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**139 Report** by Sophie M. Behr, Merve Kücük, Maximilian Longmuir, and Karsten Neuhoff

# Thermal retrofitting of worst performing buildings mitigates risk of high heating costs

- Study investigates impact of prioritizing thermal retrofitting of very inefficient buildings
- Low-income households in particular would be protected from high heating costs
- Tenancy law combined with public support should ensure that thermal retrofits do not increase the sum of rent and heating costs

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DIW Weekly Report 19 2024

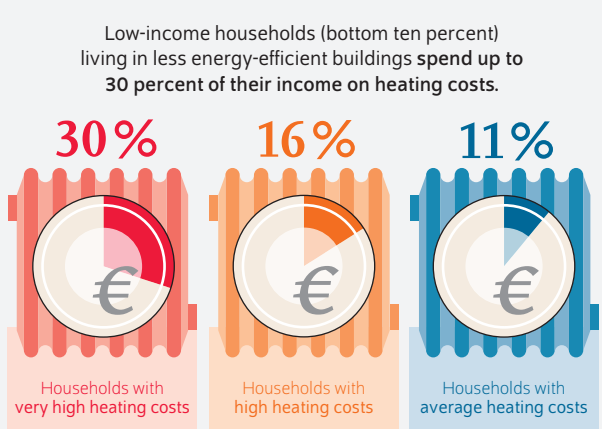
AT A GLANCE

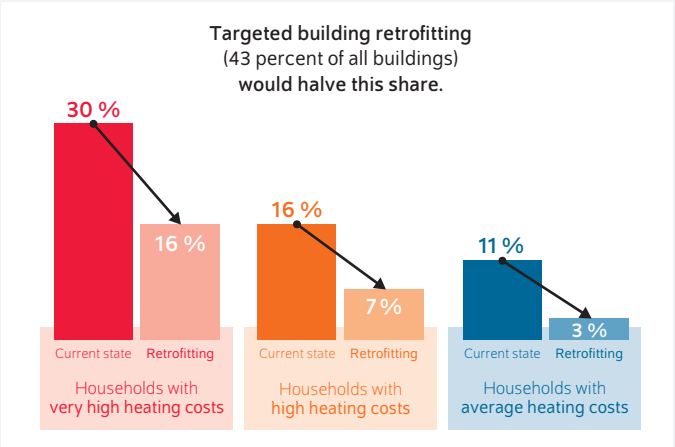
# Thermal retrofitting of worst performing buildings mitigates risk of high heating costs

By Sophie M. Behr, Merve Kücük, Maximilian Longmuir, and Karsten Neuhoff

- Retrofitting of very inefficient buildings mitigates social hardship and has economic as well as energy policy advantages
- Thirteen percent of owners have assets and income below the Wohngeld-Plus threshold and live in very inefficient buildings
- Twenty-eight percent of tenants are below the Wohngeld-Plus threshold and live in very inefficient buildings
- Tenancy law combined with public support should ensure that thermal retrofits do not increase the sum of rent and heating costs
- Minimum energy standards are also necessary in the longer run

**Targeted thermal retrofitting of inefficient buildings also has distribution advantages**




Sources: Authors' depiction and calculations.



## FROM THE AUTHORS

*"The most inefficient buildings should undergo thermal retrofitting first. In addition to the economic advantages, this also has positive effects on distribution policy."*

*— Karsten Neuhoff —*

## MEDIA

**Audio Interview** with Karsten Neuhoff (in German)
**www.diw.de/mediathek**

# Thermal retrofitting of worst performing buildings mitigates risk of high heating costs

By Sophie M. Behr, Merve Kücük, Maximilian Longmuir, and Karsten Neuhoff


## ABSTRACT

The pace of thermal retrofit of buildings in Germany remains slow. A Worst-First approach, prioritizing the retrofit of inefficient buildings, would address energy- and social policy objectives and deliver economic and climate benefits. Data from the German Socio-Economic Panel (SOEP) show how such an approach would protect especially low-income households often living in very inefficient buildings from heating costs risks. This group comprises 28 percent of all tenants and 13 percent of all homeowners. Yet, uncertainty about the cost-benefit of retrofitting and other priorities of homeowners mean that not enough buildings are retrofitted. As a result, the saving potentials, especially from very inefficient buildings, are not being realized. This would, however, be necessary to reduce heating cost risks and energy import dependency, and to meet climate targets. Better alignment of financing and subsidy instruments with the ownership structure, the further development of building standards to include minimum energy performance standards, and reform of tenancy law could improve the situation.


Thermal retrofitting can effectively reduce high energy costs and cost risks due to energy price shocks.[1] Low-income households that currently live in very inefficient buildings[2] and spend up to 30 percent of their income on heating costs would particularly benefit from such retrofits (Figure 1). The Worst-First approach, in which funding programs, building standards, and other measures are designed to ensure that very inefficient buildings are retrofitted first, would help these households specifically. Energy cost subsidies such as *Wohngeld-Plus*, which was expanded during the gas price crisis, or the climate dividend (*Klimageld*) discussed in relation to carbon prices, only partially address cost increases in very inefficient buildings, as the flat-rate payments do not cover the higher cost burdens of inefficient homes.

Although energy cost subsidies directly linked to heating or carbon costs can mitigate the burden, they lead to high fiscal costs as they reduce the incentives for investments in higher energy efficiency. This dilemma can be addressed by accelerating the retrofitting of very inefficient buildings, ideally before another energy price crisis occurs, and as a response to the climate crisis and the high level of dependency on energy imports.

## Worst-First approach as a social program

We use the German Socio-Economic Panel (SOEP) data to estimatete the heating cost distribution within income deciles for the year 2024 and to compare it with two scenarios featuring accelerated retrofitting of very inefficient buildings (Figure 1). The 2024 Energy Performance of Buildings Directive requires prioritizing thermal retrofitting of the 43 percent worst-performing residential buildings.[3] Scenario 1 assumes that 70 percent of these buildings are retrofitted, which corresponds to 30 percent of all buildings. In

1 Karsten Neuhoff, Maximilian Longmuir, Mats Kröger, and Franziska Schütze, "Hohe Gaspreissanstiege: Entlastungen notwendig," *DIW Wochenbericht* no. 36 (2022) (in German; available online). Accessed on April 15, 2024. This applies to all other online sources in this report.

2 In a European Parliament draft, 43 percent of buildings with the highest heating energy consumption are considered inefficient. European Parliament, *Energy performance of buildings (recast)* (2024) (available online). This Weekly Report refers to the buildings as "very inefficient."

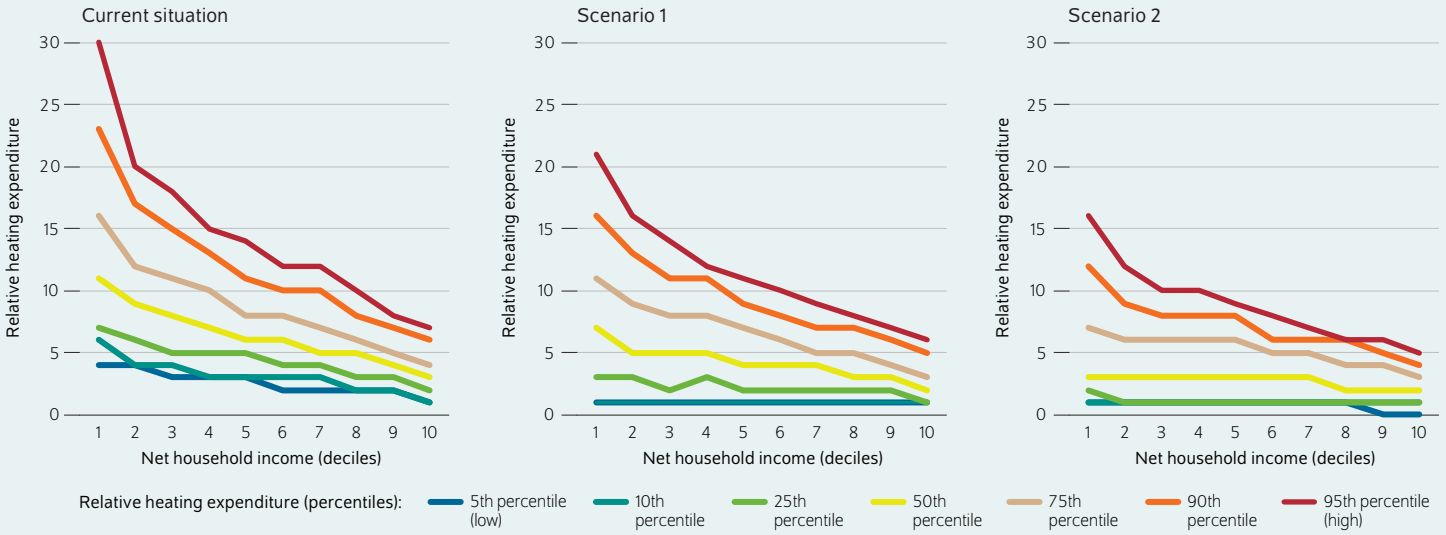
3 European Parliament, *Energy performance of buildings (recast)* (2024) (available online).



DOI: https://doi.org/10.18723/diw_dwr:2024-19-1

Figure 1

**Heating expenditure relative to income by income decile**
In percent




Legend: In Scenario 1, the relative heating expenditure falls to about 20 percent for the houses with the lowest income (first decile) and the highest shares of heating costs (95th percentile).

Note: Households are grouped according to their equivalent net household income in deciles and according to the amount of their relative heating expenditure in percentiles.

Sources: Authors' calculations based on SOEP v.37, Federal Statistical office.



Thermal retrofits reduce energy costs expenditures and risks particularly for lower income households.

Scenario 2, all 43 percent of very inefficient buildings are retrofitted (Box).

The scenario comparison shows that the energy cost burden relative to the income of households in all income brackets is starkly reduced when retrofitting of very inefficient buildings is prioritized.

Households with very high shares of energy costs will benefit from this in particular. In Scenario 1, the heating cost expenditure relative to the income falls from 19.8 percent to 15.5 percent for households with a particularly high cost burden in the second-lowest income decile (95th percentile). When all very inefficient buildings are retrofitted as in Scenario 2, the heat energy cost share drops to 11.6 percent.

Our analysis shows that tenants are considerably more affected by poorly insulated buildings than homeowners. Tenants, on average, pay higher heating costs per square meter than homeowners in all income brackets (Figure 2). On average, the energy condition of rental housing is worse than owner-occupied housing, an intensively discussed topic in the literature known as the tenant-landlord dilemma that is attributed to a number of factors.[4] For example, unlike

4 Jacob Ahlrich and Sebastian Rockstuhl, "Estimating fair rent increases after building retrofits: A max-min fairness approach," *Energy Policy* 164 (2022): 112923; Martin Görnig and Katrin Klarhöfer, "Investments in Energy-Efficient Building Renovation Are on a Downward Slide," *DIW Weekly Report* no. 32/33 (2023): 225–232 (available online).

Box

## Calculating the scenarios

It is assumed that two thirds of the retrofitted buildings undergo comprehensive retrofitting, analogous to the assumptions in the long-term scenarios of the Federal Ministry for Economic Affairs and Climate Action (*Bundesministerium für Wirtschaft und Klimaschutz*, BMWK).[1] The heating energy consumption of a single-family home is thus 55 kilowatt hours per square meter (kWh/sqm) and 40 kWh/sqm for a multi-family home. In the case of partial retrofitting, we assume that the energy consumption is reduced to 100 kWh/sqm for all buildings. A random selection is used to decide which 70 percent of the very inefficient buildings are retrofitted in Scenario 1 is depicted via random selection. In the reference year 2017, the average heating prices were 0.06 euros/kWh;[2] since then, prices have risen by 40 percent.[3] During the same period, however, incomes only rose by 17 percent.[4]

1 Bundesministeriums für Wirtschaft und Klimaschutz, *Hintergrundpapier zur Gebäudestrategie Klimaneutralität 2045* (2022) (in German; available online).

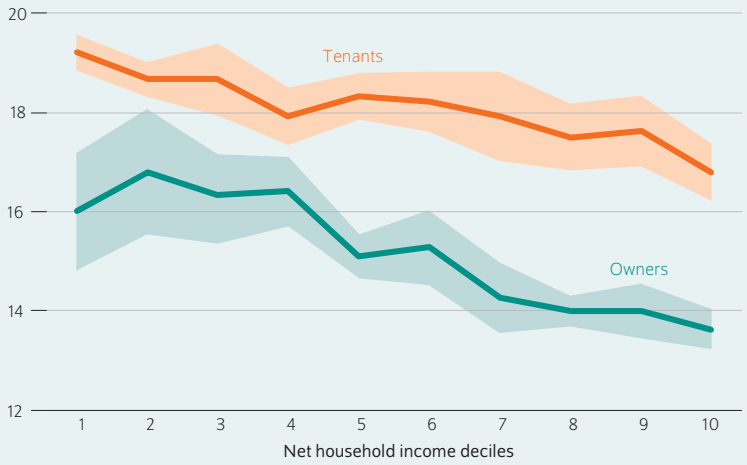
2 Puja Singhal and Jan Stede, "Wärmemonitor 2018: Steigender Heizenergiebedarf, Sanierungsrate sollte höher sein," *DIW Wochenbericht* no. 36 (2019) (in German; available online).

3 Statistisches Bundesamt, *Statistischer Bericht – Daten zur Energiepreisentwicklung – Januar 2024* (2024) (in German; available online).

4 Statistisches Bundesamt, *Reallohnindex* (2024) (in German; available online).

Figure 2

**Heating expenditure by income deciles of tenants and owners**
In euros per square meter




Note: Prices and wages for 2024 are extrapolated (Box). The shaded areas indicate the 95 percent confidence interval, meaning there is a 95 percent likelihood that the value is within this area.



In every income decile, tenants spend more on heating per square meter than owners.

owner-occupiers, landlords only benefit indirectly from heating cost savings through the modernization levy.

However, the Worst-First approach offers more benefits beyond the social components. For example, less gas would need to be imported. If the current retrofitting rate of nearly one percent was gradually increased to four percent over the next three years and the retrofitting of very inefficient buildings was prioritized, around 14.4 percent of the German gas demand in the building sector could be saved in this period.[5]

The Worst-First approach can also result in major heating cost savings. If the energy efficiency of 30 percent (or 43 percent in the second scenario) of buildings is improved, 34 (or 56) percent of heating costs could be saved.[6] In general, buildings with the worst energy efficiency offer the greatest economic opportunities for retrofitting at both an individual and the societal level. It is important to prioritize these buildings due to the limited capacity for construction and building retrofitting and to achieve the targeted increase in the annual retrofitting rate.

Ultimately, the heat supply must also become climate neutral to achieve climate neutrality in Germany by 2045. This requires an extensive switch to heat pumps in buildings and for district heating. Adequate energy efficiency of buildings also increases the efficiency of heat pumps and leads to energy savings that go beyond insulation. Reducing the maximum heat requirement reduces the investment costs for heat pumps and the electricity system costs to cover peak electricity demand during periods of cold weather.

## Uncertain profitability of thermal retrofitting is a challenge

Thermal retrofitting is often viewed as an investment risk. High-income households or households with real estate funds with a larger investment portfolio can, in principle, make profitable, albeit risky, investments more easily. For other households, the risks may be too great and result in investments not being made.[7]

When a building undergoes general modernization, the costs of an additional thermal insulation compound system for walls or more energy-efficient windows account for around one third of the total retrofitting cost. Per square meter of living space, additional investments in thermal modernization amount to 180 to 360 euros per square meter.[8] On their own, the energy costs saved cannot justify the total investment costs of 600 to 700 euros per square meter.[9] If retrofitting or modernization measures are not necessary, a targeted partial retrofitting is more cost effective. Insulation of the top floor and cellar ceilings is often an option and in many buildings insulation material can be blown into the gap between the wall and the façade. Overall, this results in total costs of around 120 euros per square meter in single-family homes.[10]

The costs mentioned provide information about the profitability of retrofitting as well as their amortization periods, but both can vary significantly. Furthermore, lower energy prices or higher interest charges can prolong the amortization period, which increases thermal retrofitting risks (Figure 3).

## Increase subsidies for low-income homeowners

Currently, a combination of standards, incentives, and subsidies provide financial support for the thermal retrofitting of buildings (Figure 4). The Federal Funding for Efficient Buildings (*Bundesförderung für effiziente Gebäude*, BEG) funds both comprehensive retrofitting measures for residential buildings (BEG WG) as well as individual measures (BEG

5 Sophie M. Behr, Merve Kücük, and Karsten Neuhoff, "Energetische Modernisierung von Gebäuden sollte durch Mindeststandards und verbindliche Sanierungsziele beschleunigt werden," *DIW akutell* no. 87 (2023) (in German; available online).

6 Calculated with the reduction in the median cost per square meter: Scenario 1 (11.04–16.8)/16.8*100 = −34.285714, Scenario 2: (7.41-16.8)/16.8*100 = −55.892857.

7 The effects of technical risks accumulate during implementation, as do energy price, real estate market, and financing risks. Claus Michelsen, Karsten Neuhoff, and Anne Schopp, "Beteiligungskapital als Option für mehr Investitionen in die Gebäudeenergieeffizienz?" *DIW Wochenbericht* no. 19 (2015) (in German; available online).

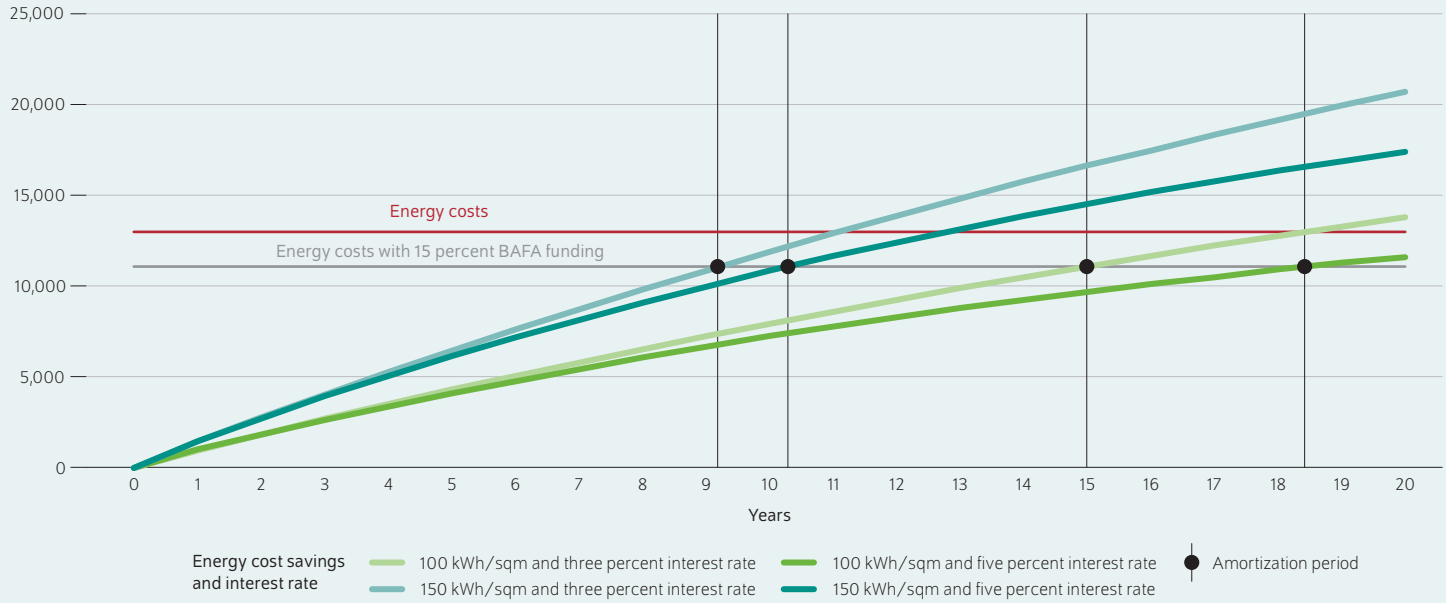
8 Katja Schumacher, Christian Nissen, and Sibylle Braungardt, *Energetische Sanierung schützt Verbraucher*innen vor hohen Energiepreisen – Vorschläge für eine soziale Ausrichtung der Förderung* (2022) (in German; available online). Savings calculated assuming energy consumption of between 200 and 250 kWh/m² pre-retrofitting and of 50–100 kWh/m after retrofitting.

9 Schumacher, Nissen, and Braungardt, *Energetische Sanierung schützt Verbraucher*innen vor hohen Energiepreisen.*

10 Guidehouse, *Ausblick auf potenziell die MEPS erfüllende Maßnahmen für Einfamilienhäuser in Deutschland* (2023) (in German; available online).

Figure 3

**Example calculation for investment costs and amortization period for subsidized retrofitting**
Costs and savings in euros




Note: Assuming a living space of 110 square meters, heating costs of 0.084 euros per square meter, BAFA funding of 15 percent, and a planned investment volume of 13,000 euros.

It is assumed that the living space is 110 square meters, heating costs are 0.084 euros per square meter, there is BAFA funding of 15 percent, and a planned investment volume of 13,000 euros. Energy cost savings are discounted.

Source: Authors' calculations.



The amortization period varies starkly depending on the interest rate and savings.

EM). Alternatively, individuals who pay income tax can write off 20 percent of the costs of measures and 50 percent of the costs of specialist planning and construction monitoring.

Both subsidy programs maintain the relatively large incentive to retrofit very inefficient buildings because in these buildings more energy costs can be saved with comparable investment costs; subsidizing a portion of the investment costs with low-interest loans or subsidies does not affect this. However, SOEP data show that the share of owner-occupiers with assets and income below the *Wohngeld-Plus* threshold who are living in very inefficient buildings is 40 percent higher than for other homeowners.[11] This indicates major challenges in implementing retrofitting in this income bracket and is consistent with the relatively higher investment and financing risks for these households. Accordingly, a higher subsidy rate[12] or supplementary financing instruments (for example subordinated loans) are necessary for the affected households, thirteen percent of all owner-occupied or six percent of all households (Figure 5).[13] Since January 1, 2023, an additional ten percent repayment bonus has been available through KfW loans for comprehensive retrofitting of inefficient buildings.

Homeowners may face challenges in financing thermal retrofitting due to limited equity capital and the resulting limited access to additional debt capital. To ensure that thermal investment measures can nevertheless be implemented profitably in the longer term, granting subordinated and low-interest loans from KfW should be considered, or, for example, providing residential building cooperatives with state-backed equity capital for such investments.[14]

## Carbon cost distribution strengthens incentives to retrofit

Landlords' incentives to thermally retrofit buildings are limited, as tenants, not owners, usually carry the energy and carbon costs and thus the related risks. Inefficient buildings do

**11** The share of homeowners below the *Wohngeld-Plus* threshold living in very inefficient buildings is 42 percent, around 40 percent higher compared to homeowners above the threshold, where the share is around 30 percent. Tax incentives are not attractive for homeowners with lower incomes who pay income taxes. However, they can take advantage of alternative subsidy programs and KfW loans.

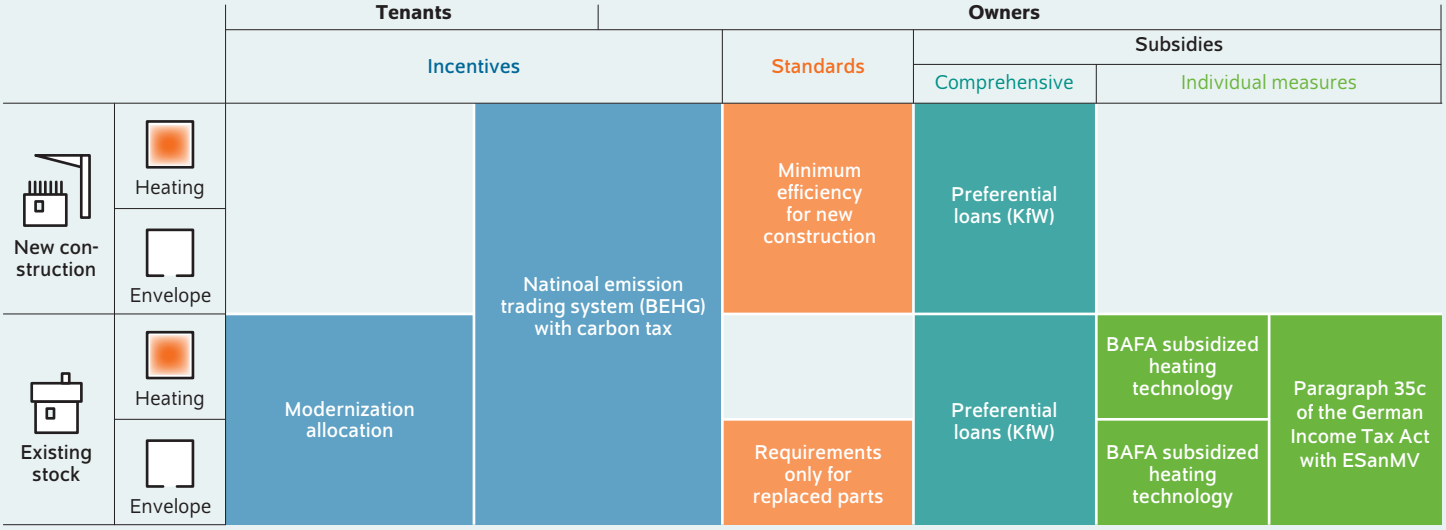
**12** For example, MaPrimeRenovation, the French subsidy program for thermal building retrofitting offers higher subsidy rates for low-income households (in French; available online).

**13** In the event of insolvency or liquidation, subordinated loans are only serviced after the claims of prioritized creditors have been met in full. This contributes to reducing risks and lowering financing costs for additional loans. Claus Michelsen, Karsten Neuhoff, and Anne Schopp, "Beteiligungskapital als Option für mehr Investitionen in die Gebäudeenergieeffizienz?" *DIW Wochenbericht* no. 19 (2015) (in German; available online).

**14** Klaus Mindrup, *Roundtable Wärmewende* (2024) (in German; available online).

Figure 4

**Incentives, standards, and subsidy instruments for thermal retrofitting**




Source: Federal Office for Economic Affairs and Export Control, (Bundesamt für Bundesamtes für Wirtschaft und Ausfuhrkontrolle, BAFA); Fuel Emissions Trading Act (Brennstoffemissionshandelsgesetz, BEHG); Credit Institute for Reconstruction (Kreditanstalt für Wiederaufbau, KfW); (Energetische Sanierungsmaßnahmen-Verordnung, ESanMV); authors' depiction.



Currently, there are no comprehensive minimum energy standards for existing buildings in Germany.

not result in rent reductions for owners, especially in regions with housing shortages and rent control. To create retrofitting incentives, the carbon costs from the German National Emissions Trading System have been split between tenants and landlords since 2023. The higher the carbon emissions per square meter, the greater the share of carbon costs carried by the landlords. In buildings with carbon emissions of more than 52 kg of $CO_2$ per square meter per year, the share is 95 percent.[15] However, there is a concern that the costs will be passed on to tenants living in buildings not subject to rent control in the medium term.[16]

## Ensuring implementation with building standards

In 1977, the first thermal insulation requirements for newly constructed buildings were defined in the Thermal Insulation Regulation (*Wärmeschutzverordnung*).[17] The Buildings Energy Act (*Gebäudeenergiegesetz*, GEG) now also stipulates thermal insulation requirements for existing buildings, for example if more than ten percent of an exterior wall is modernized.[18] In addition, certain boilers must be replaced and the top floor ceiling to unheated attics must be insulated when ownership changes.[19]

Minimum energy performance standards should be adopted to unlock the savings potential of existing inefficient buildings. Such standards will apply to non-residential buildings across the EU from 2032.[20] Some countries, such as England and Wales, already have minimum standards for residential buildings.[21] Minimum energy performance standards have the advantage that, as assumed in Scenario 2, all very inefficient buildings are retrofitted and no households remain exposed to energy cost risks (Scenario 1).

## Modernization levy should be designed to be rent neutral

Since 2001, the modernization levy has allowed landlords to pass on the costs of modernizing buildings to tenants. While this has improved the quality of rental housing in many places, the rent increases have far surpassed the energy savings.[22] Since 2019, eight percent (instead of 11 percent) of the thermal modernization investments and up to a maximum

**15** *Kohlendioxidkostenaufteilungsgesetz* (BGBl. I S. 2154) (2022) (in German; available online).

**16** To limit the burden on households due to the carbon price, a price limit of 45 euros per ton of $CO_2$ was agreed upon in the second European Emissions Trading System (ETS II) (preamble), but only implemented to a limited extent. This limits incentives.

**17** Bundesgesetzblatt, *Verordnung über einen energiesparenden Wärmeschutz bei Gebäuden (Wärmeschutzverordnung – WärmeschutzV)* (1977) (in German; available online).

**18** GEG § 48.

**19** GEG § 47, GEG § 72.

**20** European Parliament, "Energy efficiency of buildings: MEPs adopt plans to decarboise the sector", press release from March 12, 2024 (available online).

**21** Steven Nadel and Adam Hinge, *Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals* (Washington, DC: American Council for an Energy-Efficient Economy, 2023) (available online); Öko-Institut e.V. (in German; available online).

**22** Institut für Energie- und Umweltforschung Heidelberg, *Klimaschutz in Mietwohnungen: Modernisierungskosten fair verteilen. Kurzstudie zur Weiterentwicklung und Aktualisierung der „Drittelmodells"* (Berlin: 2024)(in German; available online).

of three euros per square meter per year can be passed on to tenants within six years.[23]

Twenty-eight percent of all tenant households live in very inefficient buildings and have income and assets below the *Wohngeld-Plus* threshold (Figure 5).[24] For this reason, the German Expert Commission on Gas and Heat appointed by the Federal Government recommended in 2022 that "state support should be designed in such a way that landlords can implement an almost rent-neutral retrofitting" and that the modernization levy should be adjusted accordingly.[25]

There are three advantages to reforming the modernization levy with the goal of rent increases not surpassing the heating cost savings following thermal modernization measures. First, the incentives for a Worst-First approach would increase because it is more profitable to retrofit rented buildings with higher potential energy savings. Second, landlords' motivation to use existing subsidy programs would increase, as they would not be able to increase the rent by the non-subsidized share of the investment costs, as is currently the case. Third, financial support could be linked to proof of quality so that a certain energy level is actually achieved following retrofitting.

## Conclusion: Worst-First is a promising policy approach

The Worst-First approach is a promising policy strategy. It is a social policy as it can protect highly burdened low-income households and tenants from high heating costs especially from energy price increases and has climate and energy policy benefits. Limiting the modernization levy to the heating costs saved does not only increase the acceptance among tenants, but also supports the prioritization of retrofitting the least efficient buildings.

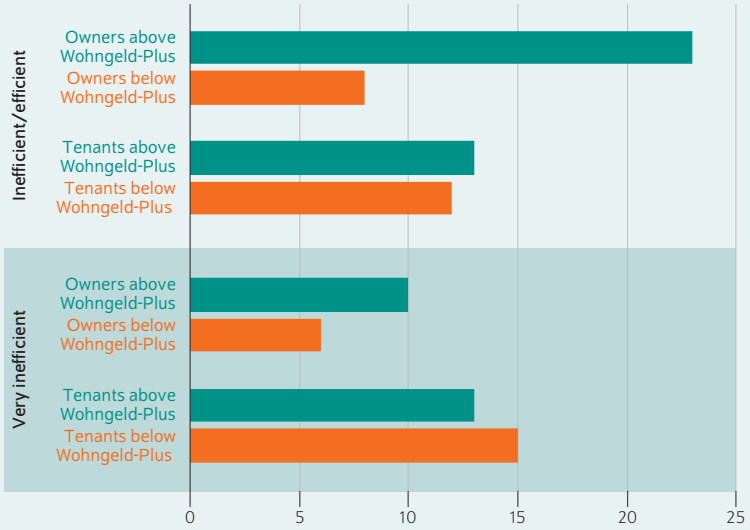
Although retrofitting entails certain risks for homeowners, it often pays off and could be further advanced by increased building standards and targeted support for low-income homeowners. Minimum energy performance standards could ensure all very inefficient buildings are retrofitted and tenants are protected from heating cost risks. The expectation that Germany might also introduce standards creates incentives for owners to already take corresponding efficiency requirements into account now in modernization measures. Minimum energy performance requirements could also be added as requirement to existing support programs, for example for heat pumps.

The persistent lack of predictability is a challenge for policymakers, homeowners, and industry, which is why the scale of retrofitting declined even during the energy crisis.[26] As the Worst-First approach has both social policy and economic policy advantages, it could help build societal and political support for building retrofit policies.

Figure 5

**Tenants and owner-occupiers by residence efficiency and income**

In percent of all households




Note: Residential buildings with the 43 percent highest heating costs per square meter are defined as very inefficient. The entitlement to a housing benefit (Wohngeld) is calculated according to rent band 4 for 2024 and estimated using SOEP data.

Source: Authors' calculations based on SOEP v.36.



Proportionally, more tenants live in very inefficient buildings than owner-occupiers.

**23** BGB § 559.

**24** The 28 percent figure results from the fact that 15 percent of households live in inefficient rental housing and are below the *WohnGeld-Plus* threshold (Figure 5). Tenants make up 54 percent of households.

**25** Expert*innen-Kommission Gas und Wärme, *Sicher durch den Winter. Abschlussbericht 2022* (in German; available online).

**26** Martin Gornig und Katrin Klarhöfer, "Investments in energy-efficient building renovation are on a downward slide," *DIW Weekly Report* no. 32/33 (available online).

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