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Comparing the financial impact of housing retrofit policies on Dutch homeowners

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Abstract. The Renovation Wave is the latest addition to a series of European measures designed to incentivise investment in a low-carbon built environment. In terms of residential retrofits, research has focused on how structural measures can reduce costs through energy savings and improve affordability in the long term. However, it is less clear how retrofit policies can positively impact households with different income levels, energy costs and savings' opportunities across time. EU Member States have provided substantial funding for retrofitting in the form of grants, subsidised loans and tax deductions. This paper addresses with the Netherlands as case study the question: how do different retrofit measures affect the finances and affordability of homeowners in the short and longer term? Our numerical analysis is mainly based on the WoON 2018 dataset, a household-level survey. By focusing on household finances under different financing schemes, this paper aims to place renovation measures in the context of the housing affordability literature. User costs are one of the most important capital-based indicators of long-term affordability. In contrast, cash flows deal with the exchange of money and indicate financial access to housing at a given point in time. In the Dutch context of rising house prices, it is crucial to measure the short and long-term economic impact of energy efficiency measures, as they are likely to have a lasting impact on affordability. Our results show that depending on policy, a majority of homes could be retrofitted with a cost-neutral margin, depending on energy prices and post-retrofit savings. The main barrier to retrofitting is the upfront cost, which threatens short-term affordability. Loans, either subsidised or private, offer an alternative to upfront costs but reduce cost-neutrality. On the other hand, from a user cost perspective, retrofitting lowers costs in the long run. Finally, a cluster analysis shows that middle and higher income groups would be most likely to benefit from retrofitting. This raises the question of the regressive nature and targeting of flat-rate subsidies and tax deductions.

1. Introduction

The European Union has been at the forefront of the legislation on energy standards for housing. As early as 2002, the Directive 2002/91/EC On the energy performance of buildings, encouraged Member States to develop Energy Performance Certificates (EPCs) as key tools to measure the efficiency of the built environment. In 2010, the establishment of the Energy Performance of Buildings Directive 2010/31/EU (EPBD), required Member States to provide information on EPCs including cost-effective retrofit measures. More recently, the European Commission (EC) has launched the Renovation Wave (COM 2020 662), which estimates that 275€ billion of public and private investment are needed for housing retrofitting per year to achieve the goals set in the Climate Target Plan 2030.

From a valuation perspective, the market viability of housing retrofit depends on how much individuals value energy efficient homes, which translates into an energy efficiency property premium, a form of value uplift. In the UK, Fuerst [1] found a positive effect of high energy efficiency over price among home-buyers, with a 5% premium for dwellings rated A/B label compared to those rated D. However, differences across stock typologies were particularly noticeable with premiums in terraced dwellings being 4.5% compared to only 1.6% in flats. In the Netherlands, Brounen & Kok [2] also identified a 3.7% premium for dwellings with B or C ratings, with this premium going up to 10.2% for A-rated units. This paper also found that energy premiums are, in some cases, higher than the expected capitalisation of energy savings pointing to possible unobserved characteristics related to the materials used in construction.

The divergence between expected and realised energy savings also poses questions about the feasibility of retrofit. Guerra-Santin & Itard [3] point out that the introduction of EPCs in the Netherlands has only resulted in a limited reduction of energy consumption in newly-built properties. Similarly, a wide heterogeneity has been found in the expected to actual savings ratio depending on the type of energy savings measure implemented [4], sometimes ranging from 0.41 to 1.30 [5]. Researchers have pointed out that energy inefficient dwellings can consume less energy than expected, while the opposite is true for energy efficient ones. These prebound and rebound effects are at the core of the gap between performance and actual energy consumption [6]. Inconsistencies between expected and realised energy savings are also particularly relevant among certain housing typologies and household characteristics, for example, the unemployed and those on low incomes [7].

From an economic perspective, housing costs have been conceptualised as user costs and cash flows. Cash flows provide an immediate picture of the financial aspects of an investment based on a balance sheet approach including operating costs, expenses and income [8] (see Tables 1 and 2). The income to housing costs ratio, usually used to measure affordability, also employs a cash flow approach [9]. Conversely, user costs, a measure of alternatives foregone by investing in housing, have been used to analyse the long-term determinants of housing prices [10].

Next to these studies from an economic perspectives, the studies on the social and economic characteristics of residential retrofits mentioned above have focused on how property markets value retrofits on the one hand, and how energy savings vary by building typology and household characteristics on the other. This approach separates retrofit impact on household expenses and underlying asset value offering a partial picture of affordability. By focusing on energy savings and market determinants, these studies ponder either on short or long-term aspects of housing affordability and do not explicitly contextualise the resulting variation in costs within household finances.

This paper combines these two approaches by asking the question: How do different housing retrofit policies impact homeowners' finances and affordability over the short and longer-term? We employ user costs and cash flows to assess the impact housing retrofit policies can have over homeowners finances through upfront costs, longer term costs neutrality of investment and user costs. Our main objective is to contextualise retrofit policies in end-user economic calculations and numerically identify where costs and benefits accrue under different policy options in the Netherlands. The Dutch case illustrates the calculations because of pre-existent affordability issues and rising property prices. By including retrofit policies together with energy consumption and property premiums in user costs' calculations we aim to evaluate retrofit's impact on affordability under a set of funding models: partial grants, subsidised loans and income tax deductions.

This array of retrofit incentivising policies are being implemented across historically unaffordable housing markets, as in 2020 9.6% [11] of Europeans are considered overburdened with housing costs, i.e. spending more than 40% of their income on housing. The Netherlands in particular has some of the highest average housing costs across OECD countries, at 21.6% of disposable income. Furthermore, 27.7% of those in the lowest income quintile spend more than 40% of their income on housing [12]. Also, according to Eurostat [13] last year house price grew in the Netherlands by 11.3% well above the European average (6.3%). Against a backdrop of rising house prices and high housing costs, energy efficiency policies are likely to have a major financial impact on the affordability and overall configuration of the housing stock.

The next section of the paper explains the background of housing retrofit policies in the EU and the Netherlands. This is followed by a definition of the financial measures and an overview of the databases and coefficients used. A cluster analysis together with descriptive statistics forms the main part of the analysis. Finally, a contextual discussion of these findings and future research paths is provided.

2. Background on demand-side policies for incentivising energy retrofit

Following the Energy Efficiency Directive (Directive 2012/27/EU), all European Union Member States have implemented financial and fiscal measures to foster housing retrofit [14]. In the case of individual households, governments implement direct grants, soft loans or post-expense tax deductions. We focus on these measures because they differ in their cost reduction strategy: while grants and tax deductions reduce total amounts, subsidised and private loans eliminate upfront costs. The immediate reduction in total costs increases the profitability of an investment. Conversely, loans alleviate liquidity constraints, but also reduce net cash flow and thus jeopardise cost-neutrality.

Examples of these policies include direct subsidies for energy retrofit such as zero-interest loans, like the French L'éco-prêt à taux zéro (éco-PTZ); grants covering a lump sum or a percentage of the renovation costs, such as the German Energieeffizienzprogramm by Kreditanstalt für Wiederaufbau (KfW) or the Estonian KredEx Fund; and income tax deductions, like the ones implemented by the Spanish Government. Other policy options, like the British Green Deal, provide credits to be repaid with the subsequent energy savings, following a Green mortgage typology.

Table 1. Parameters

	Variable	Source
Expt	**Cash flow**	**Analysis output**
r	Long term interest rate	0.005 (Assumption)
rsub	Subsidised interest rate	0.02 (Assumption)
rpriv	Private loan interest rate	0.05 (Assumption)
D	Debt	Mortgage Payment. [23]
PAY	Principal payment	
COF	Operating cash outflow	Compilation of taxes, electricity and maintenance costs. Growth 0.02 per year. [23]
E	Energy (Gas)	Quantity WoOn 2018; prices: 0.88€/m3 including renewable energy taxes, 196€ annual fixed costs, 20% VAT [26].
S	Energy Savings	Taking B as reference: C (0.103), D (0.224), E (0.264), F (0.251), G (0.264). [27]
y	Income	Net Income. Vromhh. 0.02 Increase per year. [23]
Rtexp	Retrofit Expenses	C (5,000€), D (10,000€), E (12,500€), F & G (15,000€). [26]
t_{ded}	Tax deduction	40% of investment up to a max of 7,500. Following Spanish IRPF Discount on Energy Retrofit. Applied over a two bracket income tax (37.10% up to 69,507€ and 49.10% on income above this) taking household income bibblhr [23] as that of a single individual.
G	Grant	Policy variable. Subsidie energiebesparing eigen huis (SEEH) Max 10,000€. Assuming the grant will not cover the full amount, assume 50% of costs or 10,000 € whatever is lower.
UC	**User costs**	**Analysis output**
V	Dwelling value according to tax purposes	Dwelling value (Wozwaarde) [23]
δ	Depreciation	0.03 for retrofit expenses, see p
p	Housing price inflation	0.02. Average over 20 years. [34] Existing own homes; purchase prices, price indices 2015=100 (Since there is no comprehensive data on depreciation minus price increases, in the user costs depreciation and price inflation are conflated in p) $\delta \cdot V_t - hp \cdot V_t = V_t \cdot p$
prem	One-off property premium	0.04 [2]

The Dutch government in particular offers grants for homeowners of up to 10,000€ per home, if at least two energy savings' measures are applied, under the "subsidie energiebesparing eigen huis (SEEH)" programme. For single measures, homeowners can apply to the Investment Grant for Sustainable Energy and Energy Saving (ISDE) to fund interventions such as solar boilers, heat pumps and improved insulation [15] (Ministry of Economic Affairs and Climate Policy, 2019). When it comes to green mortgages, a wide array of banks offer different products with discounted interest rates mostly geared toward acquiring energy efficient homes [16]. Finally, the National Heat Fund provides low-interest financing for housing retrofit in the form of an Energy Saving Loan of up to 65,000€ [17]. While this paper focuses on subsidies targeting individual homeowner households, there are other measures that have been implemented to encourage retrofit among homeowners, namely labelling and information campaigns [14]. At the neighbourhood level, district heating has also been assessed as a cost effective alternative [18].

3. Methodology and data

This paper compares the financial impact of housing retrofit policies by combining the user costs and cash flows, as defined in Table 2 with the parameters presented in Table 1, under these diverging financial arrangements (partial grant, market loan, low interest credit and tax deduction). These calculations do not aim to be an evaluation of actual policy, but to analyse the capacity of these policies to deliver energy savings while reducing housing costs. As Vringer et al. [19] posit, assessing the actual efficacy of individual instruments is particularly challenging because of interactions between policies, for instances grants and reduced VAT. Consequently, in this analysis policies are considered through simulated scenarios in which they perform in isolation under a set of assumed parameters (Table 1).

Table 2. Cash flow and User Cost Formulae

Scenario	Cash flow	User cost
Baseline	$\text{Exp}_{t+1} = r \cdot D + \text{PAY}_{t+1} + \text{COF} + E$	$\text{UC}_{t+1} = r \cdot V_t + COF + \delta \cdot V_t - p \cdot V_t + E$
Cash Investment	$\text{Exp}_{t+1} = r \cdot D + \text{PAY}_{t+1} + \text{COF} + E + \text{Rtexp}$ $\text{Exp}_{t+2} = r \cdot D_{t+1} + \text{PAY}_{t+2} + \text{COF} + E \cdot S$	$\text{UC}_{t+1} = r \cdot (V_t + \text{RetExp}) + \delta \cdot \text{RetExp} + COF + \delta \cdot V_t - p \cdot V_t \cdot prem + E \cdot S$
Grant	$\text{Exp}_{t+1} = r \cdot D + \text{PAY}_{t+1} + \text{COF} + E + \text{Rtexp} - G$ $\text{Exp}_{t+2} = r \cdot D_{t+1} + \text{PAY}_{t+2} + \text{COF} + E \cdot S$	$\text{UC}_{t+1} = r \cdot (V_t + \text{RetExp}) + \delta \cdot \text{RetExp} + COF + \delta \cdot V_t - p \cdot V_t \cdot prem + E \cdot S$
Private Loan	$\text{Exp}_{t+2} = r \cdot D_{t+1} + \text{PAY}_{t+2} + \text{COF} + E \cdot S + \text{PrivLoan}$ *Where* $\text{PrivLoan} = rpriv \cdot RetCost + \text{PAY}R_t$	$\text{UC}_{t+1} = r \cdot V_t + \text{COF} + \delta \cdot V_t - p \cdot V_t \cdot \text{prem} + \text{SubLoan} + E \cdot S$ *Where SubLoan* $= rsub \cdot \text{RetExp} + \delta \cdot \text{RetExp}$
Subsidised Loan	$\text{Exp}_{t+1} = r \cdot D_{t+1} + \text{PAY}_{t+2} + \text{COF} + E \cdot S + \text{Subloan}$ *Where* $\text{SubLoan} = rsub \cdot RetCost\text{r} + \text{PAY}R_t$	$\text{UC}_{t+1} = r \cdot V_t + \text{COF} + \delta \cdot V_t - p \cdot V_t \cdot \text{prem} + \text{PrivLoan} + E \cdot S$ *Where PrivLoan* $= rpriv \cdot \text{RetExp} + \delta \cdot \text{RetExp}$
Tax Deduction	$\text{Exp}_{t+1} = r \cdot D + \text{PAY}_{t+1} + \text{COF} + E + \text{RetExp} - (y \cdot t_{\text{ded}})$ $\text{Exp}_{t+2} = r \cdot D_{t+1} + \text{PAY}_{t+2} + \text{COF} + E \cdot S$	$\text{UC}_{t+1} = r \cdot (V_t + \text{RetExp}) + \delta \cdot \text{RetExp} + COF + \delta \cdot V_t - p \cdot V_t \cdot prem + E \cdot S - (y \cdot t_{\text{ded}})$

In housing retrofit in particular, cash flows are commonly used to assess investment payback and savings to investment ratios [20]. User costs are a traditional tool for the evaluation of stable homeownership expenses over time [21], see Table 2. Cash flows and user costs are also embedded in national housing taxation regimes. For instance, theoretically, a user cost approach to housing taxation would involve mortgage interest deduction and imputed rent taxation. However, tax codes across Europe are less theoretically coherent and these elements are rarely present at the same time [22].

Since the aim of this paper is to compare the impact of retrofit policies on housing affordability, we have combined fiscal benchmarks from user costs and cash flow approaches, for example by including income tax deduction as a factor on user costs. To compare the financial impact of these retrofit policies on homeowners' user costs and cash flows, we first subtract forwarded user costs and cash flows from a no-retrofit baseline. In a second stage, we calculate the Net Present Value (NPV) of the cash flows under the different scenarios presented in Table 2, together with a summation of user costs and a sensitivity analysis of energy costs and savings. Finally, to illustrate our findings we use the K-mean cluster algorithm on a subset of variables (NPV, income, property values and gas consumption), to compare the impact of different policies on household affordability and retrofit feasibility over the no-retrofit baseline. The main database used for these calculations is Woon Onderzoek Nederland (WoON) 2018 [23]. WoON is a large household survey of housing costs, affordability and quality of life collecting representative data for the whole country through the stratified sampling of approximately 60,000 respondents. This data is supplemented by a range of parameters regarding energy prices and savings as well as property premiums and retrofit costs extracted from secondary sources (see Table 2 for detail). The use of a static model with predetermined parameters carries limitations in the realistic representation on decision-making processes; however, it serves to illustrate policy impacts on affordability indicators and the built environment as a whole.

4. User cost and NPV

Cash flows and user costs show divergent pictures of the financial impact housing retrofit can have over household finances. To analyse cash flows over a 30-year period, we calculated the corresponding NPV of the cash investment through the sum of the discounted operating costs and the investment and the deduction of expected revenues, in this case energy savings for the different policy scenarios (Table 3). NPV shows a positive return of investment in an overwhelming majority of cases with a grant (85%), which diminishes significantly with tax deductions (55%), direct cash expenditures(33%) and lastly different loan agreements (25 to 4%).

Table 3. NPV and cash flow simulation of retrofit policies over 30 years, 2018 as first year

	Demand-side subsidy						
	Cash expenditure	Partial grant	Tax deduction	15 year loan, 0.5% interest	30 year loan, 0.5% interest	15 year loan, 0.2% interest	30 year loan, 0.2% interest
Percentage of households with positive NPV)	8240 (33%)	20918 (85%)	13436 (55%)	3008 (12%)	1006 (4%)	6061 (25%)	4386 (18%)
Households facing unaffordability in first period	16628 (68%)	11694 (48%)	14921 (61%)	5713 (23%)	5293 (22%)	5471 (22%)	5012 (20%)

Table 4. Households with lower cumulative user costs with respect to baseline

	Cash expense	Tax deduction	30-year loan, 0.5% interest	30-year loan, 0.2% interest
Household Count	23961 (94%)	23961 (97%)	11674 (48%)	20105 (82%)

However, cash flows in ratio with income, show an initial affordability issue with up-front retrofit costs for 68% to 48% of households in the cash expense, grant and tax deduction model all requiring households to front a proportion of the initial retrofit investment. Conversely, loan based subsidies make retrofit investments affordable for a majority of households leaving just 20 to 23% of households below the affordability threshold of 40% ratio of housing costs, but reducing positive NPV. This suggest a trade-off between higher NPVs at larger upfront costs, which may jeopardise housing affordability for cash-strapped households; and lower costs, which make the retrofit investment less viable. Similarly, recent research from the Dutch Central Bank points to only half of all homeowners disposing of the available savings to make their homes energy neutral [24]. Conversely, the user costs of housing retrofit show how property premiums together with energy savings compensate the retrofit investment in an overwhelming majority of cases except in the case of private or subsidised loans. In short, while the cash flows point to upfront affordability issues, user costs showcase the importance of property premiums in capital gains.

The user costs housing retrofit in Table 4 oscillate depending on the price of capital. In a cash only retrofit, capital gains because of property premiums and a reduction in outgoing cash flows through energy savings produce on average a reduction in user costs of about 300€ in month one when compared to a no-retrofit baseline. Reductions in user costs are lower with subsidised interest rates and negative for the first 15 years with private financing. The cumulative user costs over 30 years show cash expenses and tax deductions reducing user costs for almost all households. Following the literature on user costs [25], a reduction of this magnitude is likely to lead to a higher price, which may drive prices upwards producing affordability issues for first-time buyers. However, property premiums are likely to reduce as the adoption of higher energy efficiency becomes more widespread.

Energy-related parameters have a crucial impact over the feasibility of housing retrofit, in particular gas quantity consumed prior to the retrofit (after filtering for typology and homeownership, 24469 (93%) housing units used gas boilers as the main heating source according to WoON 2018), energy prices and post-retrofit energy savings. Energy prices show extreme volatility and are contingent on geopolitical developments, as a result its forecasting poses particular problems. On energy costs, our analysis draws from [26] and on energy savings from [27]. When it comes to post-retrofit energy savings, prior work [2][3][4][5] has shown that income, household composition and the heterogeneity of the built form make it difficult to make generalisations. The simple sensitivity analysis in Figures 1 and 2 reveals the impact these can have over the net present value of the retrofit of an average property consuming 1,575m^3 gas a year. If we exclude property premiums, the amount of gas consumed prior to the retrofit is key in determining the number of years to recoup the investment, together with the energy savings. For initial values lower than 1.250m^3, the investment recoup time is beyond 30 years, even at a high-energy price as per Figure 2.

Figure 1. NPV sensitivity analysis to energy savings and prices

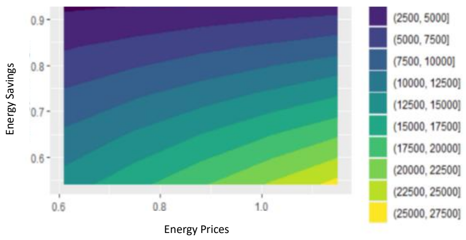


Figure 2. Payback period by initial gas volume consumed and energy efficiency band

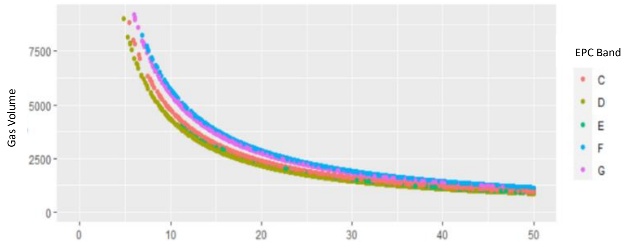


Table 5. Clusters descriptive statistics

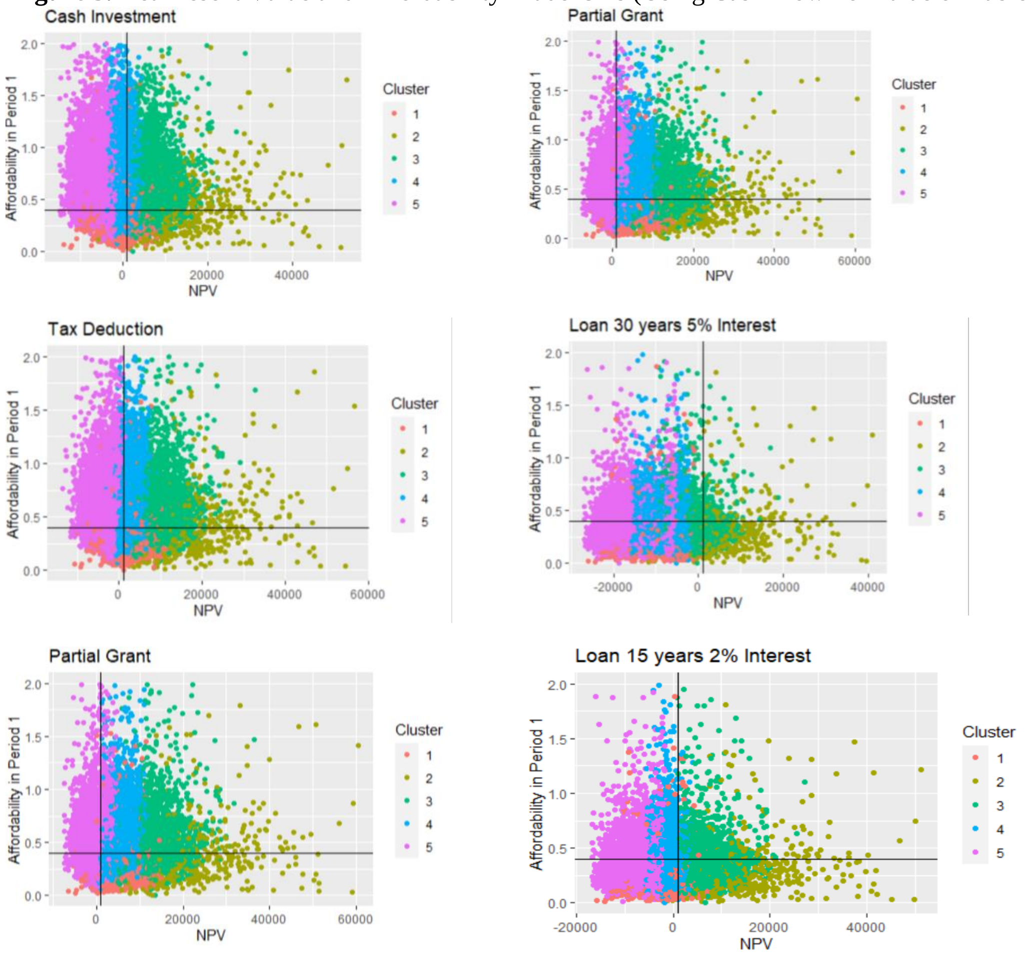
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Household Count	2273	481	2607	9867	9241
Average Annual Household Income	€ 83.649	€ 122.261	€ 45.893	€ 43.205	€ 37.375
Average Property Value	€ 451.125	€ 700.787	€ 311.053	€ 217.415	€ 193.163
Average Gas consumption before retrofit	1.884	4.420	3.029	1.777	988
Average Cumulative Energy Saving	€ 12.300	€ 32.700	€ 21.060	€ 9.090	€ 5.940
Average Cumulative Capital Gains Post-Retrofit	€ 21.962	€ 34.115	€ 15.143	€ 10.584	€ 9.404

The k-means algorithm with five clusters accounted for 53% of the total sum of squares across income, property value, NPV of cash retrofit and gas consumption before retrofit. In Figure 3, the combination of NPV and first period affordability shows how a flat-rate grant or tax deduction without means testing has the strongest impact on retrofit viability for middle and high-income groups, clusters 1, 3 and 4 but only adds to already positive NPVs in group 2 (see Table 5 for characterisation of clusters). However, a partial grant is not sufficient to improve NPV of a majority of those in cluster 5, low incomes and low energy consumption, but it reduces the initial upfront costs below affordability levels for about a half of cluster 5. In contrast, a 15 year loan at 2% interest results in a majority of households (78%) below the affordability threshold but considerably reduces NPV. Surplus capital gains post retrofit also accrue in higher income clusters, 1 and 2, because of higher property values. Although more research is needed, this points to a regressive element in fabric-dependent subsidies. The capitalisation of subsidies on property values highlights the need for means-tested grant allocation. This would improve the targeting of grants and subsidised loans to households in cluster 5 and 4, with lower incomes facing affordability issues through high up-front costs and meagre energy savings expectations that reduce NPV. In the case of cluster 3, which faces affordability issues, but positive NPVs, a subsidised loan may be enough to increase retrofit rates.

5. Discussion

This paper aims to provide a numerical analysis of how different types of subsidies reduce upfront expenses, as well as long-term costs and improve viability of housing retrofit for homeowners with varying levels of income, property values and energy saving expectations. Clusters 1 and 2, with higher incomes and retrofit costs below the 40%-affordability threshold are the ones most likely to benefit from partial grants and tax deductions. These policies improve the cost-neutrality of retrofit investments and in some cases they add to already positive NPVs. This comes on top of the reduction in user costs

Figure 3. Net Present Value and Affordability Trade-Offs (Using Cash Flow Formulae of Table 2)



due to energy premiums that increase property values. Grants and tax deductions have a larger impact in turning negative NPVs to positive ones in clusters 3 and 4. However, upfront costs are still sizeable and loans present too large of a trade-off between upfront affordability in the first period and a positive NPV. It is those in cluster 5, lower than average incomes and lower average gas consumption, that are most likely to lag behind in retrofit rates, since financial incentives are not enough to push them over cost neutrality and only in some cases loans manage to reduce upfront costs.

Means tested grants, not only linked to fabric standards but also to household income and wealth, have the potential to mitigate the capitalisation of retrofit grants on households with an already positive retrofit NPV. The lack of targeting of retrofit subsidies is a potentially relevant factor in the entrenchment of housing inequalities through the current environmental transition. The policies covered in this article are centred around fabric conditions and lack a deliberate integration of housing affordability dimensions. From a traditional economic perspective [24], subsidising the transition of asset-owning households carries the risk of further raising property prices and reducing affordability for future generations of homeowners. However, more sophisticated econometric analysis is needed to develop this point. Pay-as-you-save financing models offer a realistic alternative to flat rate subsidies. However, as the recent UK Green Deal example shows, loan conditions, savings uncertainty and administrative burdens can have a large impact on funding uptake [28]. While retrofit subsidies are designed with the objective of reducing carbon emissions, their financial impact on households has the potential to balance or eschew the distribution of housing wealth among homeowners.

Nevertheless, this paper has not addressed more complex renovation strategies that may include renewable energy production or net zero strategies [29]. In fact, heterogeneity across the building stock poses particular challenges linked to tenure, for example dealing with mixed-owned apartment buildings [30]. Another relevant area of research are the synergies between financial and institutional as well as regulatory frameworks [31] or information campaigns [14].

Recent evidence from behavioural economics [32] has also highlighted the limitations of a financial analysis based on expected utility by including cognitive biases. This stream of research has not only significantly improved the predictive analysis of decision making processes in housing retrofit, but also raises questions on the distributional impact due to retrofit uptake being contingent on income and wealth. Integrating these, together with affordability dimensions through stock management models [33] offers relevant avenues for future research to account for dynamic changes in price affecting affordability.

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