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POLICY BRIEF

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Green Signals: Energy Efficiency and German Housing Markets

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Overview

- In this study, we analyze the effect of energy performance certificates on sales prices and rents on the basis of millions of sales and rental listings in Germany in order to understand the causes of the stagnation of the refurbishment rate in the German housing stock.
- The results show that higher energy efficiency is reflected in higher prices and rents. Sales and rent premiums for energy-efficient buildings are higher when using the so-called *Bedarfsausweis* (energy demand certificate), which is based on an expert evaluation of the property's energy status. However, these premiums are noticeably lower when using the so-called *Verbrauchsausweis* (energy consumption certificate), which relies on the meter readings from the past three years.
- The rent premium for energy efficient dwellings can be fully explained by the energy cost savings when switching from low to high energy efficiency using the *Bedarfsausweis*. This suggests that when accurate information is available, market participants correctly internalize energy cost savings.
- Comparing the sale price premium with refurbishment costs suggests that refurbishment is financially viable, but only if the *Bedarfsausweis* is used.
- Despite mandatory energy performance certificates, a significant portion of property listings do not provide this information, suggesting the need for stricter enforcement.
- *Policy recommendations:* Strengthen the quality of energy performance certificates by focusing on the *Bedarfsausweis* and phasing out the *Verbrauchsausweis*. In addition, strengthen compliance with reporting requirements for energy performance certificates by introducing a sanction mechanism. This will increase transparency and can therefore contribute to an increase in the refurbishment rate.

Keywords: Energy efficiency, German Housing Markets, Energy Performance Certificates, Refurbishment

- In dieser Studie analysieren wir auf Grundlage von Millionen Verkaufs- und Mietinseraten in Deutschland den Effekt von Energieausweisen auf Verkaufspreise und Mieten, um die Ursachen für die Stagnation der Sanierungsrate im Wohnungsbestand zu verstehen.
- Die Ergenisse zeigen, dass höhere Energieeffizienz in höheren Preisen und Mieten widergespiegelt wird. Verkaufs- und Mietprämien für energieeffiziente Gebäude sind höher, wenn der Bedarfsausweis verwendet wird, der auf einer Expertenbewertung des energetischen Zustands der Immobilie basiert. Die Prämien sind jedoch deutlich niedriger, wenn der Verbrauchsausweis verwendet wird, der sich auf die Energieverbrauchsdaten der letzten drei Jahre stützt.
- Die Mietprämie für energieeffiziente Wohnungen kann vollständig durch die Energiekosteneinsparungen beim Wechsel von niedriger zu hoher Energieeffizienz erklärt werden, wenn ein Bedarfsausweis verwendet wird. Dies deutet darauf hin, dass Marktteilnehmer Energiekosteneinsparungen korrekt einpreisen, wenn genaue Informationen verfügbar sind.
- Der Vergleich von Verkaufspreisen mit energetischen Sanierungskosten legt nahe, dass eine Sanierung finanziell rentabel ist, aber nur, wenn der Bedarfsausweis verwendet wird.
- Trotz der Pflicht zu Energieausweisen enthält ein erheblicher Teil der Immobilienanzeigen diese Informationen nicht, was auf die Notwendigkeit strengerer Durchsetzung hindeutet.
- *Politikempfehlungen:* Verbesserung der Qualität der Energieausweise durch die Etablierung des Bedarfsausweises als Standard und die schrittweise Abschaffung des Verbrauchsausweises. Darüber hinaus sollte die Einhaltung der Meldepflichten für Energieausweise durch die Einführung eines Sanktionsmechanismus gestärkt werden. Dies wird zu mehr Transparenz führen und kann somit zu einer Steigerung der Sanierungsrate beitragen.

Schlüsselwörter: Energieeffizienz, Deutsche Wohnungsmärkte, Energieausweise, Sanierung

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1 Introduction

Climate change is one of the defining challenges of our time. In Germany, the operation of buildings accounts for around 36% of final energy consumption and around 30% of CO_2 emissions (Bundesministerium für Wirtschaft und Klimaschutz, 2022). Making the existing housing stock more energy efficient is therefore of paramount importance in reducing emissions. In Germany, however, the annual renovation rate of existing buildings is stagnated at 1%. This rate needs to double in order to meet the EU's Energy Efficiency and Climate Targets by 2050 (Deutsche Energie-Agentur GmbH, 2021; Popovic and Reichard-Chahine, 2024). In this policy brief, we adopt an asset pricing perspective to explore the reasons for the stagnation in the renovation rate. We ask: Is it financially viable to renovate a property? How much will the value or rental income of a dwelling increase with improved energy efficiency? Answering these questions is critical to understanding property owners' incentives to undertake energy efficiency renovations.

Using millions of apartment listings and transactions in German cities, we first quantify the impact of energy performance certificates (EPC) on house prices and rents through hedonic regressions. Overall, we find that differences in the energy efficiency of apartments are reflected in their market prices. Controlling for a large number of property characteristics, we find that A-rated apartments command a substantial premium over lower-rated apartments in both the sales and rental markets.

Moreover, we analyze the impact of different types of energy certificates and uncover highly varied effects. In Germany, unlike other EU countries, two types of certificates coexist: the so-called *Bedarfsausweis* (energy demand certificate) and the so-called *Verbrauchsausweis* (energy consumption certificate). The *Bedarfsausweis* is based on an expert assessment of the building's energy performance, while the *Verbrauchsausweis* relies on energy bills and meter readings from the past three years. Our findings show that the more objective *Bedarfsausweis* provides more valuable information to homebuyers and renters, leading to a larger price premium compared to the *Verbrauchsausweis*, which may be influenced by the occupants' heating behavior.

Next, we turn to understanding the drivers of energy efficiency premiums. To do so, we examine the time variation of energy costs. In particular, we use the Russian invasion of Ukraine as an exogenous shock to energy costs and show how this translated almost one-to-one into an increase in

the rent premium of highly efficient apartments relative to non-efficient ones. We find that, over time, the rent premium using the *Bedarfsausweis* closely tracks the energy cost savings associated with moving to a more efficient dwelling. This implies that changes in cash flows, i.e. rents net of costs, are the main driver of the energy performance premium.[1] However, this result is less pronounced when a *Verbrauchsausweis* is used.

Comparing the price premium to the cost of renovation allows us to understand whether upgrading an apartment is financially viable. The price premium for an energy-efficient apartment reflects the higher future rental income of the property. Thus, if the price premium of an A-rated dwelling is equal to or greater than the cost of renovating the dwelling, it is financially viable to undertake the renovation. As prices internalize the increased energy costs, this implies an increase in portfolio value for a landlord holding a top-rated property. Our results indicate that the renovation costs associated with making a dwelling more energy efficient are equal to the price premium using the more objective *Bedarfsausweis*. However, using the *Verbrauchsausweis* suggests that the renovation costs exceed the price premium. Thus, renovating the dwelling is financially viable if sellers report the *Bedarfsausweis* but do not use the energy *Verbrauchsausweis*. The availability of the *Verbrauchsausweis* may partly explain why owners are less inclined to renovate and why the overall renovation rate remains low.

We then analyze another reason for the low renovation rate: the lack of EPC information in online listings. Despite the legal requirement, almost half of the property listings lack information on the EPC. While we find that properties lacking this information in their listing tend to have a higher listing price, their transaction price is typically significantly lower, suggesting that the information is disclosed to buyers at a later stage.

Overall, our analysis of millions of housing transactions and rental data suggests that market prices correctly internalize the energy performance of buildings when accurate information is available. Therefore, policies that target housing market prices through subsidies or taxes are unlikely to significantly increase the refurbishment rate. Instead, policymakers should focus on stricter enforcement of energy performance certificates and move to a system based solely on the more objective *Bedarfsausweis*. In other words, policymakers should prioritize increasing market transparency.

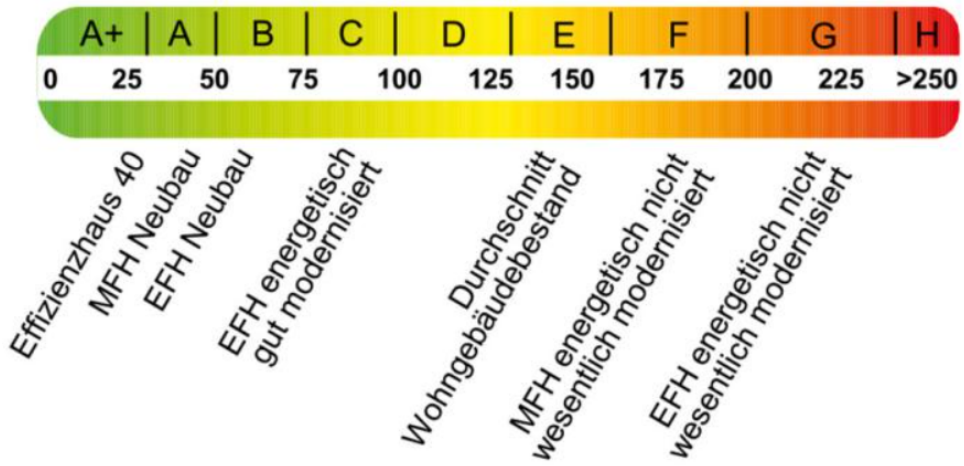
[1] Higher energy efficiency makes the house more independent of energy price fluctuations and thus acts as a hedge against future energy price increases. This can make the apartment less risky and therefore more valuable. However, we find no evidence on the risk channel even when using rental yields as a more direct measure of the risk channel. More details can be found in the working paper; available upon request.

2 Institutional Setting

The Energy Conservation Act (EnEG) forms the foundation of the legal framework governing energy standards for buildings.[2] The 2005 version of the EnEG first established the requirement to implement Energy Performance Certificates (EPC) in alignment with European guidelines. The EnEG is further detailed through the Energy Conservation Ordinance (EnEV), which outlines specific regulations. The 2007 EnEV introduced the mandatory issuance of energy certificates, requiring that they be presented upon request by prospective buyers. Moreover, the EnEV defines the calculation methods for EPCs. Since May 2014, the EnEV has been updated to mandate that energy certificates must also be included in online listings.[3] Since November 2020, the EnEG and the EnEV were replaced by the Building Energy Act (GEG), which is a fundamental revision of the previous law. However, the legal requirement for the EPC remained unchanged.

The EPC indicates the amount of energy in kWh/m²a required to heat the apartment and provide hot water. This number is supplemented with a rating from A+ to H which provides further information about the ranking of the energy efficiency of the property. Figure 1 shows the rating with their respective kWh/m²a.[4]

Figure 1: Energy efficiency classes of residential buildings



Notes: The figure shows the energy performance labels with their respective kWh/m²a.
Source: Verbraucherzentrale, https://www.verbraucherzentrale.de/wissen/energie/energetische-sanierung/energieausweis-was-sagt-dieser-steckbrief-fuer-wohngebaeude-aus-24074.

[2] For an overview of the regulation in Germany, see https://www.bmwk.de/Redaktion/EN/Artikel/Energy/energy-conservation-legislation.html or https://www.bbsr-geg.bund.de/GEGPortal/DE/Energieausweise/energieausweise_node.html (German only).

[3] See §16a EnEV.

[4] The ratings are defined in Annex 10 of the Building Energy Act (GEG) from A+ to H. See https://www.gesetze-im-internet.de/geg/anlage_10.html.

The German EPC regulation, contrary to other EU countries, is composed of the *Bedarfsausweis* and the *Verbrauchsausweis*. The former is based on an expert's analysis of the energy performance of the building, considering factors like windows and insulation. The latter is derived from the energy consumption using the bills and meter readings from the past three years as an indicator, adjusted for weathering. Owners can choose which certificate to display, except for residential buildings built before 1977 with fewer than five apartments, where the *Bedarfsausweis* is mandatory. Newly constructed buildings also require a *Bedarfsausweis* due to the lack of past consumption data.

3 Data & Methods

We use advertisement level data from Value AG, VALUE Market Database.[5] ValueAG uses an advanced scraping algorithm to extract listing information to gather a representative sample of online listings across multiple platforms covering the vast majority of the German market. Our sample contains 19 German cities, including the 9 largest cities.[6] We limit our analysis to the period from Q3 2014 to Q2 2024, as EPC reporting on online listings was not mandatory before May 2014.[7]

For this analysis, we focus on large urban centers in Germany because there are more transactions there, which makes our statistical analysis more reliable. Apartments constitute the largest market segment in these large urban centers. In addition, there is a large number of rented apartments, which allows us to examine how energy cost savings are internalized in the rental market, and thus identify differences in rental income for different energy-efficient apartments. It should be noted that single and two-family houses account for the largest share of total energy consumption and emissions in the building sector. Nevertheless, the multi-family sector accounts for 37% of energy consumption and 39% of CO_2 emissions of the German residential building sector (Gniechwitz, Paare, and Schulze, 2022) and we expect most of the findings in this analysis to hold for the other market segments as well.

Our dataset includes the energy use in kWh/m^{2}a of the dwellings displayed on the EPC as well as the type of EPC on which the calculation of the number is based on (i.e. *Bedarfsausweis* or *Verbrauchsausweis*). We classify the EPC into ratings A+ to H, following the official definition of the classes (see Figure 1). The upper panel of Figure 2 shows the composition of EPC ratings over time for the sales and rental dataset, respectively. The rating A+ and H are dominated by

[5] We thank Sebastian Hein for providing the data. Visit the website of ValueAG for more information: `https://www.value-marktdaten.de/en/portfolio/market-database/`.

[6] The 19 cities are: Berlin, Bonn, Chemnitz, Dortmund, Dresden, Duisburg, Düsseldorf, Erfurt, Frankfurt, Hamburg, Karlsruhe, Köln, Leipzig, Lübeck, München, Münster, Potsdam, Stuttgart, Wiesbaden.

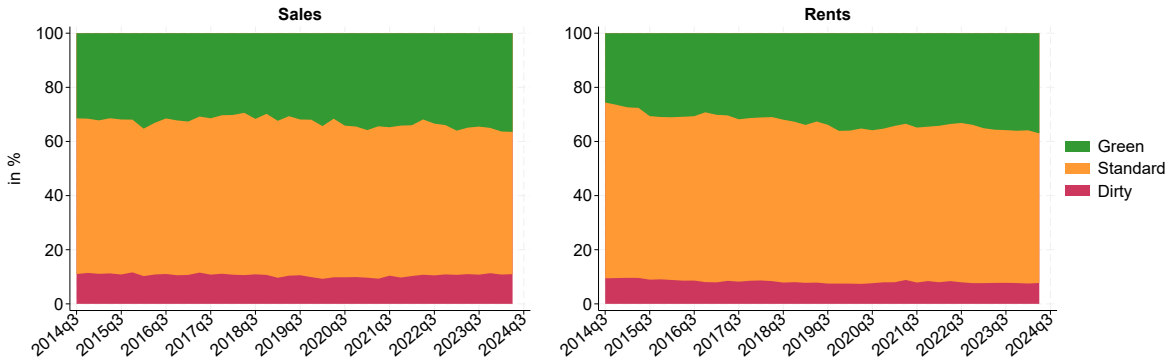
[7] We clean the dataset by winsorizing the purchase price and rent per square meter at the top and bottom 1% for each year and city, removing outliers in the 1st and 99th percentiles of the square meter distribution, and dropping listings that were online for more than a year.

other categories while rating C, D, and E are the majority of listings on the market. Notably, the composition of listings in each EPC rating remain almost stable for sales while B rated apartments slightly increased over time on the rental market.

Figure 2: Sample composition

(a) Energy performance certificate

(b) Heating type



Notes: The figures shows the composition of (a) energy performance certificates, classified according to the official rating from A+ to H for the sales and rental market. The figure is based 314,875 sales listing and 1,085,909 rent listings. Panel (b) shows the composition of heating types over time. The category "green" is composed of combined heat and power heating (CHP), pellet heating, solar panel, district heating and heat pump, with district heating being by far the most represented. The category "standard" is composed of central heating and gas heating, while gas is dominant in that group. The "dirty" category is made of room heating, electricity, oil and coal with oil being the dominant in this category. The figure is based on 476,087 sales listings and 1,745,272 rent listings.
Source: ValueAG, VALUE Market Database. Own calculation.

Additionally, our dataset includes detailed information on the heating system of the property.[8] We classify heating types into three categories: "green", "standard" and "dirty" following Hahn,

[8]Heating system data includes solar panels, pellet, geothermal and air pumps, CHP, district heating, and no heating. We also have data on fuel types (coal, gas, electricity, oil) and heating systems (central, district, room). Since many properties report multiple heating systems, we adopt a conservative classification based on the most energy-inefficient option (e.g., if both solar and oil are used, it's classified as oil-based). Tiled stove and floor heating are excluded, as they usually supplement other systems and lack clear energy source or efficiency data.

Hirsch, and Bienert (2018). The first category is composed of district heating, combined heat and power heating (CHP), pellet heating, solar panel, and heat pump, with district heating being by far the most represented.[9] Gas and central heating make up the "standard" group, while gas is dominant in that group. Finally, the "dirty" category is made of oil, coal, electricity, and room heating with oil being the dominant fuel type in this category. The lower panel of Figure 2 shows the composition of heating system in the sales and rental market over time. In both markets, the standard heating type, which is mainly gas heating, is most common. Only about 10% of the listings report an oil heating system, which makes the majority of the dirty heating category. Furthermore, Figure 2 shows that the composition of heating types is almost stable in the sales data over the past 10 years, while the green heating system only slightly increases in the rental market. Remarkably, the composition of apartments using an oil heating system remains constant over time in both samples.

Moreover, the dataset includes various other characteristics of the property which are important for our empirical analysis. To isolate the effect of the EPC, we control for an exhaustive list of characteristics of the property that also affect the price and rent.[10] This approach is known as hedonic regression and can be used to estimate the shadow value of specific property characteristics that are not directly traded, such as location or construction year, on prices or rents. We use this method to estimate the impact of the EPC on real estate prices and rents.

4 Energy certificates are reflected in market prices

In this section, we begin by quantifying the average impact of energy efficiency ratings and different heating systems on house prices and rents from 2014-2024 through hedonic regression analysis. We explore whether apartments with high energy efficiency command higher prices and rents compared to similar, less efficient properties.

For our hedonic analysis, we categorize energy ratings into four groups: A+-A, B-C, D-E, and F-H, with D-E rated properties serving as the reference group. We also evaluate the impact of various heating systems on prices and rents, using standard heating types, mainly gas systems, as

[9] We follow the definition of the German Federal Environment Agency (UBA), which identifies these as sustainable heating systems. See `https://www.umweltbundesamt.de/umwelttipps-fuer-den-alltag/heizen-bauen/heizungstausch#was-sie-beim-wechsel-ihrer-heizung-beachten-sollten`.

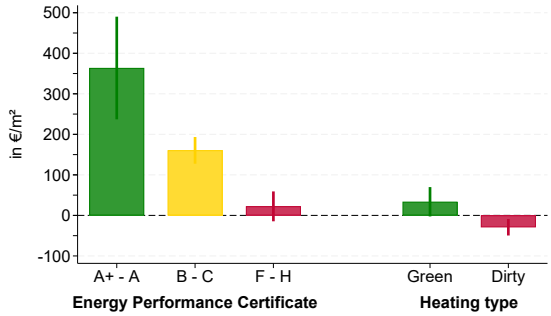
[10] This includes the zip code of the property, construction year, maintenance condition, floor space, type of kitchen, the presence of a balcony, terrace, or garden, floor number, room number, number of parking spaces, whether the dwelling is under monument protection, the year of a modernization of the property, whether the apartment is rented out, and whether the listing is provided by a commercial supplier. Moreover, we include city-time fixed effects to control for city-specific time trends. As long as property characteristics are not perfectly collinear, we can distinguish the effect of each on price. Multicollinearity between explanatory variables does not bias the estimates but increases their variance, affecting inference. However, omitting a key variable from the true model may bias the estimates (see e.g., Wooldridge (2012)).

the baseline.

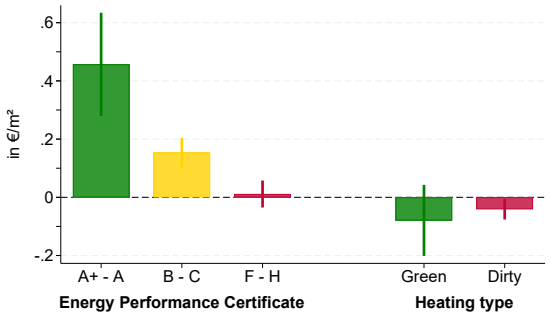
Figure 3 presents the effect of EPC ratings and heating systems on (a) prices and (b) rents. We find that apartments with an A-rating have significantly higher asking prices, around €364/m² more than comparable properties with a D-E rating.[11] This result can be interpreted as follows: if I were to refurbish my D-E rated apartment, its value would increase by €364/m², assuming all other factors remain constant. Notably, this estimate accounts for factors such as location and construction year, which may also influence prices but are unrelated to the refurbishment. Similarly, we observe a substantial premium of €160/m² for B-C rated apartments compared to D-E rated ones, with no significant discount for F-H rated apartments relative to D-E rated properties. This finding aligns with studies conducted in Ireland (Hyland, R. C. Lyons, and S. Lyons, 2013), Italy (Loberto, Mistretta, and Spuri, 2023), France (Civel, 2020), and also Germany (Taruttis and Weber, 2022).

Figure 3: Sales price and rent premium (in €/m²)

(a) Sales price premium



(b) Rent premium



Notes: The figure shows (a) the sales price premium for energy performance certificate categories A+-A, B-C, F-H relative to the category D-E, as well as for the heating type categories green and dirty relative to the standard heating category in €/m². Panel (b) shows the premium for the same energy performance certificate categories as well as heating types for rents in €/m². The bar shows the point estimate of the premium along with the 95% confidence interval indicated by the vertical line for each bar. Standard errors are clustered at the city level. The estimates are based on a hedonic regression for 19 German cities using 306,947 sales listing and 1,051,522 rent listings from 2014q3 to 2024q2.
Source: ValueAG, VALUE Market Database. Own calculations.

Our analysis further shows that apartments with a green heating system, primarily district heating, have a premium of €34/m² compared to those with standard heating systems, mainly gas. We find a significant negative premium of €29/m² for apartments with oil heating, which constitutes most of the less efficient ("dirty") heating types.

Likewise for the rental market, we find a positive and significant rent premium of €0.46/m² for A-rated apartments compared to similar dwellings with a D-E rating. This premium decreases to €0.15/m² for apartments with a B-C rating, while there is no observed discount for condos with

[11] The results are robust for using a logarithmic specification of the dependent variable. For better interpreting the size of the premiums, we use the prices and rents in €/m².

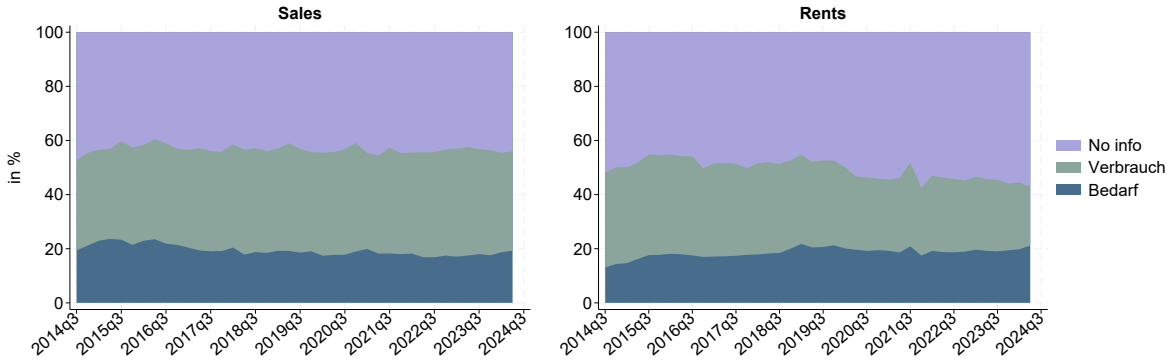
an F-H rating. Green heating systems have no effect on rents compared to gas heating, though we find a slight discount for oil heating systems of €0.04/m^2. The lack of a rent premium for green heating systems, mainly district heating, could be attributed to the fact that district heating offers no significant cost savings compared to gas heating.

5 Type of energy certificate matters

As we showed in the previous section, energy-efficient dwellings have a higher asking price and rent compared to less energy-efficient ones. As such, the information on the energy-efficiency of apartments is reflected in the price. In this section, we examine the differences in the quality of energy performance certificates and their impact on prices and rents.

In Germany, two types of EPCs coexist: The *Bedarfsausweis*, which is based on an expert assessment of the property's energy efficiency and the *Verbrauchsausweis*, which relies on the actual energy use over the past three years, adjusted only for weather conditions. Property owners can choose which certificate to use, with the *Verbrauchsausweis* being less expensive than the *Bedarfsausweis*. However, the *Verbrauchsausweis* is affected by the previous tenants' energy usage, which can distort its accuracy.

Figure 4: Composition of Bedarfs-, Verbrauchsausweis, and no EPC



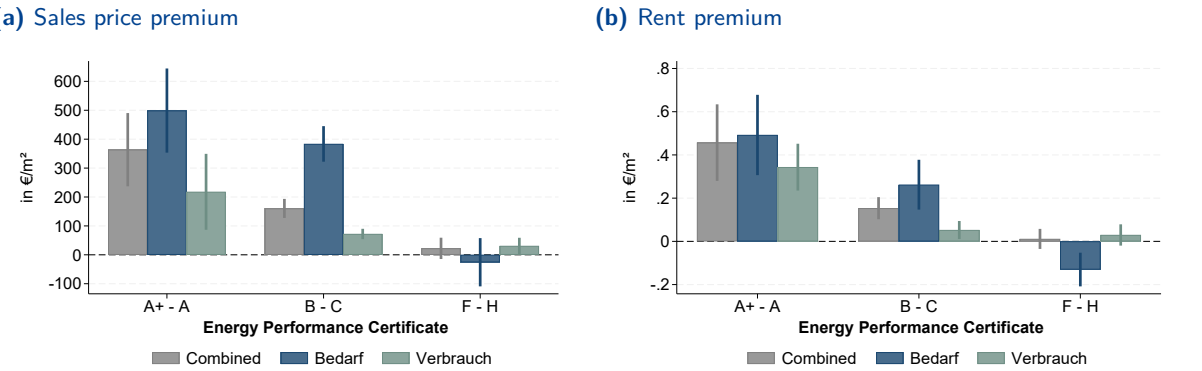
Notes: The figures shows the composition of listings with an *Bedarfsausweis*, *Verbrauchsausweis*, and no information on the energy performance certificate for the (a) sales and (b) rent dataset for each quarter. The figure is based on 554,571 sales listings and 2,188,155 rent listings of 19 German cities from 2014q3 to 2024q2.
Source: ValueAG, VALUE Market Database. Own calculation.

Figure 4 breaks down the total number of ads into the two types of EPCs, as well as the number of ads without any information on the EPC. The *Verbrauchsausweis* is the most common EPC, making up about 30-40% of all listings. The *Bedarfsausweis* is used less frequently, with a share of 20% of

all listings. The lower prevalence of the *Bedarfsausweis* can be attributed to its higher costs and the self-selection of owners who, knowing their energy consumption, may prefer the *Verbrauchsausweis* for potentially better results based on past figures. Furthermore, a very large proportion of listings have no information on the EPC, despite the legal requirement to do so.

We first decompose the price and rent premiums based on the two types of EPCs to assess the differences in the quality of information they provide about the dwelling's energy efficiency. In section 8, we investigate the effect of missing information on the EPCs on prices and rents. Figure 5 shows the results of three different hedonic regressions. We use the same EPC categories A+-A, B-C and F-H relative to D-E rated apartments as before. The gray bar shows the premium for both types combined as in Figure 3. The blue bars show the sales price and rent premium using only apartments with a *Bedarfsausweis*. Similarly, the teal bar shows the premium for the *Verbrauchsausweis*. We see that both the price and rent premiums are much more pronounced for the more objective *Bedarfsausweis*, while apartments with a *Verbrauchsausweis* have a lower premium for the same energy rating. The difference in the premium for A+-A rated dwellings is particularly strong for the sales market compared to the rental market. Overall, this is consistent with the fact that the energy performance certificate, which is based on expert analysis, is more objective and thus provides more valuable information to market participants.

Figure 5: Premiums for Bedarfs- and Verbrauchsausweis (in €/m²)



Notes: The figure shows (a) the sales price premium for energy performance certificate categories A+-A, B-C, F-H relative to the category D-E for the *Bedarfsausweis* and *Verbrauchsausweis* combined (gray bar) in €/m², the *Bedarfsausweis* only (blue bar), and *Verbrauchsausweis* (teal bar). The bars display the point estimate of the respective premiums along with their 95% confidence intervals indicated by the vertical line. Standard errors are clustered at the city level. All regression are based on 19 German cities from 2014q3 to 2024q2. The regression for the combined effect of both types of energy performance certificates is based on 306,947 sales listing, the regression for the *Bedarfsausweis* are based on 103,889 sales listing, and the regression for the *Verbrauchsausweis* is based on 202,348 sales listings. Similarly, panel (b) shows the premium in €/m² for the three different samples, as described before, for the rental market. The regression for the combined effect of both types of energy performance certificates is based on 1,051,522 rent listing, the regression for the *Bedarfsausweis* are based on 387,062 rent listing, and the regression for the *Verbrauchsausweis* is based on 663,490 rent listings.
Source: ValueAG, VALUE Market Database. Own calculations.

6 Energy savings explain premium

A natural follow-up question concerns the drivers of the premium, which we analyze next. To do so, we examine the time variation in the rent premium and compare it to the energy cost savings from improved energy efficiency. In particular, the Russian invasion of Ukraine provides an exogenous shock to energy costs that allows us to assess how energy efficiency is priced into rents.

The previous estimates reflect the average effect of the premium for energy efficient dwellings from 2014 to 2024. However, following the Russian invasion of Ukraine, the premiums differ significantly. The average rent premium from 2014Q3 to 2021Q4 for A+-A rated dwellings compared to similar D-E rated dwellings is €0.36/m^2 using the *Bedarfsausweis* and €0.29/m^2 using the *Verbrauchsausweis*. For apartments with a B-C rating, the premium drops to €0.25/m^2 with the *Bedarfsausweis* and €0.06/m^2 with the *Verbrauchsausweis*. For F-H rated apartments, the discount is €0.14/m^2 with the *Bedarfsausweis* and no significant discount with the *Verbrauchsausweis*. The average rent premium after the Russian invasion increases to €0.86/m^2 for A+-A apartments with a *Bedarfsausweis* and only slightly to €0.47/m^2 with a *Verbrauchsausweis*, B-C rated apartments have a rent premium of €0.34/m^2 with a *Bedarfsausweis* and no significant premium with a *Verbrauchsausweis*. We only find a significant discount after the Russian invasion of €0.24/m^2 for F-H rated dwellings when a *Bedarfsausweis* is used.

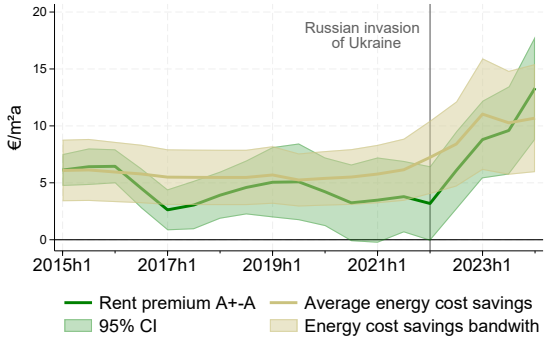
Next, we further estimate the time-varying rent and price premiums in more detail using a rolling-window hedonic regression. Specifically, we analyze all listings from Q3 2014 to Q2 2015 to estimate the premium for Q2 2015. This process is repeated by shifting the window forward one quarter, using listings from Q4 2014 to Q3 2015 to estimate the premium for Q3 2015, and so on.

We use the time-variation in the rent premium to compare it with the energy cost savings of moving to an A-rated apartment over time. To do this, we calculate a range using the maximum and minimum energy consumption differences between the two types of apartments. Specifically, the maximum energy savings is based on a comparison between an apartment at the upper limit of the E-rating (160 kWh/m^{2}a) and an A+-rated apartment (less than 30 kWh/m^{2}a), resulting in a potential savings of at least 130 kWh/m^{2}a. Similarly, the minimum energy saving is based on the difference between an apartment at the lower limit of the D rating (100 kWh/m^{2}a) and one at the upper limit of the A rating (50 kWh/m^{2}a), giving a minimum saving of 50 kWh/m^{2}a. We then multiply these limits of potential energy savings by the gas price for each period to measure the energy cost savings.

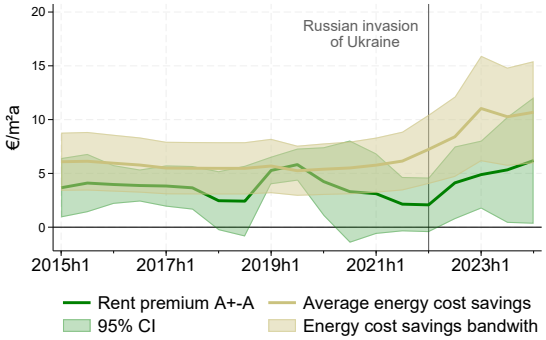
Figure 6 shows the annual rent premium for A+-A rated apartments alongside the energy cost savings bandwidth and the average energy cost savings when comparing an apartment with a D-E

Figure 6: Rent premium & energy costs savings

(a) Bedarfsausweis



(b) Verbrauchsausweis



Notes: The figure shows the time-varying annual rent premium in €/m² using rolling-window method for for the category A+-A of the (a) *Bedarfsausweis* and (b) the *Verbrauchsausweis* alongside the average energy cost savings (90kWh/m²a) as well as the energy costs savings bandwidth. The energy cost savings are constructed by using the minimum (50kWh/m²a) and the maximum (130kWh/m²a) energy savings comparing an apartment in the group A+-A with D-E multiplied by the gas price of the respective half year. Gas prices for consumers (incl. taxes) provided by Destatis for every half year from 2015-2024.
Source: ValueAG, VALUE Market Database. Destatis. Own calculations.

rating to one with an A+-A rating. Panel (a) of Figure 6 shows the annual rent premium using the *Bedarfsausweis* and panel (b) the *Verbrauchsausweis*. As the figure illustrates, the rent premium for both certificate types overlaps with the energy cost savings, indicating that the rent premium can largely be explained by the cost savings.[12] Importantly, the rise in the rent premium aligns with the increase in energy costs since Q2 2022. Moreover, the increase after the Russian invasion of Ukraine is particularly pronounced when using the more objective *Bedarfsausweis*.

The average rent premium per month before the Russian invasion of Ukraine (2014Q3-2021Q4) for apartments with an A+-A rating compared to comparable properties D-E was €0.36/m² if a *Bedarfsausweis* was used and €0.29/m² if the energy efficiency information was based on the *Verbrauchsausweis*. This compares with average monthly energy cost savings of €0.47/m². After the Russian invasion (2022Q1-2024Q2), energy costs increased significantly, resulting in an average energy cost saving of €0.79/m² for an apartment with an A+-A rating compared to apartments with a D-E rating. This is adequately reflected in the rent premium when the *Bedarfsausweis* is used. The average rent premium with a *Bedarfsausweis* increases to €0.86/m², with a *Verbrauchsausweis* only to €0.47/m².

The results show that rents internalize energy costs appropriately when accurate information is provided. Next, we ask whether it is financially viable to renovate an apartment. Specifically, do

[12] This result contrasts with the findings of Sieger and Weber (2023), who conclude that rent premiums are too low to cover energy cost savings. However, their analysis treats energy efficiency as a continuous variable in the regressions. We find that energy efficiency has a highly non-linear effect on prices and rents, which biases their estimates.

homeowners experience an increase in the value of their property equal to the cost of the renovation?

7 Refurbishments are financially viable

To understand whether energy efficiency renovations are financially viable, we compare the sales price premium to the cost of the renovation. We take the perspective of a landlord who owns an apartment and rents it out. We have shown that the landlord can earn a significantly higher rent by renting an A-rated apartment than by renting a less energy-efficient apartment. This higher future rental income translates into a higher portfolio value for a landlord who owns an A-rated property today. Whether and when the landlord decides to liquidate the property is not something we take a position on. Using the price premium allows us to determine whether an energy efficiency refurbishment is financially viable. If the price premium of an A-rated dwelling is equal to or greater than the cost of renovating the dwelling, the renovation is financially viable. If the price premium is less than the cost of renovation, the investment is not viable, i.e. the cost of renovating the apartment exceeds the increased rental income.

Calculating the refurbishment costs is complex, as expenses vary by property characteristics. To tackle this problem, we use the estimates from Gniechwitz, Paare, and Schulze (2022), who provides an assessment of refurbishment costs for multi-family houses as of Q3 2021. We focus on energy-related additional costs instead of the full costs, as general modernization also adds value independently of energy-related renovation. The energy-related cost of refurbishing an apartment ranges from €440/m^2 to €680/m^2, depending on the initial condition of the property.[13] We then use the construction price index for maintenance of residential buildings from Destatis to obtain the costs of energy-efficient renovation for the years Q2 2015 to Q2 2024.[14] In addition, we take into account the financing costs associated with renovating the apartment by multiplying the renovation costs by the interest rate of each quarter.[15]

Figure 7 shows the price premium for A-rated apartments using (a) the *Bedarfsausweis* and (b) the *Verbrauchsausweis* along with the refurbishment costs including the financing costs over time. As can be seen, the price premium using the more objective *Bedarfsausweis* matches closely the cost of renovation over time. In particular, after the Russian invasion of Ukraine and the subsequent rise in energy prices - which corresponded to the rise in both rents and price premiums with a lag - the price

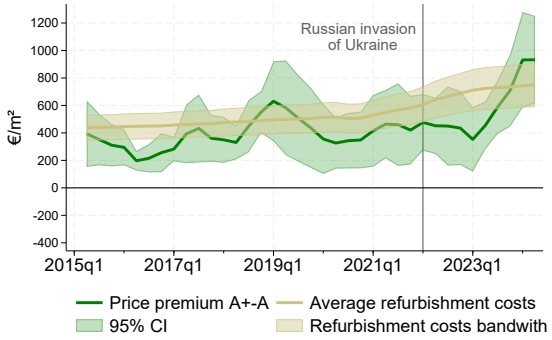
[13] Gniechwitz, Paare, and Schulze (2022) uses multi-family houses built between 1949 and 1978, estimating costs based on the initial condition of the property. They distinguish between low, medium, and well modernized properties. For the target standard, we use an energy efficiency house standard of E40, which is equivalent to energy class A+-A. The cost range reflects the energy-related costs of upgrading a low and well modernized house.

[14] This index includes the costs of thermal insulation and roofing work, which are key components of energy-efficient renovation (Gniechwitz, Paare, and Schulze, 2022).

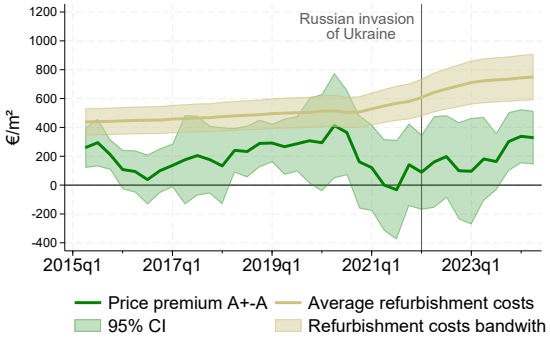
[15] We use the effective annual interest rates - average for all maturities - of housing loans from the Bundesbank.

Figure 7: Price premium & refurbishment costs

(a) Bedarfsausweis



(b) Verbrauchsausweis



Notes: The figure shows the time-varying sales price premium in €/m² using rolling-window method for for the category A+-A of the (a) *Bedarfsausweis* and (b) the *Verbrauchsausweis* alongside the refurbishment costs bandwidth depending on the initial condition of the house. We use the refurbishment costs from Gniechwitz, Paare, and Schulze (2022) as of 2021q3 in €/m² and construct the time series using the construction price index for maintenance of residential buildings from Destatis to obtain the costs for energy-efficient refurbishment for the years from 2015q2 to 2024q2. The refurbishment costs also include the financing costs, measured by the average mortgage rate from Bundesbank.
Source: ValueAG, VALUE Market Database. Destatis. Bundesbank. Own calculations.

premium exceeds the renovation costs. This shows that renovating the apartment is a financially viable investment for homeowners. Importantly, our results do not take into account government subsidies for renovating a home. As of 2023, up to 20% of the costs are subsidized in Germany, so our cost estimates are an upper bound.[16]

The average price premium before the Russian invasion of Ukraine (2014Q3-2021Q4) for apartments in the A+-A category compared to apartments with ratings D-E is €390/m² if the energy efficiency information is based on a *Bedarfsausweis* and €188/m² if a *Verbrauchsausweis* is used. The average refurbishment costs during this period amounted to €479/m². After the Russian invasion (2022Q1-2024Q2), we see a significant increase in the rent premium for energy-efficient apartments, which is also reflected in the price premium. The price premium for apartments with A+-A ratings is €652/m² for a *Bedarfsausweis* and only €226/m² for a *Verbrauchsausweis*. The average refurbishment costs including financing costs for this period amount to €705/m². It is worth noting that the difference between the average price premium for the requirement certificate and the refurbishment costs is not statistically significant.

The price premium based on the *Verbrauchsausweis* is much smaller, as also shown in figure 5. Remarkably, the price premium for A+-A rated apartments using the *Verbrauchsausweis* is smaller than the renovation cost, indicating that the renovation is not financially viable. These results suggest that renovating the apartment is only profitable when using the *Bedarfsausweis*. Apartments with a

[16] For more information about the subsidizes regarding energetic renovations see `https://www.bafa.de/DE/Energie/Effiziente_Gebaeude/Sanierung_Wohngebaeude/Gebaeudehuelle/gebaeudehuelle_node.html`.

F-H rating only have a significant discount of €65/m² when a *Bedarfsausweis* is used. We do not find a statically significant discount for F-H rated apartments using a *Verbrauchsausweis*.

The difference in the valuation of dwellings with the two types of EPC is also significant for all other ratings. Before the Russian invasion of Ukraine, the average price premium for B-C rated dwellings compared to similar D-E rated dwellings is €320/m² with the *Bedarfsausweis* and only €72/m² with the *Verbrauchsausweis*. After the Russian invasion, the price premium for B-C rated flats rises to €566/m² with a *Bedarfsausweis* and even falls to €68/m² with a *Verbrauchsausweis*. We only find a significant discount of €65/m² for apartments rated F-H before the Russian invasion when a *Bedarfsausweis* is used. There is no significant discount for F-H rated apartments before the Russian invasion when the *Verbrauchsausweis* is used, nor for either type of EPC after the Russian invasion.

In summary, we find that the energy efficiency of apartments is accurately reflected in their market prices using the more objective *Bedarfsausweis*. This indicates that buyers and sellers are correctly accounting for energy performance when it is made available through the *Bedarfsausweis*, which shows that the financial incentives for energy-efficient renovations are correctly aligned. As such, the low quality of the *Verbrauchsausweis* might explain the low renovation rate even though the pricing mechanisms are sending the right signals. In the next step, we further investigate the effect of missing information about the energy-efficiency on prices and rents.

8 Missing information on the energy certificate distorts markets

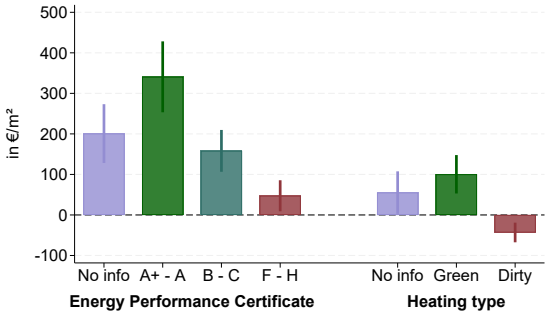
Despite the legal requirement to include the EPC in listings, we observe the EPC for only about 40-50% of all listings (see figure 4). In the following section, we examine the effect of missing EPC information on prices and rents.

Figure 8 shows the premium for the same four EPC categories as before, but also the average premium for all listings without EPC information for both (a) sales prices and (b) rents. The heating system is also not reported in some online ads. Similarly, we report the average effect of sales prices and rents relative to the standard heating type. Strikingly, we find a significant positive sales price and rent premium for listings without EPCs. Also, listings without information on the heating system have a listing price with a premium over the standard heating type.

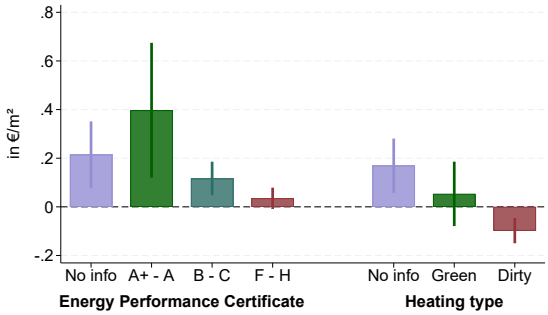
This finding is counterintuitive, as it is unclear why people would be willing to pay a higher price when they have no information about energy efficiency. However, it is important to note that these results are based on listing prices. It may be the case that listings without information about energy efficiency and the heating system end up being sold at a price that is much lower than the original

Figure 8: Premiums including ads without EPC (in €/m²)

(a) Sales price premium



(b) Rent premium



Notes: The figure shows (a) the sales price premium for energy performance certificate categories A+-A, B-C, F-H, and listings without information on the energy performance certificate relative to the category D-E, as well as for the heating type categories green and dirty and ads without information on the heating system relative to the standard heating category in €/m². Panel (b) shows the premium for the same energy performance certificate categories as well as heating types for rents in €/m². The bar shows the point estimate of the premium along with the 95% confidence interval indicated by the vertical line for each bar. Standard errors are clustered at the city level. The estimates are based on a hedonic regression for 19 German cities using 554,566 sales listing and 2,188,153 rent listings from 2014q3 to 2024q2.
Source: ValueAG, VALUE Market Database. Own calculations.

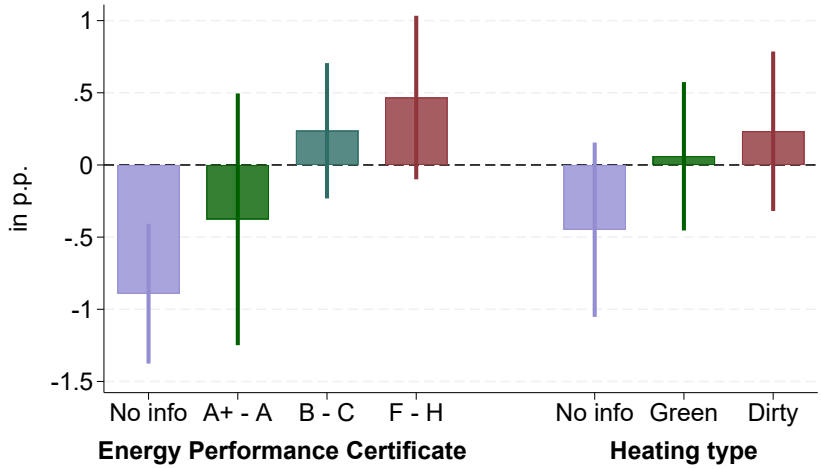
asking price. This may be the case if buyers negotiate the price down as a result of the energy efficiency information that comes to light when they visit the homes. Therefore, the next step is to analyze the spread between the listing price and the transaction price.

Figure 9 shows the spread between transaction and listing prices using a matched sample for five cities.[17] We use the comprehensive German Real Estate Index (GREIX) dataset from Amaral et al. (2023), which covers the universe of housing transaction data for German cities. We match this transaction data with property listings from the ValueAG database for five cities. Using the matched sample, we find that apartments without EPC information face a significant discount to the listing price. We find no significant discount for missing heating system information. Furthermore, we find no significant spread between listing and sales price for all other categories. This provides evidence that the results hold when transaction prices are used instead of listings.[18]

[17] The sample includes the cities of Cologne, Düsseldorf, Frankfurt, Hamburg, and Munich.

[18] When transaction prices are used instead of listings, our results on the price premium remain unchanged. However, the size of the premium decreases when transaction prices are used. This suggests that buyers have bargaining power, especially for more expensive apartments. These apartments tend to be those with an A-rating. Therefore, to isolate the effect of missing information on prices, we include the initial listing price as a control variable in the regression to control for the price level effect on the spread.

Figure 9: Spread between listing and transaction prices (in p.p.)



Notes: The figure shows the spread between listing price and transaction price for the energy performance certificates categories A+-A, B-C, F-H, and listings without information on the energy performance certificate relative to the category D-E, as well as for the heating type categories green and dirty and ads without information on the heating system relative to the standard heating category in percentage points. The bar shows the point estimate of the premium along with the 95% confidence interval indicated by the vertical line for each bar. Standard errors are clustered at the postal code level. The results are based on a matched dataset of five cities in the ValueAG, VALUE Market Database and the transaction price dataset GREIX using 63,614 observations from 2014q3 to 2024q2.
Source: ValueAG, VALUE Market Database. GREIX (German Real Estate Index). Own calculations.

9 Conclusions & policy implications

Our analysis shows that the cost savings associated with energy-efficient apartments are effectively internalized in market prices when accurate information is available. Consequently, any policy that distorts the price mechanism, such as targeted subsidies or taxes, could unintentionally lead to counterproductive outcomes.

Instead, policymakers should concentrate on refining the institutional framework to address the existing frictions that reduce the effectiveness of energy certification in the housing market. To this end, we recommend two courses of action:

Standardization of energy certification: We strongly recommend that only the *Bedarfsausweis* be accepted and that the *Verbrauchsausweis* be excluded. The *Bedarfsausweis* provides a more accurate estimate of potential energy savings, which aligns with market incentives and ensures consistency in the information provided to buyers and sellers. Although the *Bedarfsausweis* is more expensive than the *Verbrauchsausweis*, this cost could be offset by subsidies. In addition, our results can also be interpreted as *Bedarfsausweis* sending clearer signals to the market than less objective *Verbrauchsausweis*. This suggests that providing a clearer set of rules for the production of the energy performance certificates, i.e. making it less subjective, could also help.

Strengthen monitoring and compliance: Regulators should play a more active role in promoting the use of energy certificates and ensuring compliance. Penalties for non-compliance with energy certification requirements should be enforced. Given that most properties are advertised online, the cost of monitoring such compliance would be relatively low. In addition, penalties should be equal to or greater than the missing premium we estimate, as setting penalties below the premium could still incentivize sellers to hide information.

Through these targeted policies, policymakers can increase market transparency and thus its ability to reward energy-efficient buildings, while minimizing market distortions and promoting sustainable housing development.

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