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### Impact of the Flemish energy renovation obligation on house prices

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## Introduction

In this article, we analyse the impact of the Flemish energy renovation obligation, introduced in January 2023, on house prices. This policy obliges buyers of the most energy-inefficient homes, i.e. those with a class E or F energy label, to renovate within five years from purchasing the property in order to obtain at least a class D label. This policy is, to the best of our knowledge, the first of its kind in the world.

We constructed a unique dataset by merging sales data for all Belgian dwelling transactions with datasets on energy performance certificates (EPC), asbestos certificates and online real estate listings. This data coverage allows us to compare results for Flemish and Walloon houses.<sup>1</sup> In addition, our dataset allows us to take into account an extensive set of dwelling characteristics, including the age of the property, the type of dwelling, the reported building condition, the size of the dwelling, the location and several other characteristics. Finally, combining transactions data and online listings data enables us to construct indicators on the days on market (DOM) of listings and on the sales-to-listing price ratio, adding an extra dimension to the data beyond the final sales price.

First, we estimate quality-adjusted house prices for each energy label class and region, calculated as the estimated price for a house with average dwelling characteristics. Unlike average house prices, these quality-adjusted prices account for differences in property characteristics. For instance, energy-efficient houses are on average more expensive not only due to their greater energy efficiency but also because they tend to be newer and in better condition. Since the quality-adjusted price for each energy label class is calculated for a house with the same characteristics (with the exception of the energy class), the price difference between labels can be interpreted as the estimated added value of an energy label improvement. However, caution is warranted for several reasons: the estimates are subject to estimation uncertainty; the price differences could still partly reflect differences in characteristics related to quality and comfort that are not controlled for in the dataset; and, finally, the price impact can be dwelling specific.

<sup>1</sup> While this article focuses on Flemish and Walloon houses, it also presents results for apartments and Brussels houses. However, these should be interpreted with caution, considering the smaller sample size and the imperfect data on the energy score of sold apartments.

\* We would like to thank Geert Langenus for his valuable comments on an earlier draft of this article.

We find that the energy score has been an important determinant of house prices for many years and has become even more important since 2023. From 2016 to 2022, the estimated price premia for houses with a class A, B or C energy label and the price discount for those with a class E or F energy label remained relatively stable and was already sizeable.<sup>2</sup> These energy label-related price differences widened substantially in 2023 and in the first three quarters of 2024. While prices in 2023 and 2024 remained at the same level as in 2022 for houses with a class D label, they increased somewhat for those with a class C label, rose even more for those with a class A or B label, and decreased for those with a class E or F label.

This divergence in price developments between energy labels since 2023 is due to the fact that buyers and banks are increasingly taking the energy score into account in their purchase decisions and mortgage conditions. This shift can be attributed to the introduction of the Flemish renovation obligation, as well as the announcement of increasingly stringent renovation requirements in the three regions in the coming years, higher and more uncertain heating bills since the energy crisis, and the future carbon price of heating fuels set by the EU ETS2<sup>3</sup> as from 2027. Yet another reason is the sharp rise in the cost of labour and, especially, building materials, which has made energy renovations more expensive. Furthermore, the introduction of the asbestos certificate requirement for dwellings sold in the Flemish Region since November 2022 led to the availability of information about asbestos safety and increased the awareness of asbestos risks. We find the prevalence of homes deemed unsafe due to the presence of asbestos to be higher among dwellings with a class E or F energy label, which can also contribute to higher renovation costs. Finally, the collection of data on energy scores by banks has increased, from 39% of new mortgage loans in 2021 to 67% in 2022, 79% in 2023 and 82% in the first half of 2024 (NBB, 2024). This has enabled them to take energy performance into account in their lending and mortgage policies, for instance by offering a lower mortgage rate for energy efficient dwellings and by including future renovation costs in their credit affordability assessments.

Second, we use a difference-in-differences technique to study the effect of the Flemish renovation obligation on house prices. This method allows us to compare developments in the prices of Flemish houses with a class E or F energy label (the treatment group) to those with similar characteristics but that are not subject to the renovation obligation (the control group). Using a control group composed of comparable houses unaffected by the renovation requirement but with similar characteristics and a comparable economic context, we can attribute differences in price developments to the renovation obligation. We use two different control groups: Flemish houses with energy performance just below the renovation obligation threshold and energy-intensive houses with a class E or F energy label in the Walloon Region, where developments in household incomes, mortgage credit conditions and energy prices are very similar but which does not have an energy renovation obligation.<sup>4</sup>

We find that the introduction of the Flemish renovation obligation has had only a minor negative impact on the price of houses in the Flemish Region with a class E or F energy label. Energy-inefficient houses in the Flemish Region became about 2% cheaper both relative to similar houses in the Walloon Region and to those with a class D energy label in the Flemish Region. This impact was not visible immediately but rather accrued gradually over the course of 2023 and remained stable in the first three quarters of 2024. Finally, our comparison with the Walloon Region suggests that the Flemish energy renovation obligation has not pushed up the prices of houses with better energy scores, as similar price increases were observed in both regions.

2 It should be noted that energy label definitions differ between regions and that we use the Flemish energy label definition for all regions for the sake of comparability. Also, it should be noted that the estimated price premia for Brussels houses and for apartments are smaller and more erratic but should be interpreted with substantial caution due to the large degree of estimation uncertainty resulting from the small sample size.

3 EU ETS2 is the new European emissions trading system for emissions from buildings, road transport and additional sectors, which will become operational in 2027.

4 Our difference-in-differences analysis is performed only for houses due to the too small sample size for apartments with a class E or F energy label. Similarly, we did not use Brussels houses as an additional control group owing to the very small sample size.

The reason for the limited effect of the Flemish renovation obligation on the price of houses with a class E or F energy label is twofold. First, an analysis of houses sold twice reveals that a majority of buyers of houses with a class E or F energy label were renovating their properties to at least a class D level in any case, even before the introduction of the renovation obligation. As the overall quality of these houses is typically poor, renovations are often carried out anyway, including energy efficiency improvements. This finding is in line with survey evidence that many buyers undertake an energy renovation shortly after purchasing a home. The renovation obligation does not have much effect on these buyers. Second, the price discount for these houses was large beforehand as the renovation cost seems to have been largely factored into the price. Indeed, while accurate estimates of the cost of an energy renovation are lacking, an analysis of a small sample of invoices from recent Flemish energy renovations indicates that the price discount corresponds, in terms of magnitude, to the average cost of an energy renovation to a class D label. However, it should be noted that the renovation cost can vary widely from dwelling to dwelling and between regions and contractors and depends on the technologies and materials used. It also depends on whether the energy renovation forms part of a more comprehensive renovation carried out for structural or comfort reasons, whether the owner carries out the works (in whole or in part), if it is part of a collective energy renovation project, if subsidies are taken into account and if additional costs are included, such as interior finishing costs, housing-specific costs and costs related to waste management and asbestos removal.

Finally, we find that the renovation obligation has led to an increased prevalence of energy scores just below the renovation obligation threshold. We also find a similar but smaller increase in bunching just below the other energy label class thresholds in the Flemish Region as well as in the Walloon Region, driven by the heightened importance of the energy label in both regions. As we limited our analysis of bunching to houses for which only one EPC was available prior to the sale, it is likely that this phenomenon is partly the result of misreporting. Indeed, while bunching could also be the result of renovation works effectively being carried out in order to move the property's energy score just to the left of the energy label threshold, this is not likely to be the case for owners without prior knowledge of their property's energy score. However, we cannot rule out last-minute energy efficiency improvements stemming from an initial energy score estimate that was not documented in the EPC database. Misreporting-driven bunching has also been found by Lu and Spaenjers (2024) for France.

This article contributes to several strands in the literature. It is most closely related to Clara et al (2024) and Fuerst and Huang (2023), who studied the effects of minimum energy-efficiency standards on rental properties in England and Wales. The authors found that such standards have resulted in a slight increase in the rental price discount for energy-inefficient homes. Our study contributes to this literature as it is the first to examine the effect of minimum energy-efficiency standards on homebuyers as opposed to rental properties.

Second, this article contributes to a substantial strand in the literature investigating the capitalisation of energy efficiency into house prices. Our estimated price premia fall well within the range of those reported in previous empirical studies.<sup>5</sup> However, it should be noted that this range is very wide due to differences in the time periods and countries analysed, energy label definitions and methodologies, and the varying extent to which different control variables are used. As discussed above, our study relies on an extensive set of dwelling characteristics, which allows us to separate the impact of energy efficiency on prices from that of correlated quality and comfort characteristics, hence mitigating the omitted-variable bias that has impeded many hedonic house-price regression analyses based on more limited datasets. In particular, we find that not accounting for the reported building condition, a subjective assessment of the condition of the property by the seller included in the online listing, results in overestimation of the estimated energy efficiency price premia by approximately 50%.

5 Brounen and Kok (2011); Copiello and Donati (2021); Damen (2019); de Ayala, Galarraga and Spadaro (2016); Evangelista, Ramalho and E Silva (2020); Fuerst *et al.* (2015, 2016); Fuerst, Oikarinen and Harjunen (2016); Härsmann, Daghbashyan and Chaudhary (2016); Hyland, Lyons and Lyons (2013); Jensen, Hansen and Kragh (2016); Kahn and Kok (2014); Lu and Spaenjers (2024); Olausson, Oust and Solstad (2017); Reusens, Vastmans and Damen (2023); Sejas-Portillo, Moro and Stowasser (forthcoming).

Third, by merging the databases on dwelling transactions, EPCs, asbestos certificates and real estate listings, our study provides novel insight into the energy efficiency and other characteristics of sold dwellings. This could be useful for the further development of national databases and the EU Building Stock Observatory on the energy performance of dwellings, which are important building blocks for implementation of the European Energy Performance and Buildings Directive (EC, 2024). In particular, our results on the prevalence, characteristics and renovation activity for sold dwellings with a class E or F energy label are useful for monitoring the impact of the Flemish renovation obligation. In addition, our results for the other label classes could be useful for the design of future renovation policies. Finally, our results on the energy efficiency of sold dwellings also contribute to the literature on quality-adjusted house price indices, which account for changes over time in the characteristics of sold houses. Notably, we find a steady improvement in the average energy performance of sold dwellings over the past decade. This reinforces the call by Reusens, Vastmans and Damen (2023) for statistical offices to incorporate the improvement in the energy quality of sold dwellings into the construction of house price indices so as to avoid overestimating house price growth.

This paper is structured as follows. Section 1 discusses the Flemish renovation obligation as well as broader energy efficiency objectives and future renovation obligations in the three regions of Belgium as well as in the EU. Section 2 presents the data. Section 3 discusses the energy efficiency of sold homes with a focus on the prevalence and characteristics of sold dwellings with a class E or F energy label. Section 4 analyses the impact of the renovation obligation on house prices. Finally, Section 5 lays out our conclusion.

## **1. Flemish energy renovation obligation and future renovation policies and objectives in Belgium and the EU**

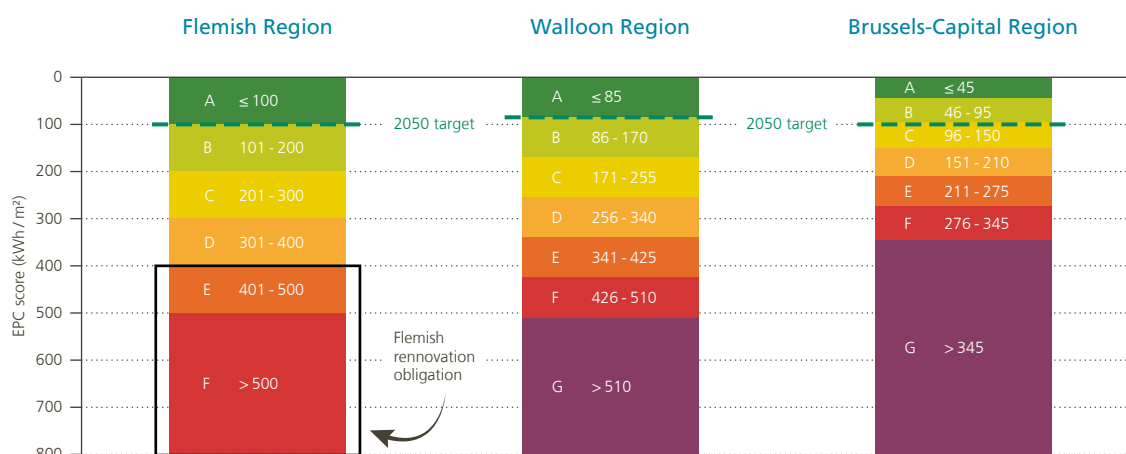
Heating accounts for a substantial portion of household energy consumption and greenhouse gas emissions in Belgium and the EU. In 2022, residential buildings accounted for 19.7% of energy consumption in Belgium, with 71.3% of residential consumption attributable to heating and 14.2% to hot water (FPS Economy, 2024). The share of Belgian emissions from residential heating is 12.6% (Klimaat.be, 2024), which is higher than in the EU, partly due to the fact that Belgian homes are, on average, larger and older.

Making homes energy efficient and decarbonised is therefore an important part of the EU's 2050 energy efficiency and climate neutrality objectives. The recently revised Energy Performance of Buildings Directive (EPBD) (EC, 2024) sets the zero-emission building as the 2050 goal for EU building stock. Such buildings have very low energy demand, zero on-site carbon emissions from fossil fuels, and zero or very low operational greenhouse gas emissions. The directive states that fossil fuel boilers should be completely phased out and puts forward 2040 as an indicative target date to reach this goal. In addition, national renovation trajectories should comply with intermediate five-year milestones designed to reduce average primary energy use in residential buildings, starting in 2030, with a focus on renovation of the worst-performing homes.

The energy efficiency of homes in the EU is documented by their energy performance certificate (EPC). This document is required when selling or renting a home and is prepared by a certified energy expert based on documentary evidence and visual inspection. The score indicates the theoretical amount of primary energy used by the building for heating and hot water over a year, expressed in kWh/m<sup>2</sup>, and depends on the insulation of walls, the roof, floors, windows and doors, the heating installations, the existence of solar panels, and characteristics such as the type of building (detached, semi-detached, terraced or apartment). While the energy score (in kWh/m<sup>2</sup>) is calculated using very similar methodologies in all three regions of Belgium, the grouping of scores for energy label purposes varies greatly from region to region and results in different scales (see Figure 1). For the sake of comparability, we apply the Flemish energy label classification to all regions.

Figure 1

Grouping of energy scores for energy label purposes in the three regions of Belgium



Sources: Brussels Environment, SPW, VEKA.

All three Belgian regions have set the objective of achieving an energy-efficient housing stock by 2050, with an average energy score of 100 kWh/m<sup>2</sup> for the Flemish and Brussels-Capital Regions and 85 kWh/m<sup>2</sup> for the Walloon Region, with so far only the latter requiring that residual heating needs be met through carbon-free supply.

In 2023, the Flemish Region introduced a renovation obligation for homebuyers, obliging purchasers of the most energy-inefficient homes, meaning those with a class E or F energy label, to renovate their dwelling within five years from purchasing the property so as to achieve an energy label class of at least D (maximum 400 kWh/m<sup>2</sup>). Renovation obligations will become much more prevalent in the future, as all three Belgian regions have recently announced the introduction of increasingly stringent minimum energy performance standards in the coming years. Table 1 shows an overview of the planned minimum energy performance standards for existing dwellings, detailing the year each standard is set to take effect (indicated in brackets) and the date the policy was decided or proposed. Minimum energy performance standards apply for homebuyers (Flemish and Walloon Regions), rental properties (Walloon Region) and all existing dwellings (Flemish<sup>6</sup> and Brussels-Capital Regions). These policies have been decided on and adopted in the Flemish and Brussels-Capital Regions but not yet in the Walloon Region. That being said, the Flemish coalition agreement of September 2024 indicated that the future tightening of minimum energy performance standards for homebuyers would be abolished.

6 It should be noted that the Flemish minimum energy performance standards for existing buildings will be included in the minimum housing quality standards, which thus far have mainly been enforced for rental properties.

Table 1

**Minimum energy performance standards for existing dwellings by year of introduction <sup>1</sup>**

(maximum energy scores in kWh/m<sup>2</sup>)

	Homebuyers (within 5 years from purchase)	New rental agreements	All existing dwellings
Flemish Region	<div style="border: 1px solid black; padding: 2px;"> <p>400 (2023)</p> <p><del>300 (2028)</del></p> <p>200 (2035*)</p> <p>100 (2040*)</p> <p>* Five years later for apartments</p> </div> <p>Decided in Oct. 2021 Decided in Oct. 2022 but reversed in Sept. 2024</p>	-	<div style="border: 1px solid black; padding: 2px;"> <p>500 (2030)</p> <p>400 (2035*)</p> <p>300 (2040*)</p> </div> <p>Decided in Dec. 2023</p> <p>* Five years earlier for terraced houses / apartments</p>
Walloon Region	<p>340 (2026)</p> <p>255 (2031)</p> <p>170 (2036)</p> <p>85 (2041)</p>	<p>510 (2027*)</p> <p>425 (2030*)</p> <p>340 (2033*)</p> <p>255 (2036*)</p> <p>* Two years earlier for first-time rental properties</p>	<p>510 (2031)</p> <p>425 (2036)</p> <p>340 (2041)</p> <p>255 (2046)</p> <p>170 (2050)</p> <p>(Proposal of March 2023, not yet approved by Parliament)</p>
Brussels-Capital Region	-	-	<div style="border: 1px solid black; padding: 2px;"> <p>275 (2033)</p> <p>150 (2046)</p> </div> <p>Decided in Feb. 2024</p>

Sources: Flemish Region (2022, 2023, 2024), Walloon Region (2023) and Brussels-Capital Region (2024).

<sup>1</sup> Minimum energy performance standards have been announced for homebuyers (left column), new rental agreements (middle column) and all existing dwellings (right column). The year of introduction is indicated in brackets.

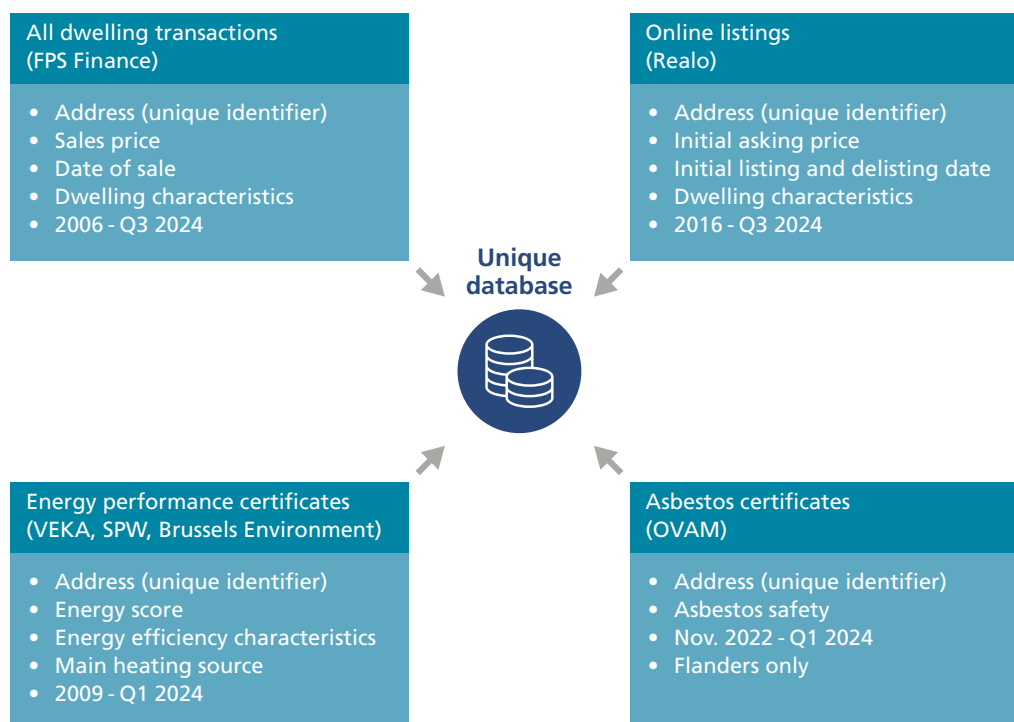
## 2. Data

We constructed our dataset by combining the universe of residential real estate transactions in Belgium with data from energy performance certificates, asbestos certificates and online real estate listings. Our dataset covers all dwellings sold in Belgium from 2006 to the third quarter of 2024, but our analysis focuses mainly on the period since 2016, for which all data sources (except asbestos certificates) are available.

Figure 2 provides an overview of the different databases. The dwelling transactions database from the Federal Public Service Finance records all sales of existing homes in Belgium, excluding new builds. It includes the sales price, the date of the notarial deed, the type of transaction (e.g., private sale, public sale or inheritance), a unique parcel identifier, and various dwelling characteristics such as the type of dwelling, the surface area, the age of the building, the number of years since the last officially recorded renovation, and the size of the garden. Data on energy performance certificates were obtained from the three regional energy agencies: VEKA (Flemish Region), the SPW (Walloon Region) and Brussels Environment. They include the energy score of the home as well as other energy efficiency characteristics and the main heating source. We also incorporated asbestos certificate data from the Flemish Public Waste Agency (OVAM). An asbestos certificate has been required for home sales in the Flemish Region since mid-November 2022. Finally, we used the property listings dataset from Realo, which includes listings data from multiple online platforms and realtors, and thoroughly scrubbed the data, including to eliminate duplicate listings. This dataset contains, for each property, the initial asking price, the initial listing date, the delisting date and additional dwelling characteristics such as the energy score, main heating source and the general condition of the dwelling. The dwelling characteristics are listed in Table 3 in Appendix B and their average value presented in Table 4.

Figure 2

Overview of the databases used



Sources: Brussels Environment, FPS Finance, OVAM, Realo, SPW, VEKA.

We merged the EPC, asbestos certificates and online listings databases with the transactions database using the address and the authentic identifier (cadastral parcel key or CaPaKey) of the property in Belgium. We used the last asbestos certificate and EPC prior to the date of sale, the latter complemented with the energy score from the listings database for the small number of dwellings for which EPC matching was not possible.<sup>7</sup> This approach allows excellent matching for houses (with the exception of a small number without a location identifier) but not for apartments as the postal box number for an apartment is defined differently across databases due to the lack of an official system for box numbers in Belgium. As a result, an apartment in the transactions database is often incorrectly associated with the EPC of another unit in the same building, which results in inaccurate matching at unit level given the wide range of energy scores within an apartment building depending on the location of the flat within the building. Luckily, it was possible to match the transactions data and Realo listings data for apartments with a reasonable degree of precision by leveraging the correspondence between the date of sale and the delisting date and between the dwelling characteristics of the datasets. In order to avoid measurement error in our hedonic regression analyses, we use only the energy score from the listings database for apartments in Section 4.

We cleaned the data in several steps. We started with the set of homes sold on the secondary market in Belgium. This yielded a sample of around 765 000 houses and 355 000 apartments for the period 2016 – Q3 2024, similar to the sales data of Statbel. After the removal of public sales (2 %), sales of multi-unit dwellings (1 %), sales of holiday homes (<1 %) and transactions that could not be matched with an energy score (about 10 %), we removed outlier observations, i.e. where one of the characteristics is higher than the 99.95<sup>th</sup> percentile or below the 0.05<sup>th</sup> percentile and with studentized residuals beyond the range of [-2, 2], following Eurostat's

<sup>7</sup> Please note, however, that the energy score from the listings database was used for dwelling transactions in Q2 and Q3 2024, as we did not have an EPC for those transactions in our dataset.

guidelines for outlier removal (Eurostat, 2017). This sample, which is close to the universe of homes sold on the secondary market for the period up to Q1 2024, is used as the basis for our analysis in Section 3.<sup>8</sup> For the hedonic regression analysis in Section 4, we performed several additional steps. We retained only transactions that could be matched with a listing (58 % of houses and 43 % of apartments), as the listings dataset contains the important “reported building condition” characteristic. We also dropped observations from the transactions dataset with missing values for important dwelling characteristics. Finally, for apartments, we used the energy score from the listings database only (see above). We ended up with a sample of about 165 000, 55 000 and 4 000 houses and around 38 000, 6 000 and 9 000 apartments for, respectively, the Flemish, Walloon and Brussels-Capital Regions.

### 3. Prevalence and characteristics of sold dwellings with a class E or F energy label

This section discusses the energy efficiency and dwelling characteristics of sold homes, with a focus on those with a class E or F energy label, which in the Flemish Region have been subject to the renovation obligation since 2023. We limit our analysis to the period up to Q1 2024, for which our sample comes close to the universe of homes sold on the secondary market (see Section 2). Section 3.1 shows that the share of sold homes with a class E or F energy label has steadily decreased over the past decade. Section 3.2 demonstrates the important finding that the quality of these homes is generally quite poor and that, even prior to the renovation obligation, a majority of buyers had taken steps to improve the energy efficiency of their dwelling, to at least a class D energy label. Finally, Section 3.3 shows the strongly increased prevalence of bunching of energy scores just below the energy label thresholds since 2023.

#### 3.1 Energy performance of sold homes

Figure 3 shows the distribution of energy label classes and the average energy score for houses and apartments sold in different years and regions. As can be seen, the average energy performance of sold homes has improved steadily over the past decade. The average energy score for both houses and apartments has dropped by 20 % to 25 % since 2012 in the Flemish and Walloon Regions, with a somewhat smaller decline in the Brussels-Capital Region. The average energy score in the first quarter of 2024 was 363 kWh/m<sup>2</sup>, 390 kWh/m<sup>2</sup> and 364 kWh/m<sup>2</sup>, for houses, and 198 kWh/m<sup>2</sup>, 230 kWh/m<sup>2</sup> and 245 kWh/m<sup>2</sup>, for apartments, in the Flemish, Walloon and Brussels-Capital Regions, respectively.<sup>9</sup> While improved, the average energy score is still far from the 2050 target of 100 kWh/m<sup>2</sup> in the Flemish and Brussels-Capital Regions and 85 kWh/m<sup>2</sup> in the Walloon Region (see Section 1). However, it should be noted that the energy performance distribution of sold dwellings is worse than that of the entire dwelling stock for several reasons. First, new builds were not included (see Section 2). Second, an EPC is issued before the sale of a property and therefore does not reflect post-sale renovation works, which are often carried out (see Section 3.2). Finally, a large portion of homes are sold when an elderly resident passes away or relocates to a retirement community. These properties tend to be older and less energy-efficient than the average dwelling (Vastmans, 2020 ; Vastmans and Dreesen, 2021).

The share of sold houses with a class E or F energy label fell strongly in the Flemish and Walloon Regions and to a lesser extent in the Brussels-Capital Region. In the period between 2023 and Q1 2024, about 35 % of houses and 7 % of apartments sold in the Flemish Region had a class E or F energy label and were thus subject

8 As we do not have data on EPCs issued after the first quarter of 2024, the sample coverage for Q2 and Q3 2023 is lower and includes only house sales for which an energy score was available in the listings database.

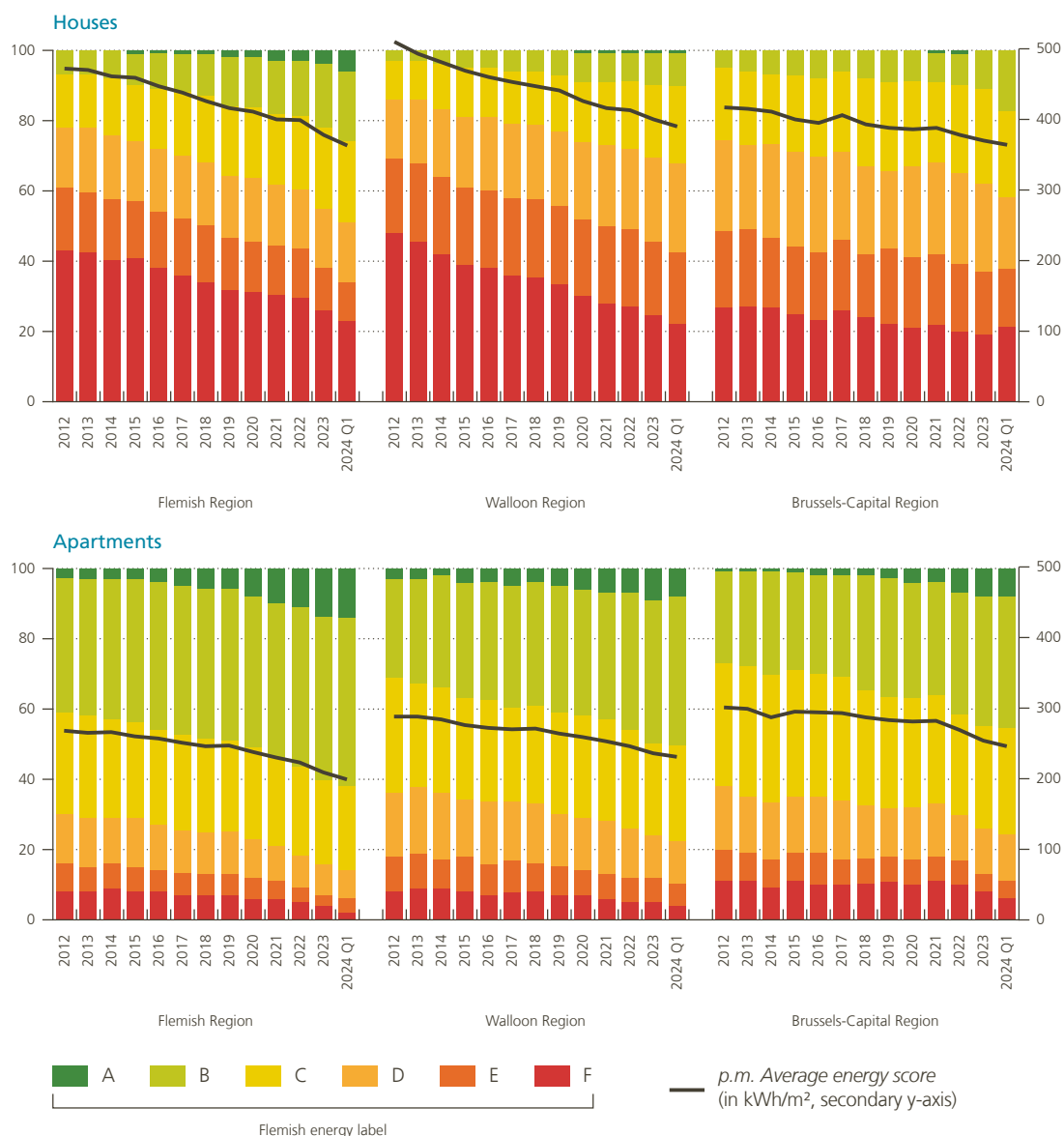
9 Note that apartments owe their lower average energy score to their building type, which often has fewer exterior walls compared to standalone houses.

to the renovation obligation. This amounts to 23 124 houses and 2 059 apartments.<sup>10</sup> It should be noted that a limited number of households brought forward the purchase or sale of their dwelling with a class E or F energy label to the last quarter of 2022 so as to escape the renovation obligation. Indeed, the share of sold houses with a class E or F energy label jumped from 41 % in the third quarter of 2022 to 47 % in the last quarter of 2022 before falling to 37 % in the first quarter of 2023 and then rising slightly to 39 % in the second quarter of 2023.

Figure 3

**Distribution of sold houses (top graphs) and apartments (bottom graphs) by energy label class**

(as a %)



Sources: Brussels Environment, FPS Finance, SPW, VEKA, own calculations.

10 It should be noted that the actual number of sold homes with a class E or F energy label is slightly higher, as the energy score was missing for a small percentage of sales in our database (see Section 2). In addition, the number of sold apartments subject to the renovation obligation should be interpreted with caution due to inaccurate matching between the transactions dataset and the EPC dataset for apartments, as an apartment in the transactions database is often incorrectly associated with the EPC of another unit in the same building (see Section 2). However, an analysis of the subset of sales that could be matched with a listing indicates that the share of sales with a class E or F energy label is very similar (although still about one percentage point lower) when relying on the more accurate matching with the listings database.

Figure 9 in Appendix A shows that the share of sold dwellings with a class E or F energy label is lower in cities. This is attributed to the higher prevalence of apartments and terraced houses, which typically achieve better energy scores due to their building structure, characterized by fewer exterior walls. Energy scores are also lower in regions with more recent homes such as northeastern Flanders and Walloon Brabant.

### 3.2 Characteristics and renovation of sold homes with a class E or F energy label

The overall quality and comfort of homes with a class E or F energy label are much worse than for more energy-efficient dwellings. Figures 10, 11, 12 and 13 in Appendix A indeed show that many dwellings with a class E or F energy label are in poor condition, old, considered unsafe due to the presence of asbestos and heated with oil.

Due to poor energy and non-energy quality, many buyers of houses with a class E or F energy label undertake renovation works to improve the energy efficiency of their dwelling even in the absence of a renovation obligation. This renovation activity has increased further since the introduction of the Flemish renovation obligation. Figure 4 illustrates the change in the energy label class for the approximately 26 000 Flemish houses that were sold twice, for the first time in the period 2009-2019 and again in 2022 or 2023 – Q1 2024, with at least a five-year interval between sales.<sup>11</sup> For second sales in 2022, we find that 60 % of homes with an initial class E or F energy label were improved to a class D label or better.<sup>12</sup> This percentage rises to 70 % for second sales in 2023 – Q1 2024, which is partially the result of homeowners performing renovations prior to the sale of their home so as to be below the renovation obligation threshold, but could likely also partially be attributed to EPC misreporting (see Section 3.3) and to the bringing forward of the sale of dwellings with a class E or F energy label to the last quarter of 2022 (see Section 3.1). These findings are in line with Clara *et al.* (2024) who observed high renovation activity on the part of both homeowners and landlords for energy-inefficient homes in England and Wales and a further increase in such activity by the latter group as a result of the introduction of minimum energy performance standards for rented residential properties.

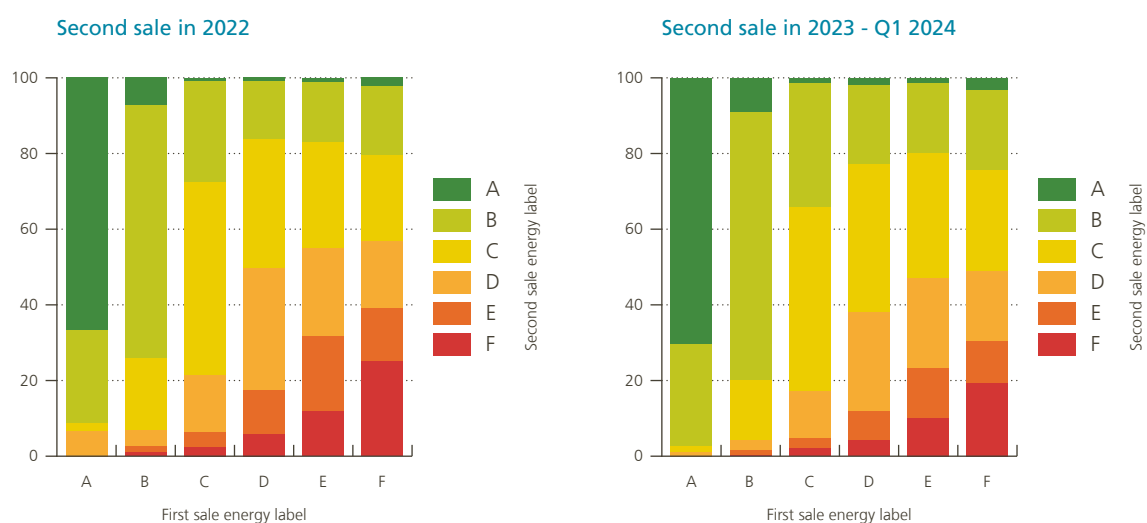
11 We could accurately analyse the improvement in energy efficiency only for Flemish houses sold for the second time since 2022. For this group alone, the EPC for the first sale could not be reused for the second sale, meaning the energy score had to be recalculated when the property was resold. Indeed, since January 2022, anyone selling a house in the Flemish Region must, by law, produce an EPC prepared as from 2019. In contrast, for repeat sales in the Flemish Region prior to 2022 and in the Walloon Region, a new EPC was often not produced for the second sale and the initial EPC from the first sale was used, even if renovations had taken place, hence resulting in underestimation of the actual change in energy efficiency. Indeed, for second sales occurring in the period 2014-2021, the share that used the EPC from the first sale was 48 % in the Flemish Region and 61 % in the Walloon Region.

12 These percentages would be even higher if sales of new constructions following demolition and reconstruction works were taken into account, for which we do not have data. It should also be noted that we could only analyse the post-sale change in energy label class for the subset of houses sold twice and that renovation activity may differ for the set consisting of all sales. Finally, note that for a small share of repeat sales, the energy label class was worse for the second sale compared to the first sale, which could be due to depreciation in the features of the home, the variability of estimates produced by different EPC certifiers and adjustments to the EPC calculation software.

Figure 4

### Change in the energy label class for Flemish houses sold twice <sup>1</sup>

(EPC distribution for the second sale, broken down by EPC for the first sale, as a %)



Sources: FPS Finance, VEKA, own calculations.

<sup>1</sup> The charts illustrate the change in the energy label class for Flemish houses with multiple recorded sales in the dataset, with at least a five-year interval between sales. In particular, they show the distribution of energy label classes for the second sale (as a percentage) broken down by energy label class for the first sale (on the x-axis). The left-hand chart displays houses for which the second sale occurred in 2022, while the right-hand chart depicts those sold for the second time in the period 2023 – Q1 2024.

Our finding that many buyers of energy-inefficient homes carried out an energy renovation shortly after purchasing is in line with survey evidence. According to the results of the large-scale 2013 housing survey in the Flemish Region, 50 % of owner-occupiers carried out energy-saving improvements between 2002 and 2012, with a higher percentage for homes in poorer condition and a lower percentage for homeowners in the lowest income quintile (Van den Broeck, 2019). The survey also revealed that major renovations are often at least partially completed before moving in. In addition, a more recent survey of Belgian homeowners conducted between 2018 and 2022 found that young households, who are the most active buyers of existing houses, are also more likely to perform an energy renovation. Specifically, 36 % of homeowners aged 25 to 39 had carried out an energy renovation in the year prior to their participation in the survey, compared with 25 % of those aged 40-54 and 20 % of those aged 55-74 (Gepts *et al.*, 2025). Furthermore, young homeowners tend to conduct more extensive energy renovations than older homeowners and are more likely to combine energy efficiency improvements with structural and other renovation works.

### 3.3 Presence of bunching

In this section, we analyse the impact of the Flemish renovation obligation on the occurrence of bunching of energy scores just below the energy label threshold values. Lu and Spaenjers (2024) have found that such bunching was sizeable for France for the period 2013-2020 and attributed it to misreporting of the energy efficiency of properties that are slightly on the ‘wrong’ (i.e., right) side of the threshold values.

Figure 5 shows the share of each EPC-score interval with a width of 5 kWh/m<sup>2</sup> as a percentage of the total number of EPCs for houses sold in the Flemish and Walloon Regions.<sup>13</sup> Like Lu and Spaenjers (2024), we limited our analysis to houses for which only one EPC was available prior to the sale so as to isolate bunching that is likely the result of misreporting. We excluded properties with more than one EPC because, for such properties, the homeowner may have carried out renovation works after having obtained a first EPC in order to move the property's energy score just to the left of the energy label threshold.<sup>14</sup> However, even though we limited our analysis to houses for which only one EPC was available prior to the sale, we cannot rule out last-minute energy efficiency improvements stemming from an initial energy score estimate that was not documented in the EPC database.

We measure bunching by comparing the prevalence of the energy score interval just below the energy class threshold with that just above, which should be about equal in the absence of bunching. It should be noted, however, that a drop in the prevalence of energy scores just above the energy class threshold could in part also be the result of homes not being put up for sale or not being sold after having received an EPC on the wrong side of the threshold.

We find a substantial increase in bunching since 2023 in both the Flemish and Walloon Regions. First, given that the Flemish energy label was only introduced in 2019, there could be no bunching in the period 2016-2018. The introduction of the energy label led to a small amount of bunching in the period 2019-2021 and in 2022, with 30% – 40% more houses sold with energy score intervals just below the threshold value than just above. Bunching increased strongly in the period 2023 – Q1 2024, with energy score intervals just below the threshold two to almost four times more prevalent than those above the threshold. This was most noticeable at the renovation obligation threshold, between the class D and E labels. As the energy label was introduced earlier in the Walloon Region, bunching was already present there during the period 2016-2018 and it remained constant in 2019-2021 and 2022, with the prevalence of energy score intervals just below the threshold values being about 50% higher. Bunching also increased in 2023, but to a lesser extent than in the Flemish Region.

The increased bunching observed since 2023 can be attributed to the heightened importance of the energy label due to its greater impact on house prices (see Section 4.1), the announcement of future renovation obligations (see Section 1) and the increased importance of energy efficiency since the energy crisis. In addition, the high prevalence of bunching in the Flemish Region at the threshold between the class D and E labels can most likely be attributed to introduction of the Flemish renovation obligation. Finally, it should be noted that bunching primarily concerns energy scores just below the threshold values, which account for a small percentage of the total number of energy performance certificates.

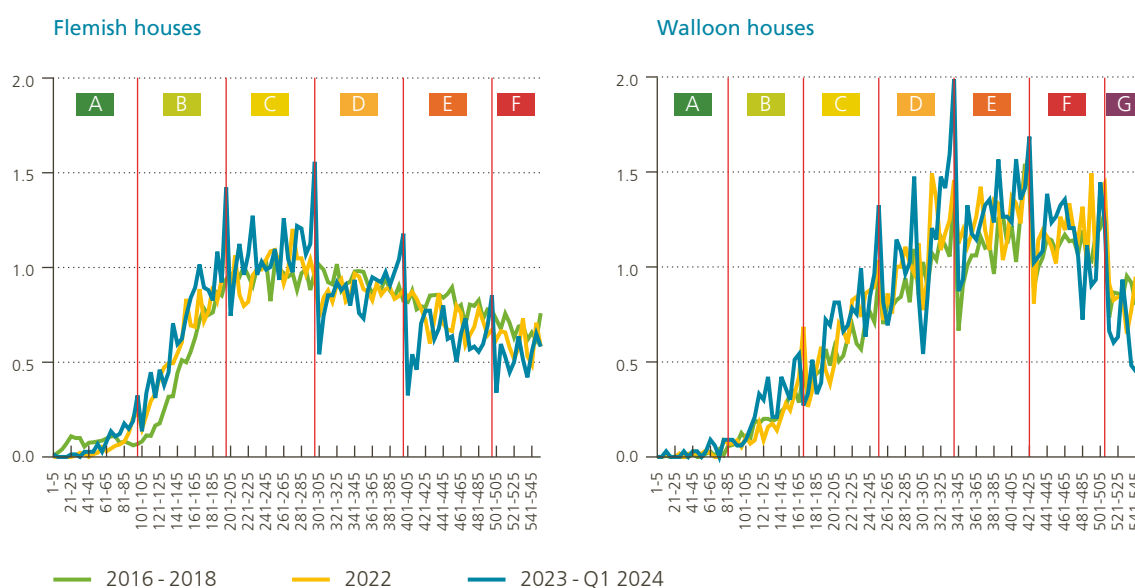
13 Note that we do not have results for apartments, as we cannot accurately select the apartments for which only one EPC was available prior to the sale due to the imperfect matching between the transactions dataset and the EPC dataset for apartments (see Section 2). We also excluded Brussels houses due to the very small number of house sales.

14 Analysing properties in England and Wales for which more than one EPC had been requested before a sale, Sejas-Portillo, Moro and Stowasser (forthcoming) found that sellers whose properties received an energy score just on the wrong side of the energy label threshold were more likely to improve their rating, which they attributed to sellers making last-minute energy efficiency improvements before listing their property.

Figure 5

### Prevalence of each energy score interval for houses sold, by year of issuance of the EPC <sup>1</sup>

(as a percentage of the number of houses sold for which only one EPC was available prior to the sale)



Sources: FPS Finance, SPW, VEKA, own calculations.

<sup>1</sup> The horizontal axis shows the energy scores, which are grouped in intervals of 5 kWh/m<sup>2</sup>. The vertical lines indicate the energy class thresholds in the Flemish and Walloon Regions. We omitted the period 2019-2021 from the graphs for the sake of readability, but the results are included in the online dataset.

## 4. The impact of the Flemish renovation obligation on house prices

This section analyses the impact of the introduction of the renovation obligation on house prices. Section 4.1 sets out the quality-adjusted house prices per energy label class in the three regions of Belgium and includes an analysis of the sales-to-listing price ratio and days on market. A statistical difference-in-differences analysis on the impact of the Flemish renovation obligation is laid out in Section 4.2.

### 4.1 House prices per energy label class

This section provides estimated quality-adjusted house prices for each energy label class and region. Unlike average house prices, these quality-adjusted prices account for differences in property characteristics. For instance, energy-efficient houses are on average more expensive not only due to their greater energy efficiency but also because they tend to be newer and in better condition.

We estimate quality-adjusted house prices for each energy label class and region, calculated as the estimated price for a house with average dwelling characteristics. Since the quality-adjusted price for each label is calculated for a house with the same characteristics (with the exception of the energy label), the price difference between labels can be interpreted as the estimated added value of an energy label improvement, while price changes over time can be seen as the actual change in price of an identical dwelling. However, caution is warranted for several reasons: the estimates are subject to estimation uncertainty; the price differences could still partly reflect differences in characteristics related to quality and comfort that are not controlled for in the dataset; and, finally, the price impact can be dwelling specific.

We use a standard log-linear hedonic regression model

$$\log(p_{it}) = \delta_t + \sum_{z=1}^5 \alpha_t^z EPC_{it}^z + \sum_{k=1}^K \beta^k x_{it}^k + \varepsilon_{it} \quad (1)$$

where  $\log(p_{it})$  is the logarithmic transformation of the price at which dwelling  $i$  was sold in year  $t$ ,  $x_{it}^k$  is the level of characteristic  $k$  of this dwelling,  $EPC_{it}^z$  is a dummy variable indicating the energy label class (as per the Flemish definition) of the dwelling,  $\delta_t$  is the time fixed effect of year  $t$ ,  $\varepsilon_{it}$  is the error term and  $K$  is the number of dwelling characteristics. The coefficients  $\alpha_t^z$  are the price premia of each energy label class  $z$ , with the class D energy label serving as the reference category. These coefficients are allowed to vary across different years. The coefficients  $\beta^k$  are the price premia of the dwelling characteristics and are assumed to be constant over time. Equation 1 is estimated using ordinary least squares, and estimated coefficients are denoted by a “hat” symbol.

The dwelling characteristic control variables are listed in Table 3 in Appendix B. We use dummy variables for the categorical dwelling characteristics and the energy label class. For the modelling of several continuous characteristics, we use the piecewise linear functions of Reusens, Vastmans and Damen (2023), a flexible solution to take into account the non-linear relationships between dwelling characteristics and sales prices.

The estimated quality-adjusted price (in euros) for a dwelling with an energy label class  $z$  and average dwelling characteristics  $\bar{x}^k$  can be written as<sup>15</sup>

$$P_t^z = e^{(\delta_t + \hat{\alpha}_t^z + \sum_{k=1}^K \hat{\beta}^k \bar{x}^k)} \quad (2)$$

Finally, we also estimate alternative versions of Equation 1, where we replace the logarithm of the final sales price on the left-hand side by the sales-to-listing price ratio and the days on market.

Figure 6 shows the quality-adjusted price (in euros) per energy label class for a house with average dwelling characteristics (top graph), as well as the corresponding price index (using 2022 as the reference year) (middle graph) and relative price difference with a comparable dwelling with a class D energy label (bottom graph). Figure 14 in Appendix B shows the results for apartments. We focus our analysis mainly on Flemish and Walloon houses, for which the coefficients were accurately estimated. While results for the Brussels-Capital Region and apartments are shown as well, these should be interpreted with caution having regard to the higher estimation error due to their smaller sample size. In particular, while the standard error for the estimated energy label class coefficients is below one percentage point for Flemish and Walloon houses, it is much larger for Brussels houses and for apartments (see Figure 16 in Appendix B).

First, while the energy score has been a significant determinant of house prices for many years, its importance grew even more in 2023 and the first three quarters of 2024 in the Flemish and Walloon Regions (see Figure 6, bottom graph). From 2016 to 2022, the estimated price premium for dwellings with a class A, B or C energy label and the price discount for those with a class E or F label remained relatively stable and was already sizeable. On average, these premia and discounts amounted to, respectively, 13 %, 11 %, 5 %, –4 % and –10 % in the Flemish Region and 16 %, 9 %, 5 %, –5 % and –10 % in the Walloon Region. Energy label-related price differences widened substantially in 2023 and in the first three quarters of 2024.<sup>16</sup> The estimated price premium for dwellings with a class A energy label was 9.6 and 4.8 percentage points higher (for the Flemish and Walloon Regions, respectively) in the first three quarters of 2024 compared with the average over the period 2016

15 For each region, the average dwelling characteristics equals the average value of the characteristics of the dwellings sold in the region between 2016 and Q3 2024. In particular, the average is calculated using the sample used to estimate Equation 1, which is very close to the average values of the universe of sales set out in Table 4 in Appendix B. Finally, the average value of each regression spline is used for dwelling characteristics modelled using a piecewise linear function.

16 This substantial widening of energy label-related price differences has resulted in strongly divergent house price index developments since 2023 (see Figure 6, middle graph). While prices in 2023 and 2024 were at the same level as in 2022 for houses with a class D energy label, they increased for those with a class C label and especially for those with a class B or A label and decreased for those with a class E or F label.

to 2022. The increase in the price premium amounted to 4.4 and 4.1 percentage points for dwellings with a class B label (for the Flemish and Walloon Regions, respectively), 2.1 and 1.6 percentage points for those with a class C label, –1.1 and –0.4 percentage points for those with a class E label, and –2.7 and –0.7 percentage points for those with a class F label. The finding that the price discount for dwellings with a class E or F energy label increased around one to two percentage points more in the Flemish Region than in the Walloon Region is in line with the results of our statistical difference-in-differences analysis on the impact of the Flemish renovation obligation (see Section 4.2).

The divergence in price developments between energy labels observed since 2023 is due to the fact that buyers and banks are increasingly taking the energy score into account in their purchase decisions and mortgage conditions. This shift can be attributed to the introduction of the Flemish renovation obligation as well as the announcement of increasingly stringent renovation requirements in the three regions in the coming years, higher and more uncertain heating bills since the energy crisis, and the future carbon price of heating fuels set by the EU ETS2 as from 2027. Yet another reason is the sharp rise in the cost of labour and, especially, building materials, which has made energy renovations more expensive.<sup>17</sup> Furthermore, the introduction of the asbestos certificate requirement for all dwellings sold in the Flemish Region since November 2022 led to the availability of information about asbestos safety and increased the awareness of asbestos risks. We find the prevalence of homes deemed unsafe due to the presence of asbestos to be higher among dwellings with a class E or F energy label (see Section 3.2), which can also contribute to higher renovation costs. Finally, the collection of data on energy scores by banks has increased, from 39 % of new mortgage loans in 2021 to 67 % in 2022, 79 % in 2023 and 82 % in the first half of 2024 (NBB, 2024). This has enabled them to take energy performance into account in their lending and mortgage policies, for instance by offering a lower mortgage rate for energy efficient dwellings and by including future renovation costs in their credit affordability assessments.

Second, the price discount for houses with a class E or F energy label was large beforehand as the renovation cost seems to have already been largely factored into the price. In 2024, the price discount for houses with a class F energy label is around 12 % in the Flemish Region and 11 % in the Walloon Region, which corresponds to a price difference of about € 40 000 for an average house in the Flemish Region and about € 25 000 in the Walloon Region (see Figure 6, top graph). While accurate estimates of the cost of an energy renovation are lacking, an analysis of a small sample of invoices from recent Flemish energy renovations indicates that the price discount seems to correspond, in terms of magnitude, to the average cost of an energy renovation to a class D label. However, it should be noted that the renovation cost can vary widely from dwelling to dwelling and between regions and contractors and depends on the technologies and materials used. It also depends on whether the energy renovation forms part of a more comprehensive renovation carried out for structural or comfort reasons, whether the owner carries out the works (in whole or in part), if it is part of a collective energy renovation project, if subsidies are taken into account and if additional costs are included, such as interior finishing costs, housing-specific costs and costs related to waste management and asbestos removal.

Third, we find that the relative price difference between dwellings with different energy labels is much smaller for apartments (see Figure 14 in Appendix B). In 2024, the price discount for apartments with a class F energy label is around 6 % in the Flemish Region and 4 % in the Walloon Region, which corresponds to a price difference of about € 14 000 for an average apartment in the Flemish Region and about € 8 000 in the Walloon Region. This lower price discount could be explained by the fact that while energy scores vary widely within an apartment building depending on the location of the flat within the building, all owners contribute to the energy renovation of common areas, which include outer walls, the roof, floors and the central heating system. However, these estimates for apartments should be interpreted with caution due to the small sample size and imperfect matching between the transactions dataset and the EPC dataset for apartments (see Section 2).

17 According to the arch-i 2021 index, the cost of building materials rose by about 40 % between 2021 and 2024. The Abex index, which measures the cost of the construction of buildings and private homes taking into account the price of both building materials and labour, increased by about 22 % over that same period. It should be noted that the increase in construction cost is also an important driver of the recent substantial increase in the price of new-build homes, for which existing energy-efficient homes are a substitute.

Fourth, in addition to an increase in the price difference between energy label classes, we find strong price discontinuities around energy class threshold values since 2023. For houses in the Flemish Region, we estimated a variant of Equation 1 in which we replaced the energy class with an energy score interval with a width of 25 kWh/m<sup>2</sup> for which the price premium is allowed to differ from quarter to quarter. Figure 7 shows the average price premium per energy score interval with a width of 25 kWh/m<sup>2</sup> for the periods 2016-2019, 2019-2021, 2022 and 2023-Q3 2024 for the Flemish Region.<sup>18</sup> While the price premia decreased gradually as a function of the energy score until 2022, strong discontinuities were noted for the period as from 2023.<sup>19</sup> The changes noted after 2023 likely result from the greater importance of energy performance due to introduction of the Flemish renovation obligation and stricter future renovation requirements, the energy crisis and higher building costs, as well as increased public awareness of energy labels. Price discontinuities at the rating band thresholds have also been reported by Lu and Spaenjers (2024) and Sejas-Portillo, Moro and Stowasser (forthcoming) for, respectively, France and England and Wales.

Finally, we find that, since 2023, the days on market and sales-to-listing price ratio have also diverged between energy labels. Figure 8 shows the sales-to-listing price ratio and the days on market for a house with average dwelling characteristics, per energy label class and region (the same results for apartments are shown in Figure 15 in Appendix B). The former compares the final sales price of a property to its initial asking price, which may differ as a result of sellers adjusting their initial asking price and negotiations between the buyer and seller. The latter is calculated as the number of days between the first listing date and the date of the notarial deed, thus including the time of, on average, about three months between signature of the preliminary sales agreement and the notarial instrument recording the sale. First, as can be seen, the sales-to-listing price is substantially lower for energy-intensive houses, especially in the Flemish Region. Second, the sales-to-listing price ratio is impacted by the housing cycle, with higher values in booming markets due to bidding wars in 2021 and 2022 and lower values since 2023 as a result of mortgage rate hikes and a general cooldown of the housing market. It has decreased most since 2023 for Flemish houses with a class E or F energy label, which we attribute to the renovation obligation. The latter two findings are also evidenced by the days on market indicator, which has increased since 2023, especially for Flemish houses with a class E or F energy label.

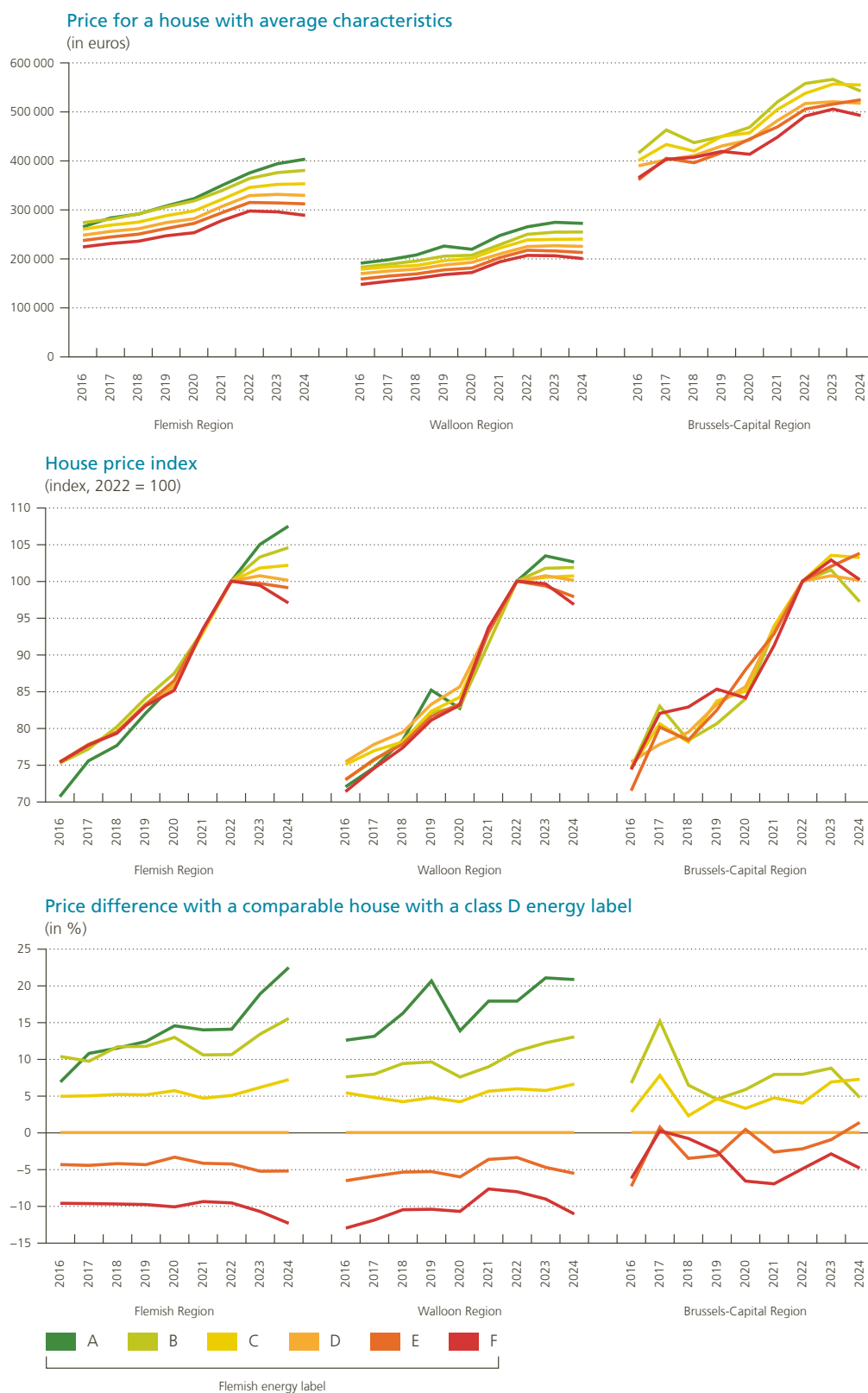
18 We display detailed results only for the Flemish Region, as energy score intervals with a width of 25 kWh/m<sup>2</sup> do not correspond to the Walloon and Brussels energy labels.

19 It should be noted that price discontinuity at energy label thresholds is possibly even larger when taking into account the impact of bunching, which is especially prevalent at the renovation obligation threshold (see Section 3.3). In particular, the price premium for dwellings at the energy score interval 376-400 kWh/m<sup>2</sup> is likely underestimated due to the fact that the upper range of the 376-400 kWh/m<sup>2</sup> interval is overrepresented and may include misreported energy scores.

Figure 6

Quality-adjusted price per energy label class for a house with average characteristics

(in euros (top graph), as an index (middle graph) and relative price difference (bottom graph))

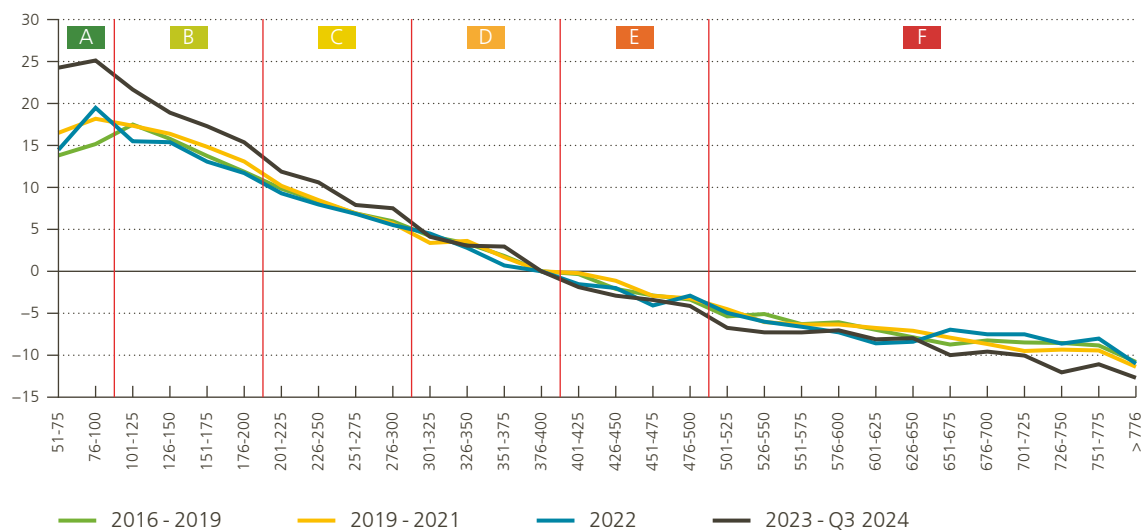


Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

Figure 7

**Price premium per energy score interval with a width of 25 kWh/m<sup>2</sup> for Flemish houses**

(as a %, price difference with a comparable house with an energy score within the 376-400 kWh/m<sup>2</sup> interval)



Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

Figure 8

Sales-to-listing price ratio (top graph) and days on market (bottom graph) per energy label class for a house with average characteristics



Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

- 1 The sales-to-listing price ratio in this article represents the ratio between the final sales price and the initial listing price.
- 2 The days on market in this article refers to the period from the first listing date to the date of the notarial deed. This duration also includes the time of, on average, about three months between signature of the preliminary sales agreement and the notarial instrument recording the sale.

## 4.2 The impact of the Flemish renovation obligation on house prices

We conducted a difference-in-differences analysis to examine how the Flemish renovation obligation has affected house prices. This approach compares the (quality-adjusted) trend in prices of Flemish houses with a class E or F energy label (the treatment group) – now subject to the renovation obligation – with that of similar houses sold in a comparable economic environment but not subject to this requirement (the control group). This comparison allows us to isolate the impact of the renovation obligation from other house price determinants, so that we can attribute differences in price trends to the renovation obligation.

We perform two separate analyses, each with a different control group. In the first, we use houses sold in the Flemish Region with a class D energy label as the control group. The main advantage of this approach is that the houses in both the control and the treatment groups are in the same region, so that any developments specific to the Flemish housing market and Flemish economic environment can be differenced out. However, while the energy scores of the control group are only just below those of the treatment group and therefore similarly affected by changes in energy prices, we cannot completely rule out the possibility that the energy crisis impacted house prices differently. In addition, the impact of the asbestos certificate requirement may vary as the prevalence of homes deemed unsafe due to the presence of asbestos is higher for houses with a class E or F energy label. As a result, this comparison does not clarify if differences in house price developments are due entirely to the energy renovation obligation.

In our second approach, we use a control group composed of houses with a class E or F energy label sold in the Walloon Region. These houses experienced very similar mortgage market, household income and energy and renovation cost developments as our treatment group. First, given that all major Belgian banks operate at the national level and use a national perspective to set their credit policies, financing conditions and mortgage rates have evolved similarly in the regions. Second, household incomes in both regions have grown at a very similar pace, due to the system of automatic wage indexation in Belgium and interregional economic linkages, commuting flows and fiscal transfers via the federal government and social security. Third, the increase in energy costs and renovation costs is very similar as we are comparing houses with the same energy performance. Given the similar development of these house price determinants, we attribute differences in price developments to the impact of the Flemish renovation obligation.

Finally, we test if the Flemish renovation obligation has led to a price increase for houses with better energy labels. This could be the case as a result of a shift in demand from houses with a class E or F label to those with a class A, B, C or D label, which, coupled with unchanged supply, would lead to a price increase for the latter group. We test this hypothesis by comparing price developments for houses with better labels between the Flemish Region (the treatment group) and the Walloon Region (the control group). As in our comparison with houses with a class E or F energy label (see above), the main advantage is that the two groups have the same energy label class and that broader shocks impacting the Belgian housing market as a whole are differenced out. While one concern could be that the better energy labels in the Flemish Region are affected differently than in the Walloon Region due to differences in expectations as to the future tightening path of renovation obligations, the tightening path in both regions is relatively similar and was announced at approximately the same time (see Table 1).

An important assumption of our difference-in-differences approach is that quality-adjusted price trends in the treatment and control groups would be similar in the absence of the renovation obligation. To test the validity of this assumption, we studied the pre-trends set out in Figure 17 in Appendix C. These pre-trends confirm very similar price developments for our treatment and control groups prior to introduction of the renovation requirement, which confirms the validity of our control groups.

Despite these stable pre-trends and the strong similarities between the Walloon control group and the Flemish treatment group, recent house price developments in the Flemish and Walloon Regions may have been affected differently by changes in housing policies, regional differences in the primary heating source of homes and

the introduction of the asbestos certificate requirement in the Flemish Region. First, the abolition of a substantial mortgage tax relief scheme in the Flemish Region in January 2020 and a reduction in the Flemish transaction tax in January 2022 impacted price developments in the Flemish Region. We control for these shifts by introducing two fiscal policy dummies in our model, which are equal to one for all sales in the Flemish Region after the change in fiscal policy. Second, due to a larger share of homes relying on natural gas as their primary heating source and a lower share of those using heating oil in the Flemish Region compared to the Walloon Region (see Figure 13), the Flemish Region was more affected by the energy crisis, during which natural gas prices rose more strongly than heating oil prices. However, the robustness check we performed (see Appendix C.3) confirms that this factor does not influence our main results. Third, the Flemish Region introduced an asbestos certificate requirement in November 2022, which could have had an impact on Flemish house prices. We address this through an additional repeat sales robustness check (see Appendix C.4), which confirms our findings.

To apply the difference-in-differences approach, we use a hedonic regression model to compare price trends between the treatment group and the control group, both before and after the renovation obligation. More specifically, we estimate the following regression<sup>20</sup>

$$\log(p_{it}) = \gamma R_{it} + \delta_t + \sum_{z=1}^Z \alpha^z E_{it}^z + \sum_{k=1}^K \beta^k x_{it}^k + \varepsilon_{it} \quad (3)$$

where  $R_{it}$  equals one if house  $i$  sold in quarter  $t$  was in the treatment group (with a class E or F energy label, located in the Flemish Region) and was sold after 1 January 2023. The coefficient  $\gamma$  is the prime coefficient of interest, measuring the price impact of the renovation obligation on the treatment group.  $E_{it}^z$  is an energy score interval with a width of 25 kWh/m<sup>2</sup>,  $x_{it}^k$  are the dwelling characteristics set out in Table 3 in Appendix B and  $\varepsilon_{it}$  is the error term. Equation 3 is estimated using ordinary least squares, based on a sample comprising the treatment group and the control group. We also estimate a variant of Equation 3 in which we allow the impact of the renovation obligation to vary across quarters since introduction of the renovation obligation. This allows us to detect if the price impact of the renovation obligation was immediate or gradual.

Table 2 shows the estimated price impact of the renovation obligation on the treatment group for each difference-in-differences analysis.<sup>21</sup> First, we find that Flemish houses with an energy label of E or F have become on average about 1.4 % cheaper since 2023, both relative to houses with a class D label and to Walloon houses with a class E or F label. However, the impact was not immediate. Rather it accrued over the course of 2023 and has levelled off at about –2 % since the fourth quarter of 2023. These effects are also statistically significant. Second, we did not find the renovation obligation to have an impact on the price of houses with “better” labels, compared with the control group of Walloon houses. The estimated impact was barely 0.35 % for Flemish houses with a class A, B or C energy label and slightly negative for Flemish houses with a class D label, but these results were not statistically significant.

The reason for the limited effect of the Flemish renovation obligation on the price of houses with a class E or F energy label is twofold. First, an analysis of houses sold twice reveals that a majority of buyers of houses with a class E or F energy label were renovating their properties to at least a class D level in any case, even before the introduction of the renovation obligation. As the overall quality of these houses is often poor, renovations are carried out anyway, including energy efficiency improvements. This finding is in line with survey evidence that many buyers undertake an energy renovation shortly after purchasing a home. The renovation obligation does not have much effect on these buyers. Second, the price discount for these houses was large beforehand as the renovation cost seems to have been largely factored into the price.

20 In the cross-regional approach, we add two fiscal dummies, which equal one if the house was sold in the Flemish Region after the change in tax policy (discontinuance of the mortgage tax relief programme in 2020 and the reduction in transaction tax in 2022, respectively). We also add an interaction term between the energy score logarithm and a Flemish Region dummy, to capture the average difference in the energy efficiency price premium between the Flemish and Walloon Regions.

21 It should be noted that the values in our tables are coefficients converted to percentages by taking the exponent of the coefficient and subtracting one (Halvorsen and Palmquist, 1980).

Indeed, while accurate estimates of the cost of an energy renovation are lacking, an analysis of a small sample of invoices from recent Flemish energy renovations indicates that the price discount corresponds, in terms of magnitude, to the average cost of an energy renovation to a class D label (see Section 4.1).

**Table 2**

**Estimated impact of the introduction of the renovation obligation on the treatment group for each difference-in-differences analysis<sup>1</sup>**

(as a %)

	Entire period	Impact per quarter <sup>1</sup>	
<b>Flemish Region</b>			
EF vs D	-1.47***	Q1 2023	0.94
		Q2 2023	-0.98*
		Q3 2023	-0.87
		Q4 2023	-2.30***
		Q1 2024	-1.79***
		Q2 2024	-2.30***
		Q3 2024	-2.90***
<b>Flemish Region vs Walloon Region</b>			
EF	-1.31***	Q1 2023	-0.53
		Q2 2023	0.02
		Q3 2023	-0.85
		Q4 2023	-1.98***
		Q1 2024	-0.06
		Q2 2024	-2.07***
		Q3 2024	-3.98***
ABC	0.35	Q1 2023	-0.50
		Q2 2023	0.87
		Q3 2023	-0.23
		Q4 2023	0.81
		Q1 2024	-0.57
		Q2 2024	1.20*
		Q3 2024	0.57
D	-0.53	Q1 2023	-1.17
		Q2 2023	0.44
		Q3 2023	-1.31
		Q4 2023	-0.02
		Q1 2024	-1.40
		Q2 2024	-0.16
		Q3 2024	-0.20

Sources: FPS Finance, Realo, SPW, VEKA, own calculations.

1 The table shows the estimated coefficients  $\hat{\gamma}$  (converted to percentages by taking the exponent of the coefficient and subtracting one) of Equation 3 for each difference-in-differences analysis. The four models are estimated on, respectively, 154 403, 153 299, 119 393 and 68 959 observations. The statistical significance of the coefficients is denoted by \* ( $p < 0.1$ ), \*\* ( $p < 0.05$ ) and \*\*\* ( $p < 0.01$ ).

## 5. Conclusion

In this article we analyse the impact of the Flemish energy renovation obligation, introduced in January 2023, on house prices. This policy obliges buyers of the most energy-inefficient Flemish homes, i.e. those with a class E or F energy label, to renovate within five years from purchasing the property in order to obtain at least a class D energy label.

Our first finding is that the energy score has been an important determinant of house prices for many years and has become even more important since 2023 in the Flemish and Walloon Regions. From 2016 to 2022, the estimated price premia for houses with a class A, B or C energy label and the price discount for those with a class E or F energy label remained relatively stable and were already sizeable. These energy label-related price differences widened substantially in 2023 and in the first three quarters of 2024. While prices in 2023 and 2024 remained at the same level as in 2022 for houses with a class D label, they increased somewhat for those with a class C label, rose even more so for those with a class A or B label, and decreased for those with a class E or F label. This divergence in price developments is due to the fact that buyers and banks are increasingly taking the energy score into account in their purchase decisions and mortgage conditions as a result of the recent energy crisis, the future carbon price of heating fuels, higher renovation costs, the announcement of stricter future renovation requirements, and better collection by banks of energy scores for new mortgages.

Second, we find that the introduction of the Flemish renovation obligation has had only a minor negative impact on the price of houses in the Flemish Region with a class E or F energy label. Energy-inefficient houses in the Flemish Region became about 2 % cheaper both relative to similar houses in the Walloon Region and to those with a class D energy label in the Flemish Region. This impact was not visible immediately but rather accrued gradually over the course of 2023 and remained stable in the first three quarters of 2024. The reasons for this limited effect are that a majority of buyers of houses with a class E or F energy label were renovating their properties to at least a class D level in any case and that this renovation cost seems to have been already largely factored into the price. Finally, our comparison with the Walloon Region suggests that the Flemish energy renovation obligation has not pushed up the prices of houses with better energy scores, as similar price increases were observed in both regions.

Our finding that the introduction of the Flemish renovation obligation has led to only a slightly higher price discount for energy-inefficient homes has redistributive implications. First, it implies a slightly negative impact on the wealth of the owners of energy-intensive homes. Second, the slightly higher discount creates a small amount of financial leeway for buyers to carry out an energy renovation. However, for those who were not planning to renovate, the renovation obligation results in a large upfront compulsory investment, on top of the purchase price. This could hamper the accessibility of home ownership for potential buyers without sufficient repayment capacity. Hence, this latter group is most affected by the introduction of the renovation obligation.

Third, we find that the renovation obligation has led to an increased prevalence of energy scores just below the renovation obligation threshold. We also find a similar but smaller increase in bunching just below the other energy label thresholds in the Flemish and Walloon Regions, driven by the heightened importance of the energy label in both regions. As we limited our analysis of bunching to houses for which only one EPC was available prior to the sale, it is likely that this phenomenon is partly the result of misreporting. While bunching could also be the result of renovation works effectively being carried out in order to move the property's energy score just to the left of the energy label class threshold, this is not likely to be the case for owners without prior knowledge of their property's energy score. However, we cannot rule out last-minute energy efficiency improvements stemming from an initial energy score estimate that was not documented in the EPC database. Misreporting-driven bunching has also been found by Lu and Spaenjers (2024) for France. It should be noted that bunching primarily concerns energy scores just below the energy label threshold values, which make up a small percentage of total energy performance certificates. While we did not investigate the existence of more generalised EPC misreporting, it seems evident that the growing importance of the energy label for homebuyers,

banks and policymakers has increased the risk of misreporting. Indeed, an increase in misreporting could be expected based on Goodhart's law, which states that when a particular measure becomes a (policy) target, it will become less effective as people start to game the system to meet the target.

Finally, as the Flemish Region is, to the best of our knowledge, the only region in the world to have introduced an energy renovation obligation for homebuyers, our findings may be of interest to the many other countries that are considering a similar policy. In particular, they are relevant for other EU member states, as the recently revised Energy Performance of Buildings Directive sets energy efficiency targets for residential building stock to be met by 2030, with a focus on renovation of the worst-performing residential dwellings, using minimum energy performance standards as a possible lever.

## Appendices

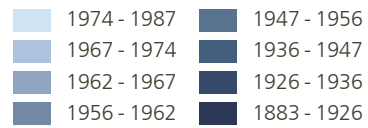
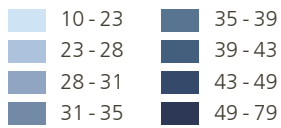
### Appendix A: Additional charts for Section 3

Figure 9

Share of dwellings with a class E or F energy label and average year of construction for dwellings sold in the period 2023 – Q1 2024

Share of sold dwellings with a class E or F label  
(in %)

Average year of construction

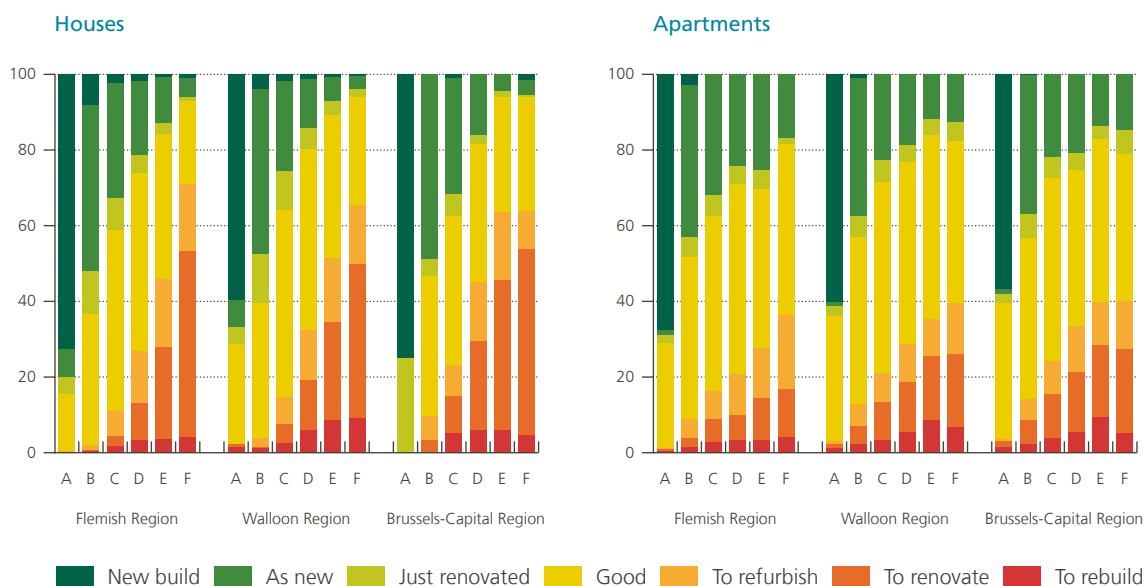


Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

Figure 10

Condition of sold houses (left graph) and apartments (right graph) as advertised by the seller, as per the Flemish energy label classification <sup>1</sup>

(as a %)



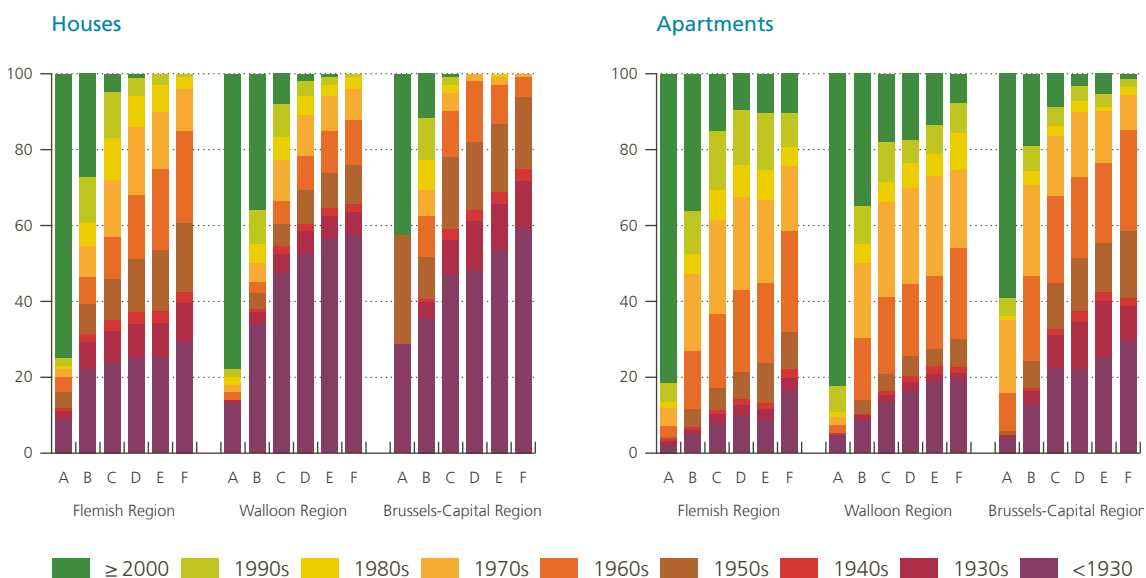
Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

<sup>1</sup> The building condition refers to the reported general condition of the building. This is a subjective aspect of the listing without a precise definition and is often a somewhat euphemistic representation of reality. It should be noted that the share of houses to be rebuilt is underestimated, as most of these dwellings are advertised as a "building plot" and thus not included in the dataset of sold dwellings.

Figure 11

Year of construction of sold houses (left chart) and apartments (right chart), as per the Flemish energy label classification

(as a %)

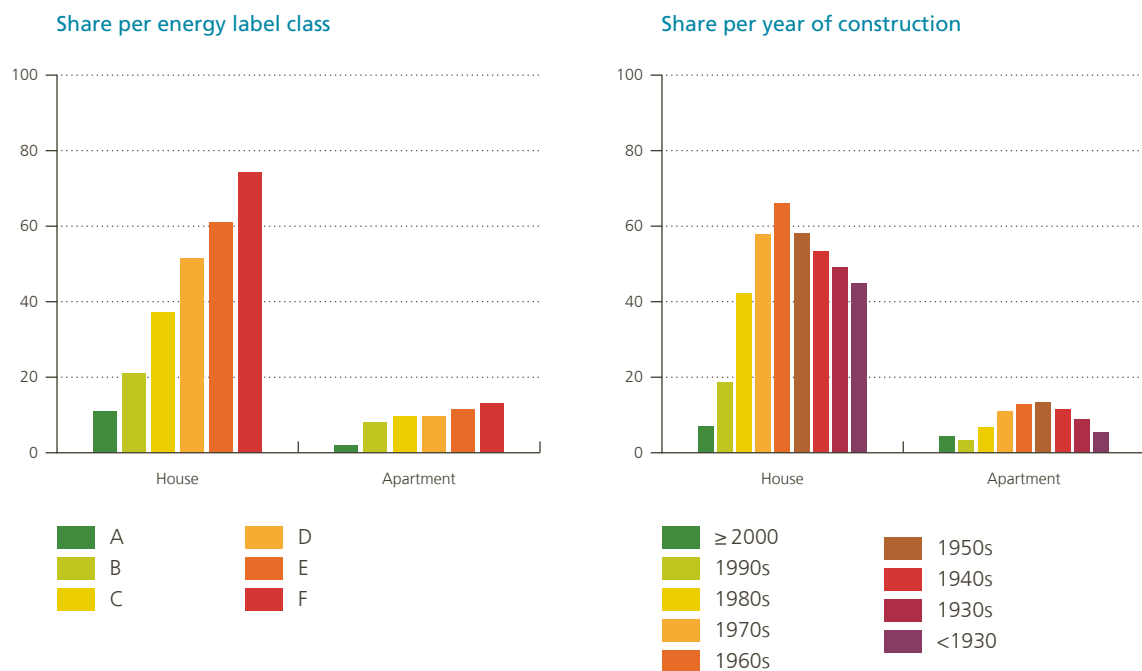


Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

Figure 12

Share of sold Flemish dwellings deemed unsafe due to the presence of asbestos, by energy label class (left chart) and by year of construction (right chart) <sup>1</sup>

(in %)



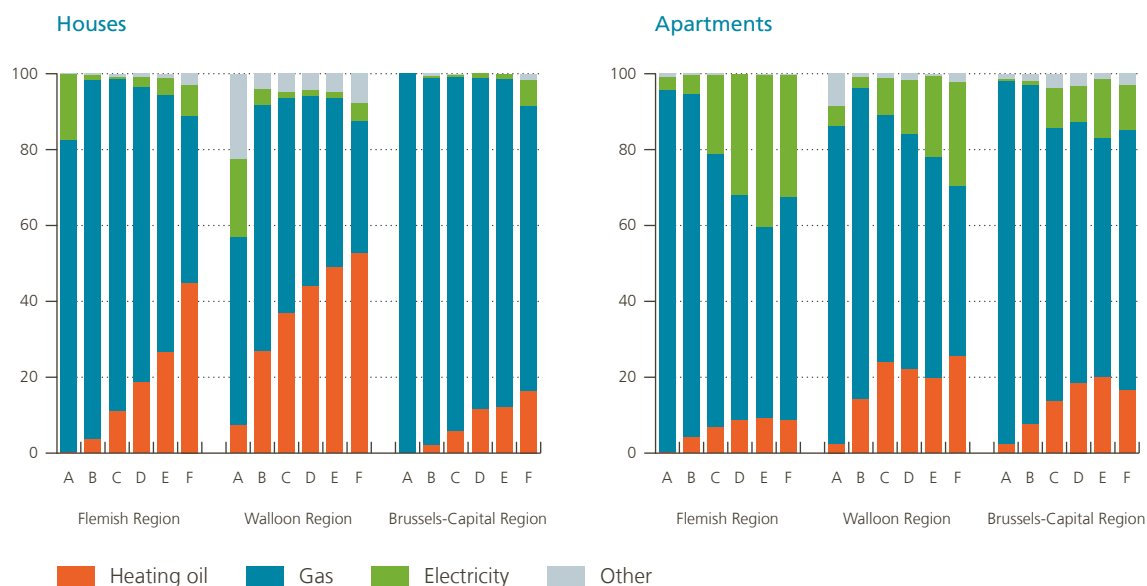
Sources: FPS Finance, OVAM, Realo, VEKA, own calculations.

<sup>1</sup> The chart includes sales between 2023 and Q1 2024. It should be noted that the incidence of asbestos unsafe apartments is lower as the asbestos certificate does not yet cover asbestos in the common areas of apartment buildings.

Figure 13

Main heating source of sold houses (left chart) and apartments (right chart), as per the Flemish energy label classification

(as a %)



Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

## Appendix B: Additional results for Section 4.1

Table 3

### Dwelling characteristics used in the models described in Sections 4.1 and 4.2

Control variable	Type	Source
Energy score	Categorical dummy	VEKA, SPW, Brussels Environment, Realo
Building type	Categorical dummy	FPS Finance
Building condition	Categorical dummy	Realo
Officially recorded renovation	Dummy	FPS Finance
Number of years since the last officially recorded renovation (if renovated)	Piecewise linear	FPS Finance
Presence of a garage	Dummy	FPS Finance
Number of garages (if present)	Linear	FPS Finance
Number of rooms	Linear	FPS Finance
Number of bedrooms	Linear	Realo
Garden size	Piecewise linear	FPS Finance
Surface area	Piecewise linear	FPS Finance
Number of floors	Categorical dummy	FPS Finance
Age	Piecewise linear	FPS Finance
Distance to submunicipal centre	Linear	Realo
Mobility score	Linear	Realo
Municipality	Categorical dummy	FPS Finance
Presence of solar panels <sup>1</sup>	Dummy	Realo
Presence of asbestos <sup>1</sup>	Dummy	OVAM
Main heating source <sup>1</sup>	Categorical dummy	VEKA, SPW, Brussels Environment, Realo

Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

<sup>1</sup> The presence of solar panels is an additional control variable that is used in the model set out in Section 4.2. The presence of asbestos and the main heating source are used only in the robustness checks in Appendix C.

Table 4

**Average value of dwelling characteristics per region for apartments and houses sold in the period 2016 – Q3 2024<sup>1</sup>**

	Houses			Apartments		
	Flemish Region	Walloon Region	Brussels-Capital Region	Flemish Region	Walloon Region	Brussels-Capital Region
Share of each building type (in %)						
Terraced	40	38	80			
Semi-detached	28	29	15			
Detached	32	34	5			
Share of dwellings based on building condition (in %) <sup>1</sup>						
New build	7	3	3	25	21	13
As new	21	18	20	26	24	24
Renovated	9	7	7	7	7	8
Good	36	41	34	34	39	38
To refurbish	12	13	12	5	6	8
To renovate	14	14	21	2	3	8
To rebuild	1	3	2	1	1	1
Share of dwellings with an officially recorded renovation (in %)	29	34	28	18	27	20
Average number of years since the last officially recorded renovation (if renovated) <sup>1</sup>	18	17	14	9	10	9
Share of dwellings with a garage (in %)	66	58	46	29	28	41
Number of garages (if present)	1.1	1.1	1.1	1.1	1.1	1.1
Average number of rooms	5.7	5.7	6.9	3.6	3.6	3.9
Average number of bedrooms <sup>1</sup>	3.2	3.1	3.8	2.0	2.0	2.0
Average garden size (in m <sup>2</sup> )	453	529	163			
Average surface area (in m <sup>2</sup> )	167	164	177	89	88	90
Average number of floors	1.7	1.7	2.3			
Average age	67	91	86	42	50	62
Average distance to submunicipal centre (in meters) <sup>1</sup>	1 136	884	1 013	988	841	1 023
Average mobility score <sup>1</sup>	0.71	0.70	0.85	0.79	0.82	0.86

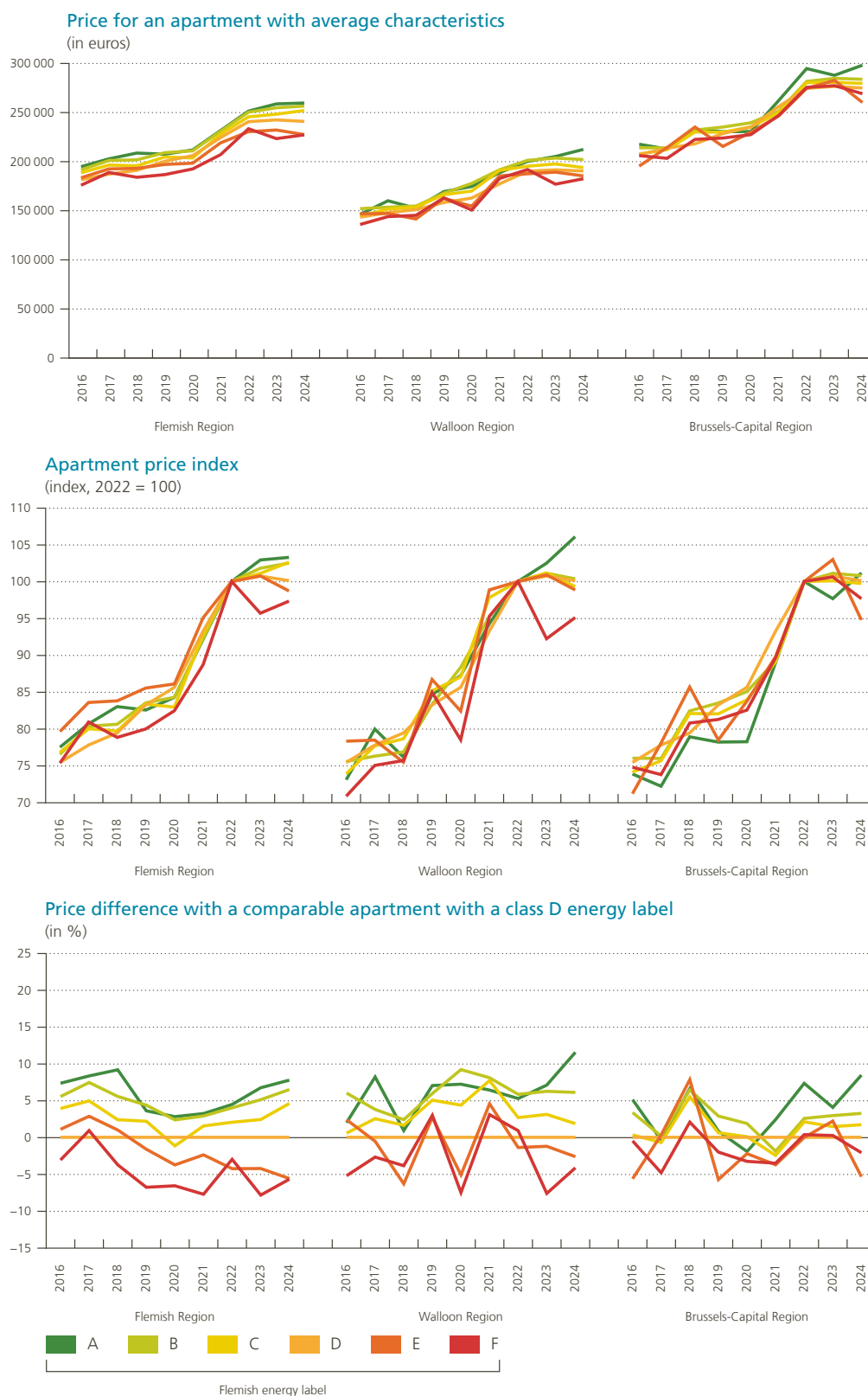
Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

<sup>1</sup> For variables obtained from the listings dataset, the average was calculated for sales for which listings data were available.

Figure 14

Quality-adjusted price per energy label class for an apartment with average characteristics

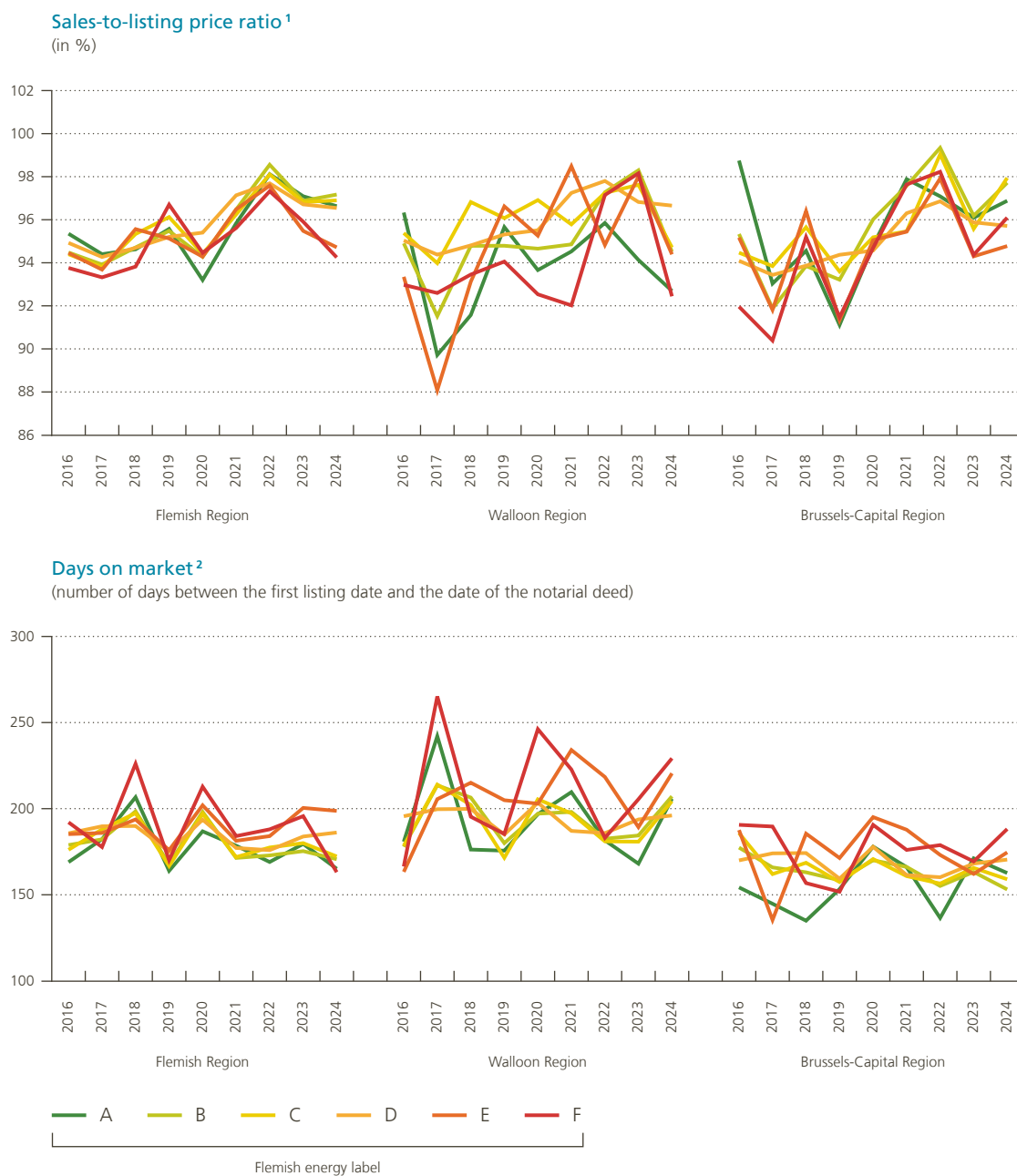
(in euros (top graph), as an index (middle graph) and relative price difference (bottom graph))



Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

Figure 15

Sales-to-listing price ratio (top graph) and days on market (bottom graph) per energy label class for an apartment with average characteristics



Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

1 The sales-to-listing price ratio is the ratio between the final sales price and the initial listing price.

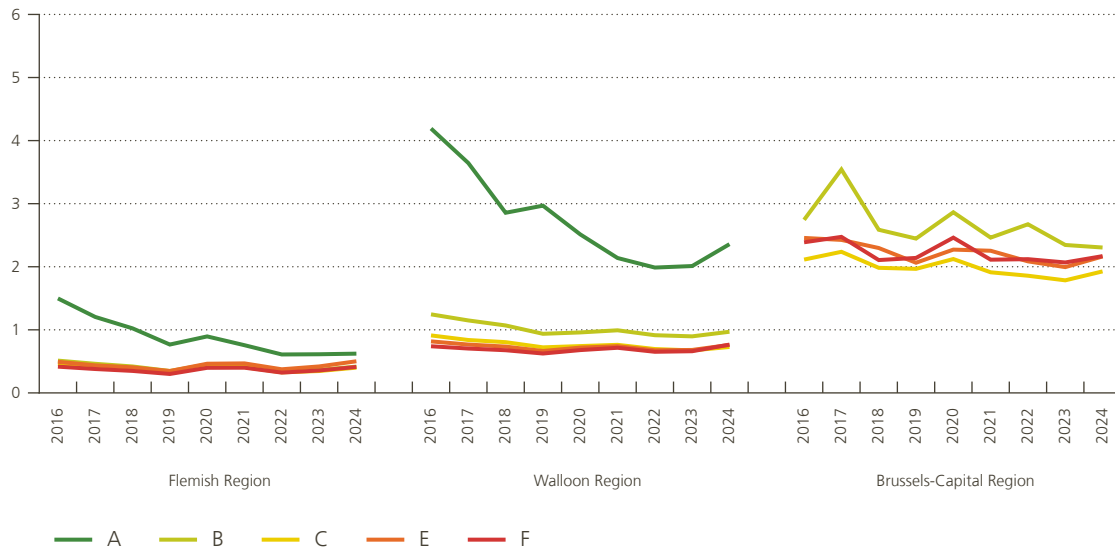
2 Number of days between the first listing date and the date of the notarial deed, thus including the time of, on average, about three months between signature of the preliminary sales agreement and the notarial instrument recording the sale.

Figure 16

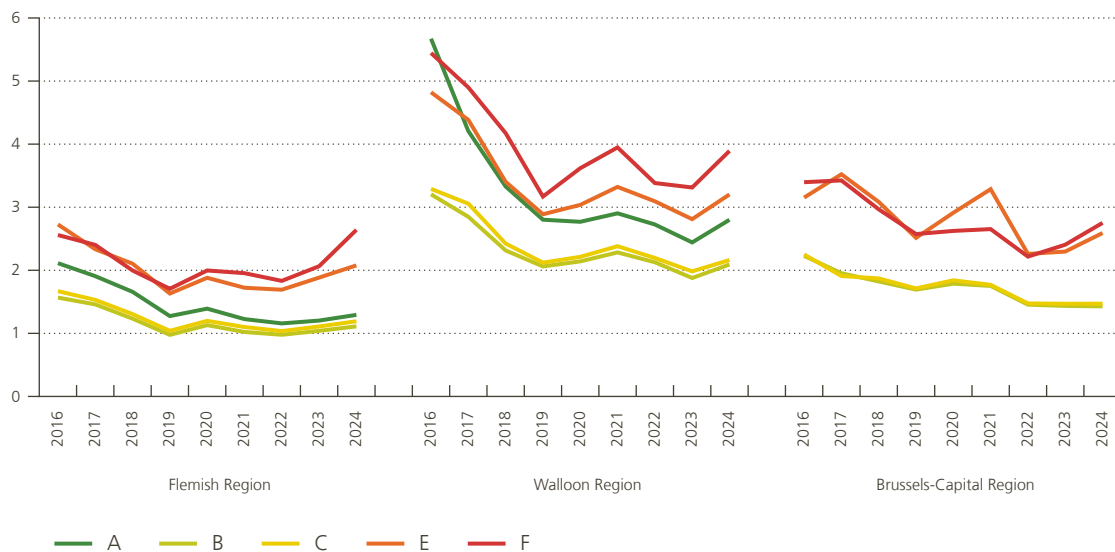
Standard error for the estimated energy label class coefficients  $\alpha_i^z$  in Equation 1

(in percentage points)

Houses



Apartments



Sources: Brussels Environment, FPS Finance, Realo, SPW, VEKA, own calculations.

## Appendix C: Additional results of the difference-in-differences analysis set out in Section 4.2

Below we set out additional results for the difference-in-differences analysis performed in Section 4.2. First, we show that price developments in our treatment and control groups were very similar prior to the introduction of renovation requirements, which confirms the validity of our difference-in-differences methodology. Furthermore, we present several robustness analyses for our difference-in-differences model, using a different sample period, sample size and control variables (Section C.2) and taking into account differences in the primary heating source (Section C.3) and the introduction of the asbestos certificate requirement (Section C.4). These robustness checks confirm our main finding, set out in Section 4.2, that the introduction of the Flemish renovation obligation has had a minor negative impact on the prices of houses in the Flemish Region with an energy label of E or F and has not affected the prices of houses with a “better” label.

### C.1. Estimated pre-trends

To test the validity of our difference-in-differences methodology, we checked if price developments in our treatment and control groups were similar prior to the introduction of the renovation requirement. Large divergences in price developments would indeed be problematic for our identification strategy, as it would be harder to argue that a divergence in price developments after introduction of the renovation requirement resulted from this policy instead of from chance, other shocks or diverging trends. To verify the similarity of price developments between the treatment and control groups prior to the renovation obligation, we estimated the following model:

$$\log(p_{it}) = \sum_{\tau=1}^T \gamma_{\tau} R_{it}^{\tau} + \delta_t + \sum_{z=1}^Z \alpha^z E_{it}^z + \sum_{k=1}^K \beta^k x_{it}^k + \varepsilon_{it} \quad (4)$$

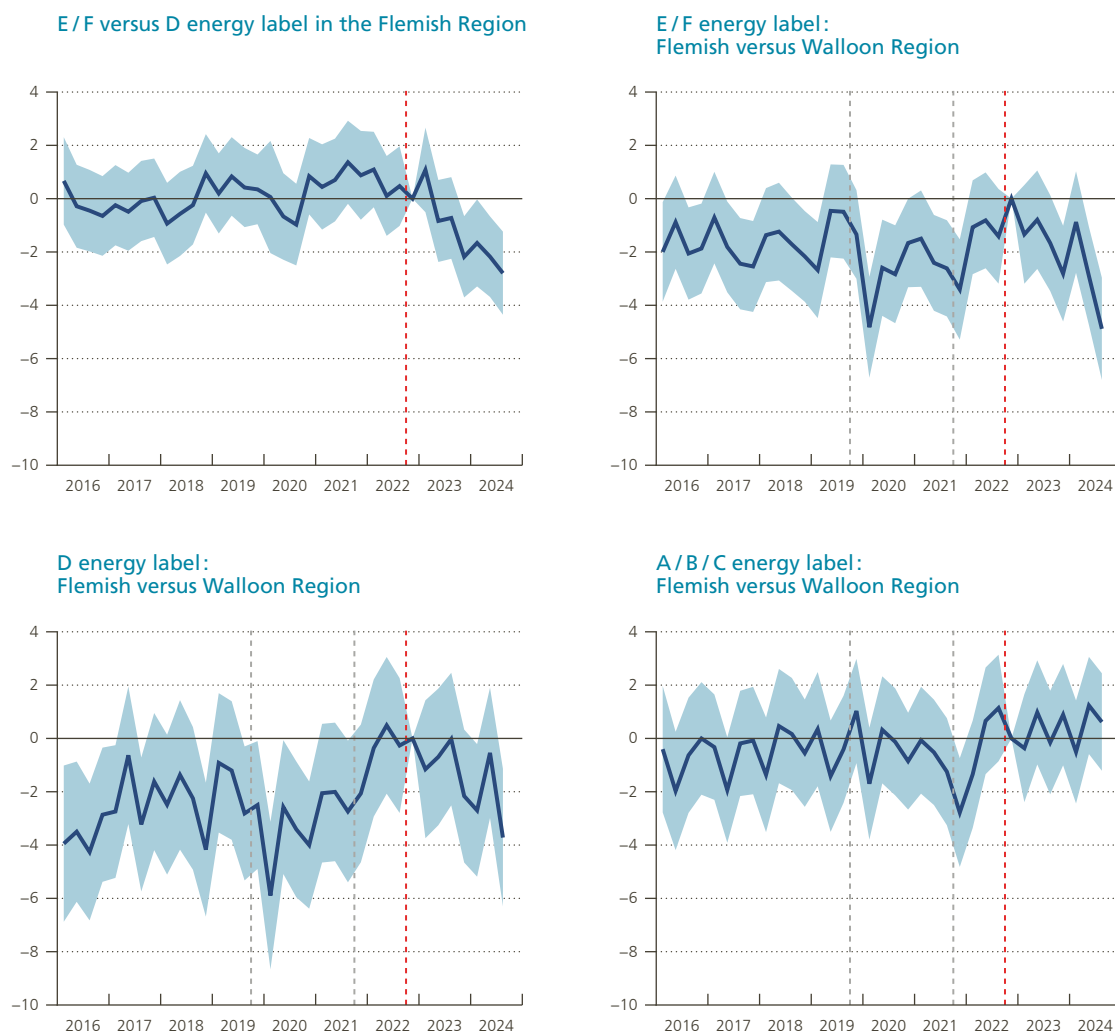
in which  $R_{it}^{\tau}$  is a dummy that equals one if house  $i$  is in the treatment group (i.e. one with a class E or F energy label and located in the Flemish Region) and was sold in quarter  $\tau$ . We use the same notation as in Equation 3 for the other variables and coefficients.  $\gamma_{\tau}$  is set to zero for the last quarter before the policy change so that Q4 2022 is the reference quarter. For the other quarters, it is the difference in price developments (relative to the reference quarter) between the treatment group and the control group.

The estimated  $\hat{\gamma}_{\tau}$  values are shown in the event study plot in Figure 17 for each control group. They confirm that price trends in the treatment and control groups were very similar prior to introduction of the renovation obligation. A discrepancy was noted for the Walloon control groups after abolition of the Flemish mortgage tax relief scheme in January 2020 and the Flemish transaction tax reduction in January 2022. However, these changes resulted in a level shift, which are taken into account in our difference-in-differences model by the inclusion of fiscal dummies as discussed in Section 4.2.

Figure 17

**Difference in price trends (relative to Q4 2022) between the treatment group and the control group<sup>1</sup>**

(in percentage points)



Sources: FPS Finance, Realo, SPW, VEKA, own calculations.

<sup>1</sup> The red dotted vertical line shows the introduction of the Flemish renovation obligation, while the gray dotted vertical line shows the changes in fiscal policy in the Flemish Region (discontinuance of the mortgage tax relief programme in 2020 and the reduction in registration duties in 2022).

## **C.2. Robustness checks with a different sample period, sample size and control variables**

As a first robustness check for our difference-in-differences analysis, we estimated Equation 3 on a different sample period, sample size and set of control variables. These results are displayed in Table 5. The first column in this table reiterates our baseline results from Table 2, estimated on the full set of control variables and a sample period up to Q3 2024. The other columns display the results for a sample period up to Q1 2024. The reason for this more limited sample period is that we do not have data on EPCs issued after the first quarter of 2024, meaning our sample of house sales since Q2 2024 includes only those for which an energy score was available in the listings database. The second column shows the results of the baseline model, estimated for the sample period until Q1 2024. The third and fourth columns display the estimates produced by the model excluding control variables originating from the online listings database: the third column displays the estimated results based on the same sample as the baseline while the fourth column indicates the results for a larger sample that includes observations for which online listing indicators were missing. Comparing the estimates in column 3 and column 4 allows us to assess whether using only observations for which online listing data are available biases our results.

Our robustness checks confirm our main finding that the renovation obligation has had a small negative impact on the prices of houses with a class E or F label and no significant impact on the prices of houses with better energy labels. First, for our analysis comparing houses with a class E or F energy label to those with a class D energy label in the Flemish Region, the results are still statistically significant if we exclude the last two quarters of the analysis period (second column), but the average effect drops to  $-0.85\%$  as the effect was larger in these omitted quarters (see Section 4.2). The estimates of the model with a more limited set of control variables (third column) and its variant with a larger sample (fourth column) show average effects of  $-1.9\%$  and  $-1.5\%$ , respectively, which are similar to our baseline result. Second, when we exclude Q2 and Q3 2024 from the analysis of houses with a class E or F energy labels in the Flemish Region versus the Walloon Region, the average effect of the renovation obligation drops to  $-0.7\%$  and is not statistically significant. The estimates of the model with fewer control variables (third column) and its variant with a larger sample (fourth column) are even smaller and also statistically insignificant. However, we still find similar estimates for the quarterly impact as in our main analysis; the lower estimated average effect could be the result of the omission of the latest quarters, for which the renovation impact is largest. Finally, as in our main analysis, the estimated impact of the renovation obligation on houses with a class A, B or C energy label is close to zero and statistically insignificant in all columns.

Table 5

Robustness checks for the estimated impact of the renovation obligation<sup>1</sup>

(as a %)

	Baseline results of Table 2			Baseline model, but sample period until Q1 2024		Excluding control variables from the listings database			
	Entire period	Impact per quarter		Entire period	Impact per quarter	Baseline Sample		Larger Sample	
		Entire period	Impact per quarter			Entire period	Impact per quarter	Entire period	Impact per quarter
<b>Flemish Region</b>									
EF vs D	-1.47***	Q1 2023	0.94	-0.85***	1.02	-1.89***	0.42	-1.53***	0.20
		Q2 2023	-0.98*		-0.93		-1.81***		-1.19**
		Q3 2023	-0.87		-0.79		-1.89***		-1.30***
		Q4 2023	-2.30***		-2.18***		-3.40***		-2.77***
		Q1 2024	-1.79***		-1.27		-2.85***		-3.04***
		Q2 2024	-2.30***						
		Q3 2024	-2.90***						
<b>Flemish vs Walloon Region</b>									
EF	-1.31***	Q1 2023	-0.53	-0.74	-0.43	-0.57	-0.64	-0.12	-0.31
		Q2 2023	0.02		-0.19		-0.09		1.41**
		Q3 2023	-0.85		-0.66		-0.34		0.41
		Q4 2023	-1.98***		-1.95***		-1.69**		-1.56**
		Q1 2024	-0.06		-0.27		0.15		-0.69
		Q2 2024	-2.07***						
		Q3 2024	-3.98***						
ABC	0.35	Q1 2023	-0.50	0.17	-0.58	0.52	-0.62	0.71	-0.85
		Q2 2023	0.87		0.81		0.81		0.73
		Q3 2023	-0.23		-0.14		0.28		0.64
		Q4 2023	0.81		0.77		1.68**		1.62**
		Q1 2024	-0.57		-0.20		0.12		1.36
		Q2 2024	1.20*						
		Q3 2024	0.57						
D	-0.53	Q1 2023	-1.17	-0.67	-1.14	-0.3	-0.98	-0.28	-1.85*
		Q2 2023	0.44		0.18		0.17		0.19
		Q3 2023	-1.31		-1.23		-0.85		-0.15
		Q4 2023	-0.02		-0.22		0.84		0.09
		Q1 2024	-1.40		-1.01		-0.95		0.50
		Q2 2024	-0.16						
		Q3 2024	-0.20						

Sources: FPS Finance, Realo, SPW, VEKA, own calculations.

<sup>1</sup> The table shows the estimated coefficients  $\hat{\gamma}$  (converted to percentages by taking the exponent of the coefficient and subtracting one) of Equation 3 for each difference-in-differences analysis (rows) and robustness analysis (columns). The statistical significance of the coefficients is denoted by \* ( $p < 0.1$ ), \*\* ( $p < 0.05$ ) and \*\*\* ( $p < 0.01$ ).

### C.3. Robustness check for the main heating source

Our second robustness check reveals that the estimated impact of the renovation obligation does not change when taking the main heating source into account. As shown in Figure 13 and discussed in Section 4.2, the Flemish Region has a larger share of houses relying on natural gas as their primary heating source and a lower share of houses using heating oil compared to the Walloon Region. These variations, despite sharper price increases for gas than oil during the 2022 energy crisis, do not appear to affect our findings.

We verified this by including fuel type as a control variable in Equation 3, creating dummies for gas and oil, with gas as the reference category. Data on fuel types are available up to the first quarter of 2024. We then introduced an interaction term between the heating source and the treatment group dummy ( $R_{it}$  in Equation 3).<sup>22</sup> The coefficient of this interaction term measure if houses using different heating sources responded differently to the renovation requirement. As the difference in heating source is regional, we specifically focus on the comparison of houses with a class E or F energy label in the Flemish and Walloon Regions.

The interaction coefficients are not statistically significant. This implies, for houses heated with oil, that the measured impact of the renovation requirement does not differ significantly from the reference category (gas). The estimated price impacts of the renovation requirement for houses with a class E or F label range from  $-0.3\%$  to  $-1.1\%$ , which are consistent with our main findings. These estimates are however not statistically significant, which aligns with the findings of our first robustness check and reflects the omission of the latest quarters (for which the renovation impact is largest) and possibly also the smaller sample size due to missing values in the main heating source variable.

### C.4. Robustness check for the asbestos certificate requirement

Our third robustness check accounts for introduction of the asbestos certificate requirement on 23 November 2022, obliging sellers in the Flemish Region to disclose the asbestos safety of the dwelling. This requirement could potentially impact our results, as houses with a class E or F energy label are more likely to be deemed unsafe due to the presence of asbestos (see Figure 12). The database we constructed includes information stemming from asbestos certificates dated from November 2022 to Q1 2024, enabling us to address this issue. As this requirement does not apply in the Walloon Region, our focus is on the analysis comparing houses with a class E or F energy label to those with a class D energy label in the Flemish Region.

To isolate the impact of the renovation obligation from the effect of the asbestos certificate requirement, it is necessary to focus on a subsample of houses that were sold before and again after 23 November 2022, for which the asbestos status remained constant and no major renovations took place. Hence, we removed houses that underwent renovation works that improved the energy score by at least 100 kWh/m<sup>2</sup>, assuming that the asbestos status and building quality remained unchanged for the remaining sample. For these houses, we can use the asbestos certificate, issued for the second sale, as a source of information on the presence of asbestos at the time of the first sale. This yielded a sample of 2 730 Flemish houses.

By controlling for the stable presence of asbestos and house quality, we can attribute any observed price changes to the information disclosed by the asbestos certificate. We test this using a repeat sales model with a variable indicating if a house was unsafe due to asbestos and was sold after introduction of the policy.

Our fixed effects regression is specified as:

$$\log(p_{it}) = \gamma R_{it} + \delta_t + \theta A_{it} + \kappa_i + \varepsilon_{it} \quad (5)$$

22 It should be noted that we also included interactions between fuel type and region, to capture any regional price differences.

In this equation,  $\delta_t$  represents time fixed effects,  $\kappa_i$  denotes house fixed effects and  $A_{it}$  equals one if house  $i$  at quarter  $t$  was unsafe due to asbestos and was sold after introduction of the asbestos certificate requirement. Thus,  $\theta$  captures the price impact of the asbestos certificate, measuring the increase in price discount between houses that are deemed unsafe due to the presence of asbestos and asbestos safe houses. As before, we use the dummy  $R_{it}$  for a house with class E or F energy label sold after 1 January 2023 and coefficient  $\gamma$  measures the price impact of the renovation obligation on this treatment group.

The results confirm our main findings. We find that Flemish houses with an energy label of E or F have become on average 1.8% cheaper since 2023 relative to houses with a class D label as a result of the renovation obligation, which is statistically significantly different from zero and similar to our baseline result. Meanwhile, the asbestos certificate interaction term indicates that publicly disclosing asbestos information (independently of its presence) leads to a 2% price decrease for houses deemed unsafe due to the presence of asbestos compared to houses declared asbestos safe. These results should however be interpreted with caution, given the small sample size of this robustness analysis.

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# Conventional signs

i.e. id est

## List of abbreviations

EC	European Commission
EPC	Energy performance certificate
EPBD	Energy Performance of Buildings Directive
ETS2	European Union Emissions Trading System 2
EU	European Union
DOM	Days on market
FPS	Federal Public Service
kWh	Kilowatt per hour
OVAM	Openbare Vlaamse Afvalstoffenmaatschappij (Flemish Public Waste Agency)
SPW	Service public de Wallonie
VAT	Value added tax
VEKA	Vlaams Energie- en Klimaatagentschap

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