

Article

To What Extent Could Alternative Economic Models Increase Investment in the Renovation of and Reduce Energy Poverty in Social Housing in Flanders?

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Abstract: An important share of the social housing stock in Flanders is outdated, resulting in a high energy demand for heating. Energetic renovation is hence urgently needed. The current economic model, however, does not stimulate this due to a split incentive. As energy prices have increased in the past few years, more tenants have suffered from energy poverty. This paper investigates three alternative economic models aiming at increasing the incentive for renovation, while financially protecting the tenants. In the first alternative model, tenants are protected by inducing a maximal cost of living based on their income. In the second alternative model, a fixed rent is applied, while the third alternative model proposes to share the cost benefits of the energetic renovation. The paper analyses the alternative models by assessing the costs and income for social housing companies and the costs for tenants for an unrenovated building, a renovation with a low investment cost and a deep energetic renovation. The results show that limiting the cost of living based on income seems most interesting as this is beneficial for the tenants and gives an incentive for the social housing companies to renovate. To reduce energy poverty, a deep renovation is necessary.

Keywords: energy renovation; life cycle costing; social housing; affordability; cost of living; financial feasibility



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1. Introduction

The use and operation of buildings in Europe is responsible for 36% of the European greenhouse gas (GHG) emissions [1]. More specifically, households are responsible for 27% of the energy use in Europe [2]. A comparable situation is found for Flanders, where residential buildings are responsible for 22% of the non-ETS GHG emissions [3]. Besides the environmental consequences related to high energy use, there is an important social consequence, namely energy poverty. Recent data [4] show that 20.6% of households in Flanders suffered from energy poverty in 2021. The majority of those households have an energy cost that is too high compared to their income (14.9%). Additionally, a smaller number of the households suffer from “hidden energy poverty” (4.5%), as they do not heat their houses properly because they cannot afford to pay for heating. Finally, 3.2% of the households suffer from “subjective energy poverty” as they are worried that they will not be able to afford to heat their houses. The situation in social housing is even worse as 41.5% of the tenants suffer from energy poverty [4]. The situation in Flanders is not exceptional, as in 2018, nearly 34 million Europeans (7.6%) were unable to afford to keep their homes adequately warm [5]. According to the literature, income levels, the energy efficiency of the housing stock and energy prices are the three drivers of energy poverty [6,7].

Deep energy renovation cannot only mitigate climate change; it can also decrease the risk of energy poverty. This paper focuses on the social housing sector because of its urgent problem of energy poverty and because the majority of the housing stock is outdated [8]. There is, however, an important challenge related to the renovation of social housing as

the sector faces a split incentive where the social housing companies (SHCs) need to make the investment for the renovation, while the tenants benefit from the reduction in the energy cost.

To overcome this split incentive, an energy correction fee for houses with lower energy use has been proposed since 2019 [9]. In practice, this correction fee is not sufficient for the energy renovation as the fee is about EUR 10–20 per month per house [10]. The current financial model for social housing is hence still characterised by this split incentive. To date, the maximum rent for social housing in Flanders is determined by the income of the tenants [11]. For energy, the tenants rely on the tariff of the energy supplier. Although there are different energy suppliers on the market in Flanders, each offering multiple tariff formulas (for example, one single tariff, split tariff for day and night consumption, fixed or volatile energy process, etc.), it is often difficult for tenants to select the appropriate energy contract for their specific needs, often resulting in high energy prices.

A recent paper argues that to reduce energy poverty, policies should, besides considering income, energy efficiency and energy prices, additionally look into vulnerable groups such as social welfare recipients and their right to decent housing [12].

This paper investigates whether alternative economic models for social housing could increase the renovation rate by solving/reducing the issue of the split incentive and simultaneously reducing energy poverty.

2. Materials and Methods

This section describes the methods used in the research. Energy poverty as defined in this paper is discussed, followed by a clarification of the assumptions and type of data used for the analyses. Subsequently, three alternative economic models are presented, and finally, the calculation methods used in this paper are presented.

2.1. Definition of Energy Poverty

In its recommendation on energy poverty, the European Commission defines energy poverty as a situation in which households are unable to access essential energy services [5]. In the recommendation, the European Commission proposes various indicators to assess energy poverty, such as indicators comparing spending on energy with income; indicators based on self-assessment (for example, households are asked to what extent they feel able to afford energy to keep their home warm enough in winter and cool enough in summer); and indirect indicators such as housing quality. Bouzarovski and Petrova define energy poverty as the inability to attain a socially and materially necessitated level of domestic energy services [13]. The EU statistics on income and living conditions (EU-SILC) refer to three indicators regarding energy poverty: (1) inability to keep home adequately warm, (2) population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames or floor and (3) arrears on utility bills.

To assess energy poverty in social housing in Flanders, a quantitative definition is used in this paper. According to Meyer and Coene [4], households suffer from energy poverty when their energy cost, for both electricity and natural gas, is higher than 9.6% of the monthly income of the household after the subtraction of the cost of living. This definition is more strict than the definition of energy poverty of Boardman [14]: “Energy poor persons or households are those for whom the energy costs incurred to maintain indoor temperatures exceed 10% of the household income”, which is still used in current research [15]. As this paper focuses on energetic renovation, the definition of Boardman is used to define energy poverty, as this definition focuses on the energy cost of heating. As a sensitivity assessment, the results are checked against the definition of Meyer and Coene.

2.2. Clarification of the Assumptions

Data on the average income of tenants and the average rent of social housing in Flanders are retrieved from sector statistics [16], which have been collected by an umbrella organisation called Wonen in Vlaanderen (Living in Flanders). The data show that in 2021,

the average yearly income of the tenants in social housing in Flanders was EUR 15,000 and the average rent was EUR 335 per month. The average monthly rent is thus 2.2% of the average yearly income, which is in line with the general guidelines to define the monthly rent as 1/55th of the yearly income, with some corrections depending on the size of the family or the quality of the housing, as described in the regional standard since 2017 [11]. As only data up to 2021 are available, an estimation is made on the average income of households for 2023. To estimate this income, the Flemish indexation on loans and allowances due to the increased consumer prices since 2022 is used. The assumed increase in the income for households in 2023 is thus based on the increase in minimum allowances in Flanders, which were 23% higher in 2023 compared to 2021 [17,18]. Since the calculation standard to define the monthly rent for social housing has been unchanged since 2020 [11], the monthly rent for 2023 is assumed to be 2.2% of the yearly income for 2023, namely EUR 412.

Data on the average energy use for households in Flanders are based on the statistics of the Flemish energy regulator. Their statistics for 2020 show an average energy use for households in Flanders of 17,000 kWh per year for natural gas and 3500 kWh per year for electricity [19]. The regulator, moreover, reports on the prices for electricity [20] and natural gas [21] on the Flemish market, both expressed in EUR per kWh. As for 2021, no data on the price of natural gas is available for Flanders, the data for 2021 are searched in the Eurostat database [22,23]. In this paper the price for 1 kWh natural gas in 2021 and 2023 is assumed to be, respectively, EUR 0.05 and EUR 0.1. For electricity, the price for 1 kWh in 2021 and 2023 is, respectively, EUR 0.27 and EUR 0.39. All prices include taxes and levies.

The reduction in energy use and the environmental and financial impact of social housing through various renovation measures have been studied in detail by Van de moortel [10]. To avoid burden shifting, not only the reduction in energy use but also the reduction in total environmental impact, i.e., the impact on multiple indicators (climate change, particulate matter, biodiversity, human health, land use, etc.) over the whole service life of the building were assessed in this study [10]. For this paper, two renovation options for a representative dwelling for social housing in Flanders are selected from this broad study. Detailed information on the case study and the selected renovation options can be found in the Supplementary Materials. The representative dwelling is a terraced one-story single-family house (79 m² usable living area) located in Mol, Flanders, constructed in the seventies of the previous century. The first renovation option is an option with minimal financial investment cost, i.e., replacing the windows and replacing the low-efficiency gas boiler (97%) with a new condensing gas boiler with higher efficiency (104%). The second renovation option is an option that maximally decreases the environmental impact, i.e., thermally insulating the full building envelope and replacing the boiler with a heat pump with a Seasonal Performance Factor (SPF) of 2.86. For the renovation option with the lowest investment cost, a reduction in energy use of 24% was found, along with a reduction in the total environmental impact of 11%. For the deep renovation option, the reduction in energy use and total environmental impact were, respectively, 86% and 45%. An overview of the efficiency of the heating system, the gross and net energy use for heating, and the yearly cost for heating before renovation and after renovation (for the two selected renovation options) is provided in Table 1.

Table 1. Efficiency heating system, energy use and yearly cost for heating before and after renovation.

	Without Renovation	Low-Investment Renovation	Deep Renovation
Gross energy use for heating (kWh)	17,526	12,807	2454
Efficiency heating system (%)	97	104	286
Net energy use for heating (kWh)	17,000	13,320	858
Yearly cost for heating in 2021 (EUR)	850	640	232
Yearly cost for heating in 2023 (EUR)	1700	1281	335

The investment cost for these renovation options is based on the calculation standard to define the maximal loan for construction works in the social housing sector in Flanders—the so-called “FS3 system” [24]. The financial support in this system consists of a loan at market rates provided by VMSW and a yearly intervention by the Flemish Government, resulting in a reduced interest rate. The repayment period for the loan is set at 33 years. The FS3 system defines a maximal amount for a loan for renovation, determined by the floor area of the house and the type of renovation. For the first renovation option, an investment cost of EUR 19,500 is estimated, while for the second renovation option, the estimated investment cost is EUR 48,500. This results in yearly repayments for a loan of, respectively, EUR 522 and EUR 1299 in 2021. As a consequence of the geopolitical context in 2022, the prices of materials and labour increased significantly in Flanders. The increase in renovation cost is assumed to be similar to the increase in income, namely 23%. The yearly cost to repay the loan for renovation in 2023 is therefore assumed to be EUR 642 for the first renovation option and EUR 1597 for the second option: deep renovation.

2.3. Alternative Economic Models

The first alternative model originates from a discussion with SHCs during a research project on the sustainable renovation of social housing [10]. It was proposed to limit the monthly cost of living, COL, (i.e., the cost of rent and the cost of energy for heating) based on a percentage of the yearly income of the tenant, instead of only limiting the rent to a percentage of the income of the tenant, as is the case to date. In 2021, the average monthly COL was 2.7% of the yearly income. To lower the COL for the tenants, it is assumed in this paper that the monthly cost of living could not exceed 2.5% of the average yearly income. This alternative economic model, moreover, implies that the SHCs would function as an energy supplier. To date, an SHCs is allowed to pay the reduced tariff for natural gas, i.e., 0.02 EUR/kWh, when the building is heated with a collective installation using natural gas [25]. It is currently being investigated whether this legislation can be applied to a collective heating system on electricity. In this paper, it is assumed that this will be possible in the future, and the reduced tariff for electricity, namely 0.21 EUR/kWh, is applied in this economic model. This alternative model is further referred to as “model COL 2.5%”.

A second alternative economic model is based on the literature, more specifically on the work of Khan, who describes the economic model of social housing in the Netherlands [26]. Here, the SHCs obtain a loan on the private market at market rates. The rental price for social housing in the Netherlands is regulated by the government and is set to EUR 512. Additionally, the government supports low-income households with a subsidy if they cannot afford the rent. In this paper, the fixed amount for rent is assumed to be 30% of the average income, so EUR 375.00 in 2021 and EUR 462.38 in 2023. This assumption is based on the Flemish Housing Council’s advice on living in poverty, where it is stated that a ratio of rent compared to income higher than 30% is assumed to be too high [27]. This second alternative model is further referred to as “model NL”.

A third economic model is based on a 50–50 division of the benefits due to reduced costs for heating after renovation. This model was proposed by SHCs in Flanders during a stakeholder meeting for a research project on reducing the environmental impact of energy poverty in social housing in Flanders [28]. The third alternative model is further referred to as “model 50–50”.

2.4. Method to Calculate Energy Use and Energy Correction Fee

In this paper, data from previous research on sustainable renovation of social housing are used. More information on the case study and the renovation options that are used as a basis for this paper is included in the Supplementary Materials. A detailed description of the methods used to assess the energy use, life cycle environmental impact and the energy correction fee can be found in the publication of Van de moortel [10]. A short summary of the methods used is presented in this paragraph. To estimate the energy use for heating, the Equivalent Heating Degree Day method (EHDD) [29,30] is used. This method estimates

the net energy used for heating based on the heat loss surface and heated volume of the building, the average heat transfer coefficient of the building envelope, the ventilation rate, airtightness, indoor and outdoor temperature, solar gains, and internal gains.

To assess the environmental impact of the building before and after renovation, the Belgian LCA method for buildings [31] and the corresponding monetisation method [32] have been used.

The energy correction fee is calculated following the formula presented in the regulation published in 2019 [9]. The amount of the fee is based on the ratio of the primary energy use of the specific house compared to the primary energy use of a default building defined in the regulation, considering space heating and the production of sanitary hot water. As this paper is based on average values for a representative dwelling, the monthly energy correction fee after renovation is assumed to be EUR 10 for the low-investment renovation option and EUR 20 for the deep renovation option.

3. Results

3.1. Current Risk of Energy Poverty

To gain insight into the evolution of energy poverty in social housing in Flanders over the past five years, an overview of the ratio of the costs for energy compared to the income of the tenants is presented by the full line in Figure 1. Additionally, in Figure 1, the ratio of the costs for heating compared to the income is presented by the dashed line. As shown in Figure 1, the total cost for energy exceeds the 10% threshold for all years, meaning that families suffered from energy poverty according to the definition of Meyers and Coene [4]. A remarkable increase is shown for 2022, due to the significant increase in energy costs as a result of the geopolitical situation. During the first months of 2023, the energy prices decreased again; however, they are still at a higher level compared to the situation before 2022. If only the cost for heating is studied, the ratio was well below 10% until 2021. Due to the increase in energy prices over the past two years, the cost of heating approaches 10% of the income threshold. As a result, according to the definition of Boardman [14], the households have suffered from energy poverty since 2022.

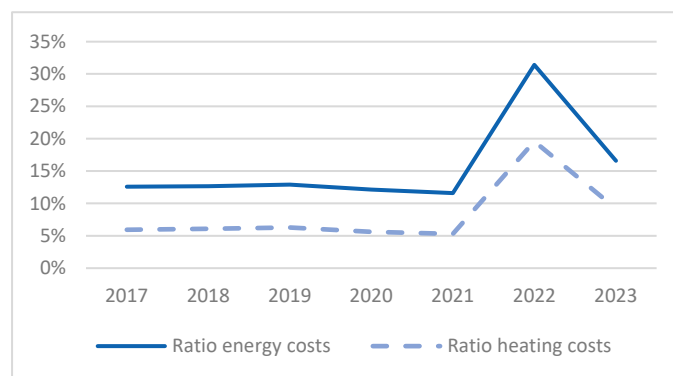


Figure 1. Ratio of the yearly costs for energy and yearly costs for heating compared to the yearly income of tenants over the past five years.

3.2. Results Alternative Economic Models

The results for the existing economic model and the three alternative models are presented for the SHCs in Figure 2 and for the tenants in Figure 3. For each economic model, the results for the building before renovation, after renovation with the low investment cost and after the deep renovation are presented for 2021. To give insight into the effect of the increased prices for energy and materials and increased income and rent, a sensitivity assessment is conducted for 2023. The total income of the SHC, i.e., income from rent minus the costs to repay the loan for renovation, is presented by the dark blue line in Figure 2. The cost of living for the tenants, i.e., the cost of rent plus the cost of energy for heating, is presented by the orange line in Figure 3.

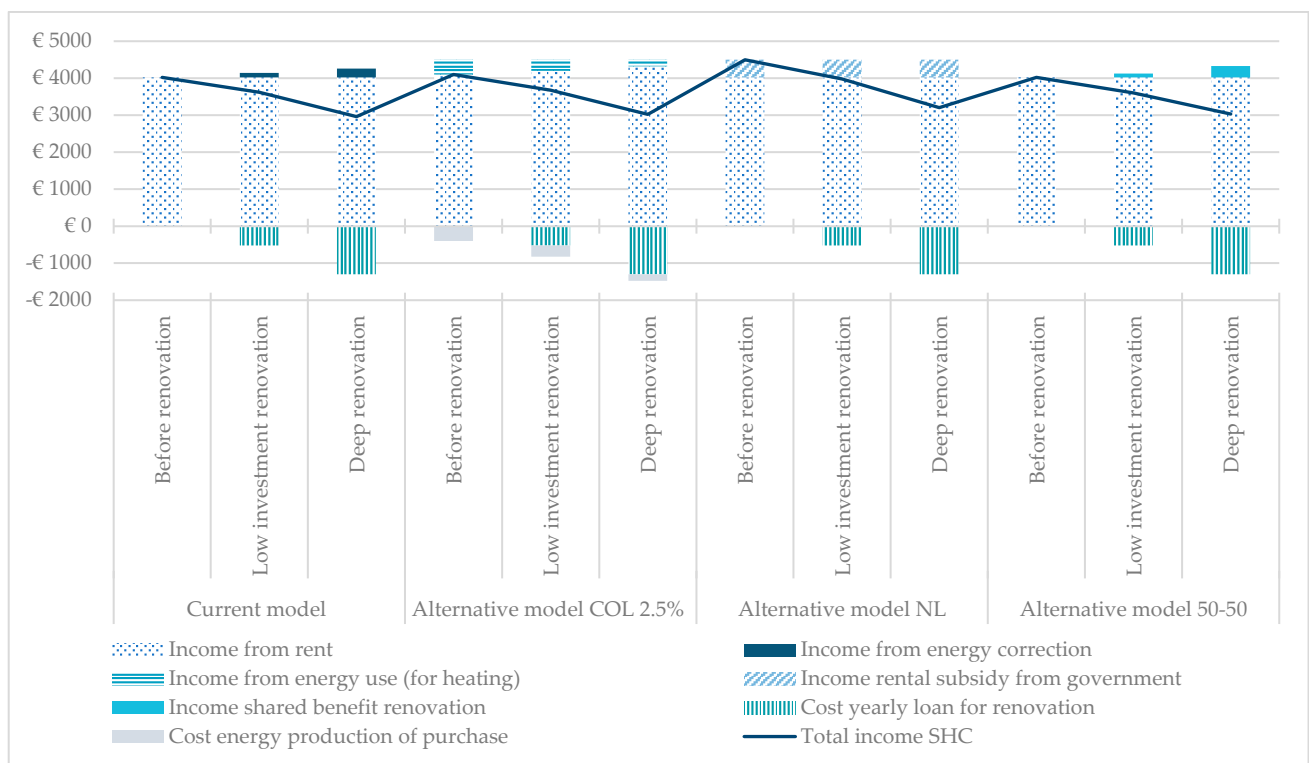


Figure 2. Overview of yearly income and costs for SHCs before renovation and for two renovation options in four economic models.

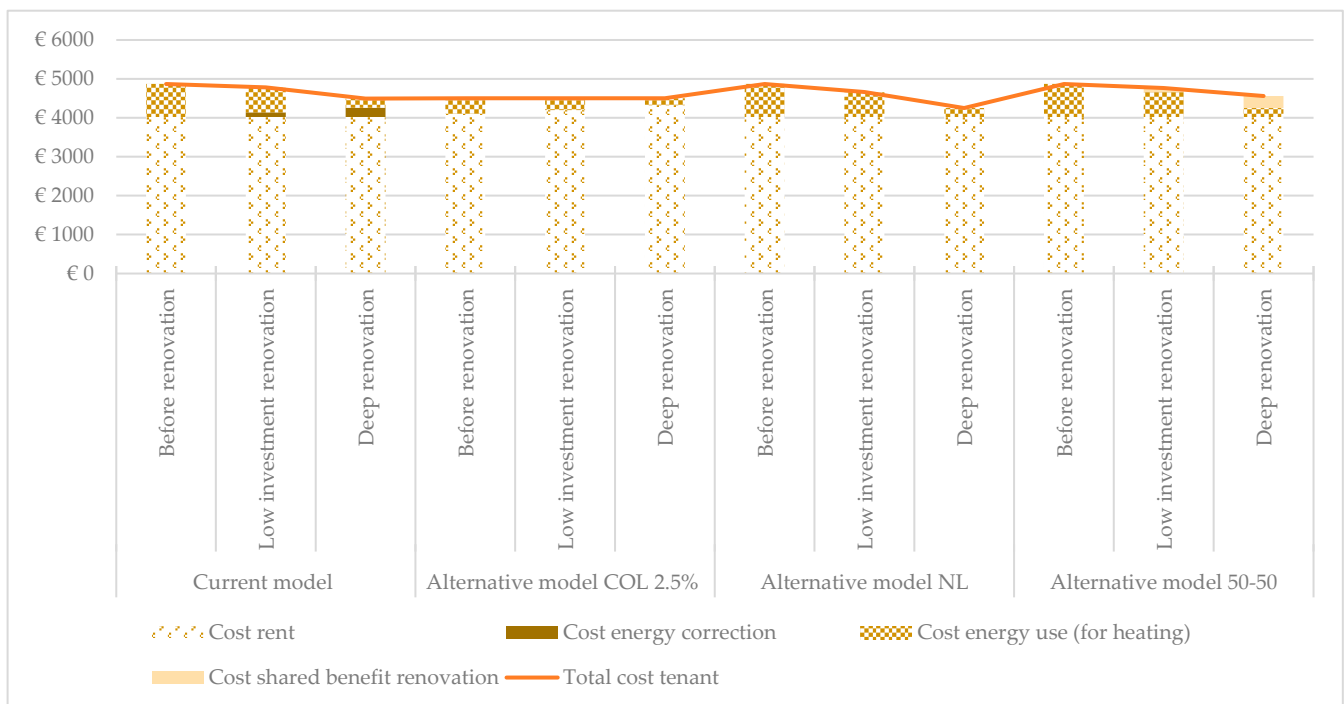


Figure 3. Overview of yearly costs for tenants before renovation and for two renovation options in four economic models.

The results for the SHCs show that the yearly income from rent is sufficient to repay the cost of the loan for renovation for all renovation options. In the current economic model, the energy correction is not sufficient to compensate the loan for the renovation,

resulting in a lower total income for the SHCs. For the first alternative economic model (COL 2.5%), the income from rent before renovation increases by 2%, compared to the current economic model and by 5% and 8%, respectively, after the low-investment and deep renovations. This is due to the reduced energy cost after renovation, allowing for an increase in the rent without exceeding the 2.5% ratio for the monthly cost of living compared to the yearly income. Although the increased income from rent is insufficient to compensate for the investment cost of renovation, the increased income from rent after renovation could be an incentive for the SHCs to invest in renovation. For the second alternative economic model (NL), an increase in income from rent of 12% is found compared to the current economic model. Since the increase in rent is not related to the renovation, this economic model does not result in an incentive to invest in renovation. The increase in rent is, however, not enough to compensate for the cost of the loan for both the low-investment and the deep renovation options. In the third alternative economic model (50–50), no increase in rent is included. The shared benefit from the energy renovation is not sufficient to compensate for the renovation cost. Again, this model does not result in an incentive to invest in renovation. Regarding the total income for the SHCs, the dark blue line in Figure 2, a decrease in income after renovation is found in every economic model. Comparing the different economic models, a similar decrease in total income for the SHCs of, respectively, 10% and 26%, after the low-investment and deep renovation is found in the current economic model and alternative economic models COL 2.5% and 50–50. In the alternative economic model NL, a decrease in the total income for the SHCs of, respectively, 12% and 29%, is found after the low-investment and deep renovations. When comparing the total income of the SHCs over the different alternative economic models, some differences are found, as presented in Table 2. The smallest increase in total income for the SHCs compared to the current economic model is found for alternative model 50–50, 0% to +2.6%, and for alternative model COL 2.5%: +1.9% to +2.4%. The highest increase in total income for the SHCs compared to the current economic model, +8.1% to +11.9%, is found for alternative model NL. However, in alternative model NL, the total income of the SCHs compared to the current economic model is smaller after renovation. Although smaller profits are expected from alternative models COL 2.5% and 50–50, they give an incentive for renovation compared to the current economic model.

Table 2. Overview of total income for SHCs in alternative economic models compared to the current economic model.

	Before Renovation	Low-Investment Renovation	Deep Renovation
COL 2.5%	+1.9%	+2.1%	+2.4%
NL	+11.9%	+10%	+8.1%
50–50	+0%	+0.1%	+2.6%

Considering the tenants' perspective, the total cost decreases after renovation in all economic models, except for the alternative economic model 'COL 2.5%', where the cost is limited to a percentage of the yearly income regardless of the renovation, as shown in Figure 3. Table 3 presents an overview of the total cost for the tenants in the alternative economic models compared to the current economic model. For the alternative economic model 'COL 2.5%', the difference with the current economic model is the highest before renovation and is comparable after deep renovation. This is due to the limited cost of energy use after deep renovation, resulting in a total cost for the tenant in the current model close to 2.5% of the yearly income, whereas before renovation the cost for heating is much higher in the current economic model. In the second alternative economic model 'NL,' the increased rent is paid by the government. This results in identical costs for rent and energy use for the tenant compared to the current economic model. Since the energy correction is not included in this alternative economic model, the total costs are, however, lower compared to the current economic model. It should be noted that in this alternative

economic model, the tenants still have to negotiate their individual contracts with energy suppliers. The ‘50–50’ economic model results in a comparable total cost for the tenants compared to the current economic model. This is because the energy correction for the low-investment renovation is similar to 50% of the energy benefits. However, for the deep renovation, the current energy correction fee is lower than 50% of the shared benefits after renovation, resulting in a small increase in total cost for the tenants compared to the current economic model. From a tenant’s perspective, limiting the monthly COL to 2.5% of the yearly income is the most beneficial.

Table 3. Overview of total cost for tenants in alternative economic models compared to the current economic model.

	Before Renovation	Low-Investment Renovation	Deep Renovation
COL 2.5%	−7.6%	−5.1%	−0.5%
NL	0%	−2.5%	−5.4%
50–50	0%	+0.1%	+1.7%

To provide insight into the effect of the increased prices for energy and materials and the increased income and rent, the results of the sensitivity assessment for 2023 are presented in Figure 4. For the SHCs, a similar trend is found for 2021 and 2023. For the tenants, however, the effect of renovation on the total cost has increased. This is due to the high increase in energy costs in 2023. Although the effect of energy prices is more important in 2023, alternative economic model ‘COL 2.5%’ remains the most interesting as it provides an incentive for deep renovation to the SHCs and reduces the total cost for the tenants.

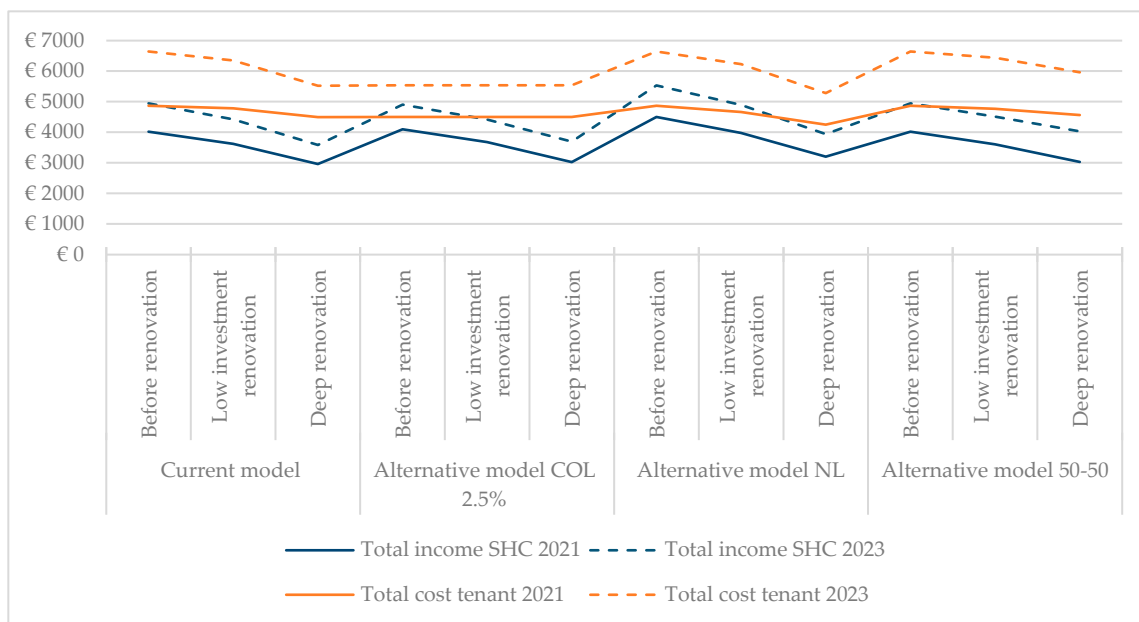


Figure 4. Overview of total income for SHCs and total cost for tenants for 2021 and 2023.

A second sensitivity assessment investigates the importance of the income of tenants. Therefore, the calculations are done assuming the lowest (1% of the tenants earn EUR 2500 per year) and highest (6% of the tenants earn EUR 40,000 per year) income presented in the statistics of the sector for 2021 [16]. The detailed results of this sensitivity assessment are presented in the Supplementary Materials of this paper. As the rent is based on the income from tenants, a lower income affects the income from rent for the SHCs. When tenants have a low income, the rent is no longer sufficient to compensate the cost to repay

the loan for the deep renovation, neither in the current economic model, nor in any of the alternative economic models. For economic model 'COL 2.5%', where the total cost of living is based on income, it is even not possible to pay for the loan of the low-investment renovation option. The alternative economic model 'NL' is most beneficial for the SHCs considering low-investment renovation of the houses, while the economic model '50–50' results in the smallest loss for the SHCs after deep renovation compared to the situation before renovation. To enable the income from rent to compensate the cost to repay the loan, the income of tenants should be at least EUR 5000 per year, which is the case for 98% of the tenants.

The cost for heating before renovation is 34% of the monthly income of tenants, while after the low-investment and deep renovation, the monthly cost for heating is, respectively, 26% and 9% of the monthly income in the current economic model and in the economic models 'NL' and '50–50'. Due to the possibility of paying the reduced tariff for energy in economic model 'COL 2.5%', here, the monthly cost for heating before renovation and after the low-investment and deep renovation are, respectively, 16%, 12% and 7% of the monthly income. In all economic models, deep renovation is needed to avoid tenants with low incomes suffering from energy poverty.

For tenants with a higher income, there is no risk of suffering from energy poverty as their monthly cost for heating is between 1% and 2% of their monthly income in all economic models. However, since in economic model 'COL 2.5%' the COL is linked to the income of the tenant, this economic model results in an increase in the COL compared to the current economic model. For tenants with higher incomes, the economic model 'NL' results in the highest decrease in COL compared to the current economic model. Likewise, according to the findings for the average income for tenants, the income from rent is sufficient to repay the loan for renovation in all economic models, and economic model 'COL 2.5%' gives the highest incentive to invest in deep renovation. The increased rent, moreover, results in an increased profit for the SHCs.

The results of this sensitivity assessment find that economic model 'COL 2.5%' is most beneficial for tenants with a very low income, while economic model 'NL' is more interesting for tenants with a high income. The economic model '50–50' results in the smallest loss for the SHCs when tenants have a very low income, while economic model 'COL 2.5%' gives the highest incentive to invest in deep renovation when the tenants have a high income.

3.3. Risk of Energy Poverty after Renovation

Finally, the cost for heating and the total energy cost (heating and electricity) are compared to the total income for both renovation options (option 1 is the renovation option with low investment cost and option 2 is the deep renovation option), to assess the effect of renovation on energy poverty. As shown in Figure 5, the increase in energy prices in 2023 has a significant effect on energy poverty. Following the definition of Boardman, both renovation options can reduce energy poverty in 2023 as here the ratio of the heating costs compared to the income is below 10%. However, before the increase in energy prices, both renovation options resulted in a ratio under 5%. Based on the data from 2023, the deep renovation results in a ratio of heating costs compared to income of around 5%, in line with the situation before renovation in 2021. A deep renovation is thus necessary to keep the costs for heating at a similar level. Considering the definition of Meyer and Coene, both renovation options result in a ratio of the total energy cost compared to the income close to 10%, based on the data of 2021. However, due to the increase in energy prices in 2023, none of the renovation options are sufficient to decrease the ratio of the total energy cost compared to the income below 10%. An additional decrease in the electricity use for lighting and appliances is needed.

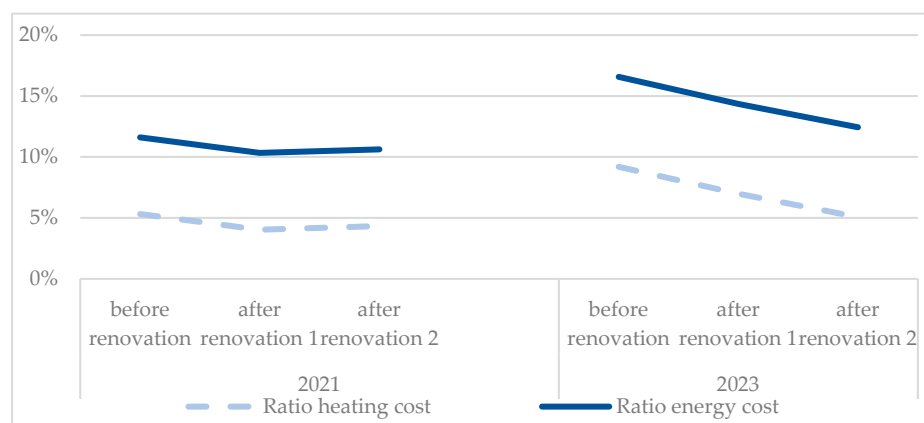


Figure 5. Ratio of the yearly costs for energy and yearly costs for heating compared to the yearly income of tenants before and after renovation for 2021 and 2023.

4. Conclusions and Discussion

This paper studied whether an alternative economic model could result in an increased investment in the renovation of social housing and a decrease in energy poverty. Three alternative economic models were proposed and evaluated. In the first alternative economic model, ‘COL 2.5%’, the monthly cost of living, i.e., the cost of rent plus the cost of energy for heating, is limited to 2.5% of the yearly income. The second alternative economic model, ‘NL’, follows the approach from the Netherlands where the monthly rent is limited to a fixed amount (here assumed to be 30% of the monthly income) and where the government provides a rent subsidy to households who cannot afford rent. A third alternative economic model, ‘50–50’, proposes to share the benefits of energy renovation equally between the social housing company and the tenants. The alternative economic models are evaluated based on the building before renovation, a light renovation option with a low investment cost and a limited reduction in energy use and environmental impact, and a deep renovation option with a high investment cost and significant reduction in energy use and environmental impact.

The results show that for the existing economic model, as well as for the three alternative economic models, the yearly income from rent is sufficient to repay the cost for the loan, considering a yearly income of minimal EUR 5000, which is the case for 98% of the tenants. In all economic models, the total income of the SHCs decreases after renovation. However, alternative economic models ‘COL 2.5%’ and ‘50–50’ provide an incentive to invest in renovation, as the total income for the SHCs after renovation increased compared to the current economic model. As stated by Halkos and Aslanidis, this economic incentive is necessary to support building renovation [7]. A transition to an alternative economic model for social housing in Flanders is thus required to increase the renovation rate.

For tenants with low incomes, it is most beneficial to limit the cost of living to a percentage of the income, especially with the current high energy prices, while for tenants with a high income, alternative economic model ‘NL’ results in the lowest COL.

Based on the results for the income of the SHCs and the costs for the tenants with low income, the first alternative economic model, with a limited cost of living based on the incomes, seems to be most interesting as this is most beneficial for the tenants and results in a higher income for the SHCs compared to the current model. The selection of an alternative economic model that is beneficial for both the housing association and the tenants is supported by the findings of Tozer, MacRae and Smit [33], who claim that access to low- or no-cost retrofit options alongside tenant protection mechanisms would make energy retrofit policies aimed at vulnerable households more effective. Adapting the current economic model to the more service-based ‘COL 2.5%’ model is in line with the findings of Bouzarovski and Petrova, who mention, amongst other suggestions, that

widening energy poverty amelioration frameworks towards ‘services’ might enable a form of public engagement, where the tenants can participate in the utility provision [13].

To reduce energy poverty, the results showed that a deep renovation is necessary, in line with the findings of Tozer, MacRae and Smit [33]. With the current high energy prices, only a deep renovation results in a ratio of the cost for heating compared to the income of around 5%, which is in line with the situation of the unrenovated building before the energy crisis. Considering the total energy cost, it was found that lowering the costs of heating is not sufficient to lower the risk of energy poverty. An additional decrease in the electricity use for lighting and appliances is needed.

Using average values is a clear limitation in this paper. More detailed research based on a broad set of actual data on energy use, energy costs, income, rent, etc., is needed to validate the results. Additionally, more renovation options and the possibilities of collective heating systems should be studied to investigate whether these options could further reduce energy costs. Moreover, as the literature suggests that the use of renewable energy could decrease the risk of energy poverty [7,34], the application of renewable energy in social housing in Flanders should be studied. Finally, the assumptions defining the maximal rent as 30% of the income and the monthly cost of living as 2.5% of the yearly income should be refined based on more extensive research.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/buildings13123001/s1>; Detailed information on the case study and the selected renovation options.

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