10. APPENDICES

1. Search Query
2. Data Management Plan
3. Research Plan

# APPENDIX 1. 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)

# APPENDIX 2. DATA MANAGEMENT PLAN
## Plan Overview

*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 | .csv | Accessible with | To segment the market based on | TU Delft OneDrive | Same as above |

| | | | | | |
|---|---|---|---|---|---|
| regarding anonymous survey data, data used: specifications of dwelling, demographic information like income and education level and energy label (EPC) | | institutational account (TU Delft) via DANS. | demographics and energy labels | | |
| 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 | .pdf, .xlsx | Contact information for participants taking part in interviews or expert panel, received from professional network. Informed consent forms | For administrative purposes: obtaining informed consent and communicating with participants | SURF drive | Same as above |

| | | | | | |
|---|---|---|---|---|---|
| number | | are signed digitally and contain participants' name + email. | | | |
| Audio-recordings of expert panel with policymakers and real estate experts | .mp3 | Expert panel with 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 | Capturing the opinions on current policies and creating new policy recommendations/ reacting to policy recommendations | External recording device (temporary storage) + SURF drive | Same as above |
| 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 constent 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.

# APPENDIX 3 RESEARCH PLAN

# RESEARCH PLAN

*Dylan Schroevers - 5913195*

CURRENT WEEK 4

| ACTIVITY | START | DURATION | ACTUAL START | ACTUAL DURATION | PERCENTAGE COMPLETION |
|---|---|---|---|---|---|
| Realigning Research | 7 | 1 | 0 | 0 | 0% |
| Dataset Acquisition | 7 | 1 | 0 | 0 | 0% |
| Set Up Analytical Tools | 7 | 1 | 0 | 0 | 0% |
| Develop Cleaning Guidelines | 8 | 1 | 0 | 0 | 0% |
| Data Cleaning | 8 | 2 | 0 | 0 | 0% |
| Data Integration | 10 | 1 | 0 | 0 | 0% |
| Quantitative Analysis: Stage 1 (Pricing and TOM) | 11 | 1 | 0 | 0 | 0% |
| Quantitative Analysis: Stage 2 (Market Segmentation) | 12 | 1 | 0 | 0 | 0% |
| Participant Recruitment for Qualitative Research | 12 | 1 | 0 | 0 | 0% |
| Quantitative Analysis: Stage 3 (Subsidy Allocation) | 13 | 1 | 0 | 0 | 0% |
| Prepare for Interviews/Panel Discussions | 13 | 1 | 0 | 0 | 0% |
| Conduct Interviews/Panel Discussions | 14 | 2 | 0 | 0 | 0% |
| Thematic Analysis | 14 | 3 | 0 | 0 | 0% |
| Draft Report | 11 | 8 | 0 | 0 | 0% |
| Peer Review and Revision | 19 | 1 | 0 | 0 | 0% |
| Final Proofreading and Submission | 20 | 3 | 0 | 0 | 0% |