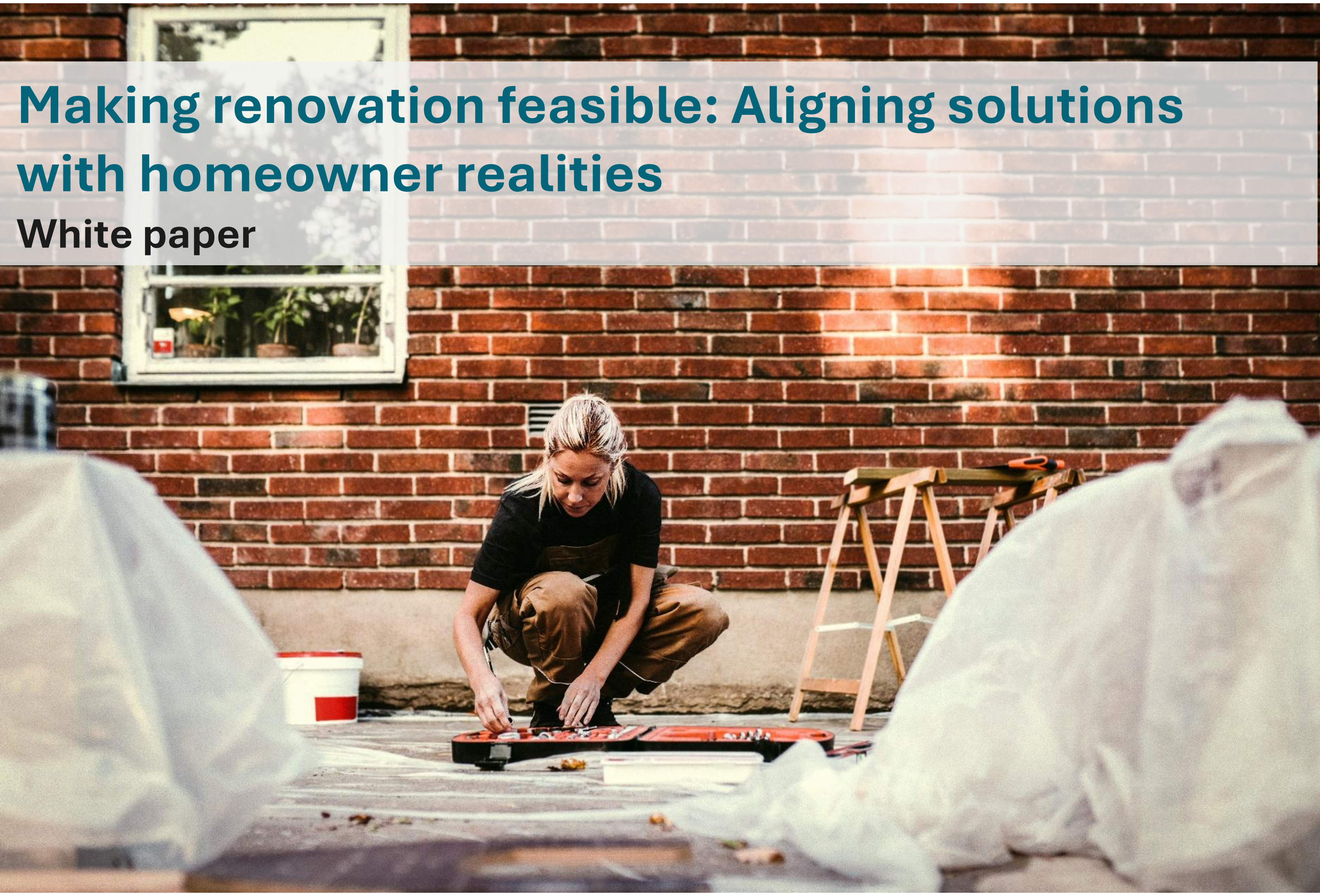
Making renovation feasible: Aligning solutions with homeowner realities

White paper



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Reference No.: 230015
August 2026
http://www.guidehouse.com/

The analysis was completed by June 2026.

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Foreword from ING

At ING, our purpose is empowering our customers to stay a step ahead – and that includes staying ahead on some of society's biggest challenges, like energy insecurity, inflation, housing affordability, and climate change. Research shows us that most customers in Europe want to play a positive part in the transition to a more sustainable future, and we're finding ways to help them do that. As a systemically important bank we can play a significant role in financing the change that is needed.

One way we do this is through our mortgage portfolio. As one of Europe's largest home loan lenders, we aim to incentivise homeowners to protect – or even enhance – their property value while reducing their emissions. In many markets we are working to enable customers to upgrade their homes to become both more energy efficient and future-fit. Like with our innovative energy efficiency renovation loan Baufi Energy in Germany or with end-to-end platforms like the ING Upgrader service in The Netherlands. The challenge, and opportunity, is how to convince customers at scale that renovating their homes is a win-win – for them, with lower energy bills and increased living comfort and property value; and for the environment and society's transition to a low-carbon economy.

Beyond our products and services, we're also playing an active role in engaging with stakeholders across the housing value-chain to create an ecosystem that supports faster, more affordable, and more impactful renovations. This includes conducting research to understand what expectations and initiatives are directed toward homeowners, and whether these are realistic, fair, and likely to be successful. This research informs our discussions with policy makers and others who are trying to support homeowners in this journey.

We also want to be part of efforts to better understand what expectations homeowners themselves have of others in that renovation journey. Our customers have told us that, when it comes to renovating their homes, they are most interested in the potential savings from energy-use reductions, and the possible increase in their home's value. Understanding these expectations and motivations, and seeking ways to address them, is critical to ensure an inclusive transition.

With this research paper we want to stimulate the discussion on how policy and financial instruments can be better tailored to different homeowner profiles in the different markets. Progress can only be achieved through collaborative action, and we are eager to discuss this further with all stakeholders, so please reach out to us to share your views, and let's make impact together.

Pinar Abay
Head of Retail Banking and member of the ING Management Board Banking

Executive summary: From renovation ambition to homeowner decision

Despite growing ambition for residential decarbonisation, renovation pathways remain predominantly technology- and building-centric. While previous analyses, including our 2025 white paper, identify technically feasible routes to net zero, they often do not systematically account for two critical factors: the cost of renovation measures and the ability of homeowners to finance and adopt them. This creates a disconnect between ambitions at the sector-level and practical reality faced by homeowners. A more cost-optimal view of the transition can help identify renovation strategies that deliver meaningful emissions reductions while remaining economically feasible and practically achievable for homeowners.

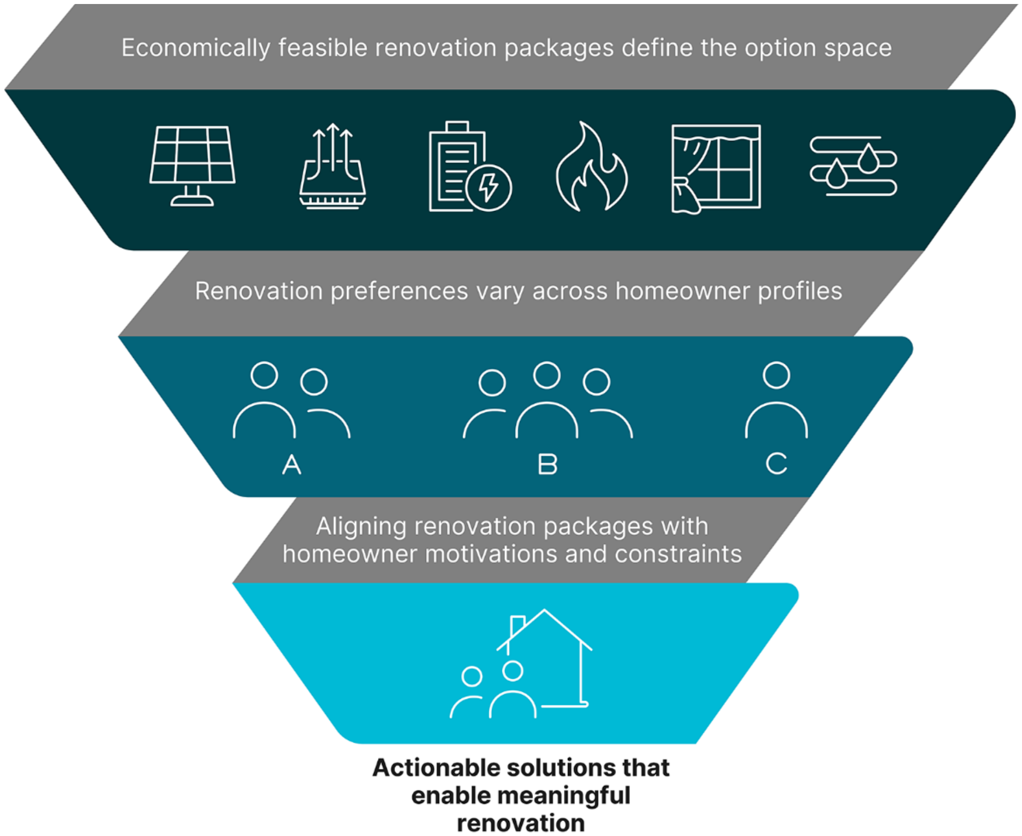
> **The core message is simple: Renovation decisions are not driven by technical feasibility alone; they are shaped by whether measures are perceived as worthwhile, affordable, manageable, and timely. As a result, many solutions that appear optimal from a system or lifecycle-cost perspective fail to materialise at scale.**

This white paper addresses that gap by combining two complementary perspectives. First, it identifies cost-optimal renovation packages through detailed modelling of renovation measures across representative building types in Belgium, Germany, and Netherlands. Second, it assesses the likelihood that different homeowner groups will adopt those packages based on their need, ability and motivation to act. Combining these perspectives provides a more realistic view of which renovation pathways are not only technically and economically sound, but also capable of being delivered at scale.

Existing research[1] provides valuable insights into retrofit cost-effectiveness, multi-criteria assessment and homeowner decision-making, but less often shows how these insights can be converted into real-world decarbonisation impact. This is the added value of this paper: It links economically meaningful renovation packages to distinct homeowner profiles, assesses how likely different homeowner types are to adopt them, and identifies the targeted policy, finance, guidance and delivery interventions needed to close the gap between economic potential and real-world uptake.

[1] Daniel & Ghiaus (2023) – Multi-Criteria Decision Analysis for Energy Retrofit, and Schünemann et al. (Buildings & Cities, 2025) – Systemic decision-making model

Figure 1: Ideal homeowner decision-making funnel

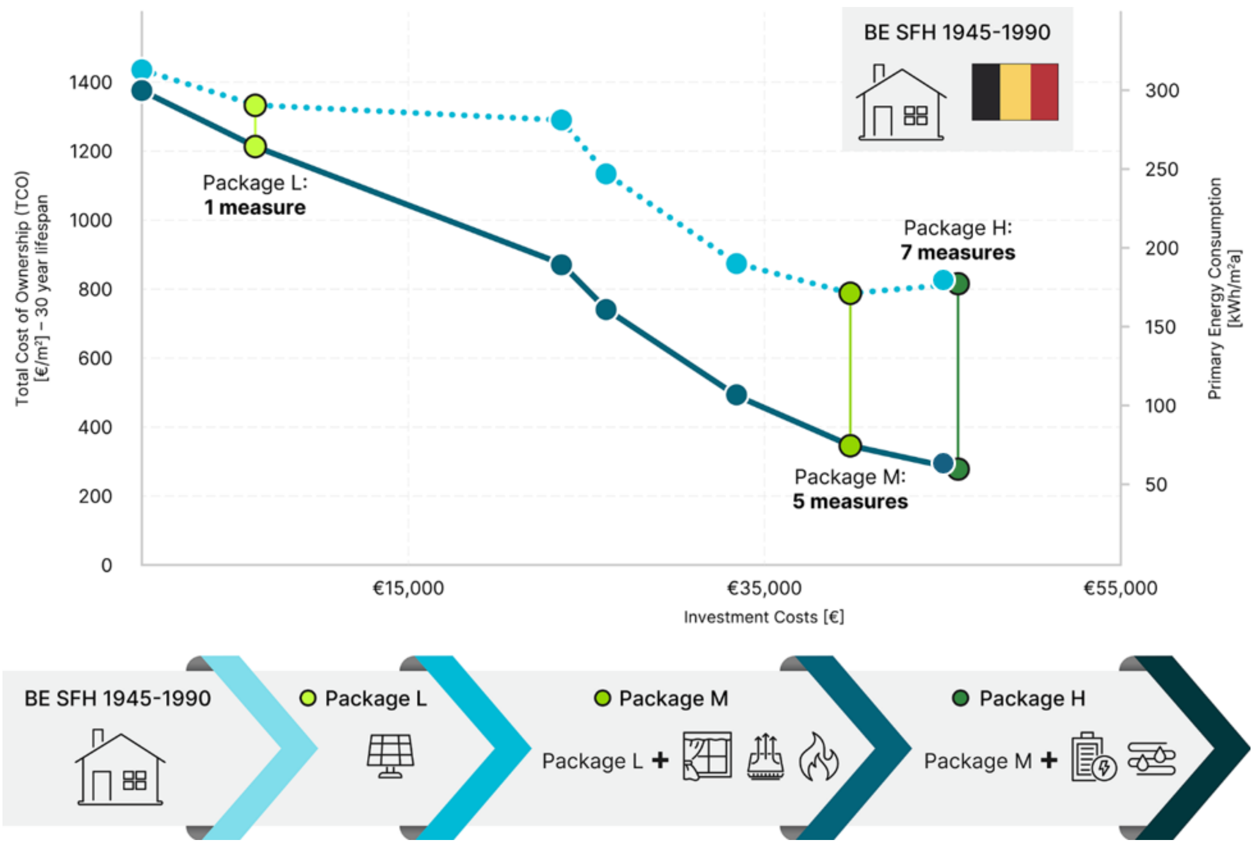


This approach is illustrated in Figure 1 through a homeowner decision-making lens, highlighting how potential renovation options are progressively filtered, from what is technically possible, to what is economically viable, to what fits homeowners' needs and conditions, and ultimately to what is implemented in practice. The figure represents a successful alignment between renovation potential and meaningful homeowner adoption. In practice, however, many potentially effective renovation solutions fail to progress through this funnel due to limited awareness, financial constraints, competing priorities, or other barriers to adoption. The analysis therefore indicates that the primary constraint to decarbonisation is not the lack of viable solutions, but the limited share of feasible solutions that successfully pass through this decision process.

Zooming in first on the cost-optimality analysis, the findings reinforce that there is no "one-size-fits-all" renovation pathway. For older, less efficient homes, medium-intensity packages – combining targeted insulation improvements with heating system upgrades – often offer the best balance between upfront investment and lifecycle cost savings. While deeper renovations further reduce energy demand and exposure to energy price risks, higher upfront costs and longer payback periods can constrain uptake. For newer or better-performing homes, lower-intensity measures often capture most of the available economic benefits, with deeper interventions driven more by climate or resilience objectives than by direct cost-optimisation. Figure 2 provides an example cost-optimality curve and different renovation packages for an older single-family house (SFH) in

Belgium, highlighting how total cost of ownership (TCO)[2] as well as primary energy consumption decrease as more extensive renovation measures are implemented.

Figure 2: Cost-optimality curve and renovation packages for a 1945-1990 SFH in Belgium. The grey line (left axis) shows TCO against investment costs, the blue line (right axis) shows primary energy against investment costs. Renovation measures in each package are shown below.



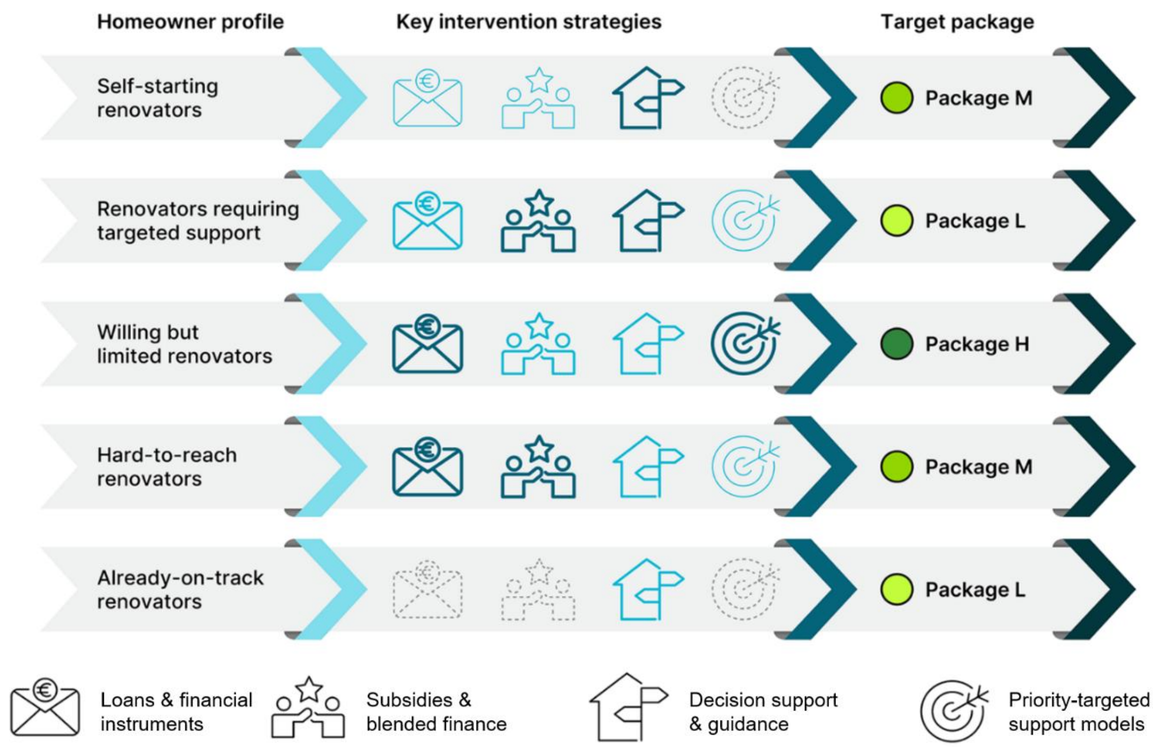
However, economic viability alone does not determine outcomes. The below segmentation shows that **homeowners substantially differ in both their ability and willingness to act**. Five representative homeowner profiles are identified, capturing differences in need, ability and motivation to act. These profiles demonstrate that renovation barriers are highly heterogeneous, ranging from affordability constraints and competing priorities to structural challenges such as collective decision-making in apartment buildings. As a result, policies or financial products designed for an "average" homeowner are only effective for a limited subset of households.

[2] Net present value of total lifecycle costs (TCO) over a 30-year assessment period, considering both initial investment costs and subsequent energy related and operational expenditures. See section 2 for more details on TCO.

> **This leads to a persistent "decision gap": a disconnect between economically viable renovation options and their real-world uptake. Bridging this gap requires better translation – from system-level ambition to homeowner-relevant choices, from generic policy design to targeted interventions, and from access to capital to integrated decision support.**

By mapping renovation packages to homeowner profiles and identifying profile-specific barriers and intervention strategies, the paper shows how tailored solution offerings (such as targeted financial instruments, integrated advisory services or collective-action mechanisms) can increase both renovation uptake and depth. This is illustrated in Figure 3 below.

Figure 3: Key intervention strategies to connect homeowners and renovation packages



For policymakers, this means moving beyond uniform policy design towards approaches that explicitly account for differences in financial capacity, risk tolerance and decision context. Financial institutions, subject to their risk appetite and regulatory requirements, can play a complementary role in translating these enabling conditions into action at the customer interface, particularly through solutions that are tailored to distinct homeowner situations, with the aim of having financial offerings that are closely aligned with individual decision contexts.

As such, collaboration becomes a practical requirement centred on the decision realities that ultimately determine whether homeowners act. This, in turn, requires continuing to evolve instruments to more closely reflect the diversity of real homeowner circumstances rather than an "average" profile. Segmentation approaches should be used more systematically to account for the financial, practical and behavioural factors that shape whether renovation is seen as relevant, manageable and worthwhile.

The environmental effect of targeted intervention strategies is quantified through scenario analysis comparing renovation uptake under two conditions: a baseline case without additional targeted action, and a scenario incorporating targeted interventions across homeowner profiles. By modelling uptake rates of low-, medium- and high-intensity renovation packages across profiles, the analysis shows that **targeted action can significantly accelerate emissions reductions.** The impact is particularly pronounced in segments where homeowners have direct decision authority and can act independently but also highlights the importance of tailored solutions for more complex contexts, such as multi-owner buildings.

The core implication is clear: Europe's renovation challenge will not be solved by ambition or optimisation alone, but by enabling homeowner decisions at scale. Three messages follow:

1. **First, cost-optimality helps identify which renovation packages make economic sense but does not determine uptake.**
2. **Second, homeowner segmentation shows who is likely to act, under what conditions and with which barriers.**
3. **Third, targeted policy, finance, guidance and delivery models are needed to close the remaining decision and affordability gap, so that viable solutions become widespread action.**

This is what makes the transition more successful: not only knowing what should happen to the building stock, but designing the conditions under which homeowners are more likely to choose the most effective renovation package and carry out the renovations that make it happen.

1. Why renovation depends on homeowners

The role of homes in Europe's climate transition

Since the adoption of the Paris Agreement, reducing GHG emissions has become a central priority in addressing climate change for governments, businesses, financial institutions and other key stakeholders. This climate objective is now reinforced by a more immediate political and economic concern: Europe's exposure to imported fossil fuels and volatile energy prices. The European Commission's AccelerateEU Communication links faster electrification, energy efficiency and clean energy deployment to energy security, affordability and resilience, noting that 57% of the energy consumed in Europe is imported fossil fuels.

Buildings play a particularly important role in this transition and response to energy security and affordability. Across the European Union (EU), they account for around 40% of total final energy consumption and 33% of GHG emissions. Residential buildings are especially relevant, as they make up about two thirds of both total floor area and final energy demand, and 62% of GHG emissions. Most energy usage and emissions from homes are linked to space heating, domestic hot water, and electricity use for lighting and appliances. Improving the energy performance of homes is therefore not only a decarbonisation measure, but also a way to reduce homeowners' exposure to future energy price shocks and strengthen financial resilience.

From a technical perspective, many of the solutions are already available. Measures such as improving insulation, replacing inefficient heating systems, or integrating low-carbon technologies like heat pumps and rooftop solar can significantly reduce energy demand and emissions.

However, technical feasibility alone does not determine outcomes. What ultimately matters is whether these solutions are adopted, financed and implemented at scale. This depends on a combination of policy frameworks, market conditions and financial instruments, but also on decision-making at the homeowner level.

Homeowners as the critical decision-makers

Homeowners' decision-making and affordability are a defining layer, alongside technical feasibility and national context. Across the EU, renovation outcomes depend on how homeowners make decisions under real-world constraints, including financial capacity, risk perception, disruption, and competing priorities. To illustrate how these dynamics play out in practice, this paper uses Belgium, Germany and the Netherlands as case studies. While these markets differ in building stock, cost structures and energy prices, they share common patterns in how homeowners approach renovation decisions, that can be translated into broader EU context.

> **Ultimately, the key decision maker is the homeowner – whether as landlord or owner-occupier. In this paper, we focus on homeowners given their decision authority, investment responsibility and direct benefits of lower energy costs and improved comfort.**[3]

[3] In owner-occupied SFH, homeowners generally control the whole-building renovation decision. In multi-owner buildings, measures affecting common elements require collective agreement, so targeted engagement with individual owners can support, but not determine, the decision.

Why policy ambition does not automatically translate into action by homeowners

To address emissions from buildings, the EU has introduced a range of clearly defined policies aimed at improving energy performance, most notably the Energy Performance of Buildings Directive (EPBD). The EPBD provides a clear framework for reducing energy use and emissions with a view to achieving a zero-emission building stock by 2050, by encouraging the renovation of existing buildings, and prioritising, with a view to affordability, the least energy-efficient ones.

National Building Renovation Plans (NBRPs) are intended to strengthen implementation, particularly in relation to financing, investment needs, implementation resources and affordability. However, progress in developing these plans remains uneven. As of mid-May 2026, only a subset of Member States had published draft plans. Even where plans are advanced, such as in the Netherlands and Wallonia, they primarily define what needs to happen at the level of the building stock: targets, pathways and obligations. They do not yet fully explain how different types of homeowners are expected and enabled to act in practice.

This highlights a structural translation challenge: while policy frameworks define ambition at system level, renovation decisions are taken at homeowner level. The revised EPBD and emerging NBRPs already point towards a broader policy mix, including targets, pathways, obligations, financing considerations and support measures.

> **The practical question is therefore not whether policy should rely on incentives or requirements, but how the full mix of instruments can be designed so that it reflects the different realities of the homeowners expected to act.**

This is where segmentation becomes important. Treating homeowners as a homogeneous group risks designing instruments that only work for a limited subset, thereby constraining overall uptake. A more differentiated understanding of homeowner needs, abilities and motivations can help policymakers calibrate enabling measures, such as advice, subsidies, concessional finance and delivery support, alongside phased regulatory expectations where these are needed to overcome delay, short planning horizons or persistent inaction. It can also help financial institutions complement their existing customer insight with a more renovation-specific view of which households are likely to need finance, guidance, de-risking or staged solutions.

Policy frameworks, therefore, remain essential, but their effectiveness depends on how well system-level ambition translates into homeowner-level action. Targets, regulations and technology pathways are typically defined at a systemic level, but their success depends on whether they translate into decisions that are financially realistic, socially feasible and practically workable for homeowners. This paper therefore focuses on the link between economically meaningful renovation options, homeowner decision realities and the targeted mix of instruments needed to turn policy ambition into implementation.

Learnings from a multi-stakeholder journey

This paper builds on the 2025 publication Decarbonising residential buildings: A multi-stakeholder journey, developed by Guidehouse with the support of ING, which outlined critical steps for the residential real estate sector to get back on track to reach net zero emissions (a summary of the 2025 publication is provided in Appendix 1).

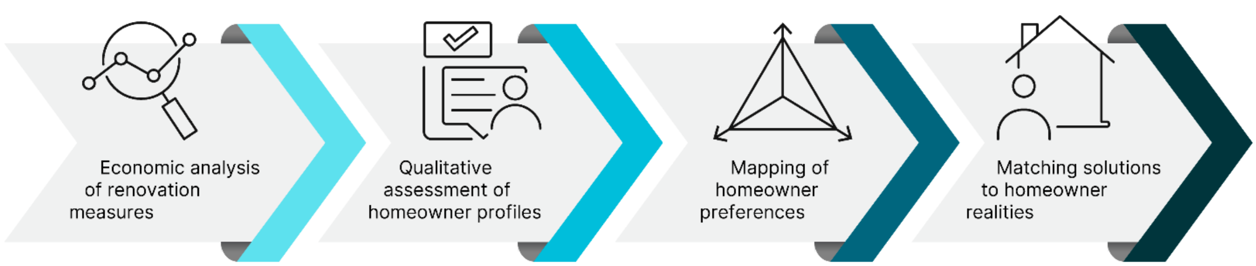
The results of the 2025 publication underscored that progress depends not only on the availability of solutions, but on an integrated ecosystem approach that aligns the incentives and actions of multiple actors, including policymakers, financial institutions, market actors and homeowners. Engagements with regulators, national ministries and stakeholders across the finance, housing and construction sectors highlighted the need to move beyond defining decarbonisation pathways and to focus more closely on the economic realities of renovation decisions as well as the diversity of homeowners in order to bridge the remaining gaps.

Advancing the residential decarbonisation debate

This white paper builds on these system-level insights but advances the debate by linking ambition more closely to the economic and decision reality of homeowners. The analysis identifies patterns and trends at a European level, with Belgium, Germany and the Netherlands serving as case study markets to demonstrate the challenge. Rather than focusing only on system-level scenarios, this white paper examines how renovation decisions materialise in practice through the interaction between economic performance and homeowner decision making.

We start by identifying renovation packages that are economically meaningful under current market conditions, followed by an assessment of the reasons why homeowners do not select these options uniformly. Subsequently, we link renovation packages to homeowner profiles to analyse where uptake is likely and what support can close the remaining decision gap. The overall approach adopted in this white paper is shown in Figure 4 below.

Figure 4: Step-by-step process for identifying solutions that enable meaningful renovations



This approach can help inform engagement strategies with customers, and engagement with policymakers and market stakeholders on how to accelerate residential decarbonisation in a way that is both ambitious and socially accepted in practice.

2. Defining economically meaningful renovation options

Scaling up residential decarbonisation requires a clear view of which renovation packages are not only technically feasible, but also economically meaningful for homeowners. For most homeowners, the decision to renovate is likely to be influenced by the balance between upfront investment and future operating costs, rather than by energy performance targets alone. This section therefore defines the renovation packages that make the most sense economically: it assesses which combinations of measures perform well under current market conditions, using a consistent cost-optimality framework.

We assess economic performance using the concept of cost-optimality as defined under the EPBD: a renovation package is considered cost-optimal when it minimises the net present value of total lifecycle costs (total costs of ownership or TCO) over the assessment period, taking into account both initial investment costs and subsequent energy related and operational expenditures.[4]
This provides a transparent basis for comparing renovation choices from a homeowner perspective. The use of TCO is explained further in the next section.

In the underlying modelling we have evaluated combinations of measures for each building type and country. To communicate these results, we translate the full set of combinations into a limited set of representative packages that capture distinct points along a “renovation journey”. These packages are labelled low, medium, and high intensity (L, M, H) and are designed to illustrate the key trade-offs between investment, energy performance and TCO. Importantly, they should be read as analytical reference points, not as one-size-fits-all prescriptions: real renovation journeys for individual homes may differ in composition and sequencing, but they tend to follow similar economic patterns. They therefore define the economically meaningful options for renovations from which real-world homeowner choices may emerge, rather than prescribing the choices homeowners will make.

This framing is conceptually aligned with the “shallow, medium, and deep” renovation language used in the 2025 white paper, while the groupings here are derived directly from the cost and performance results rather than predefined categories for “renovation depths”. In this section, we first explain the modelling approach, then present results across building types and countries, and finally summarise the most decision relevant insights that flow into the homeowner analysis.

[4] Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)

Methodological notes and limitations

We use Guidehouse's hourly-resolution Building Energy Performance (BEP) tool to calculate building energy consumption in a way that approximates expected real-world, metered consumption (see Appendix 3 for more detail). The global-cost calculation follows the logic of the EPBD cost-optimality framework, while the analysis adds electricity uses beyond the minimum EPBD scope to better reflect homeowner-relevant economics, in particular the impact of PV and battery storage through self-consumption, avoided electricity purchases and storage value. This is important because the results in this study - TCO, payback periods and savings - are intended to inform real-world investment decisions, not only asset-performance comparisons (see Appendix 2).

The TCO assessment uses a 30-year calculation period, as prescribed by the European Commission for the assessment of cost-optimal packages for residential buildings. This provides a consistent long-term basis for comparing renovation packages across building types and countries and is appropriate for assessing building-level economic performance from a policy perspective. At the same time, many homeowners apply a shorter decision horizon. They may expect to move before the end of the calculation period, may prioritise upfront affordability over lifetime savings, or may attach greater importance to whether renovation affects property value. The analysis therefore also reports simple payback periods as a more intuitive short- to medium-term indicator of how homeowners may assess the investment case.

Potential changes in property value are not quantified in the TCO or payback calculations. This is an important limitation, particularly for homeowners with shorter expected occupancy periods, for whom resale value may be more relevant than lifetime energy savings. However, robustly attributing property-value effects to specific renovation packages across countries would require assumptions that are highly context-specific and uncertain. The analysis therefore focuses on investment costs, replacements and energy-cost effects, while recognising that property-value impacts may influence real-world decisions.

Simple payback periods are calculated using static energy costs. This reflects the type of simplified decision logic many homeowners may apply when asking how long it takes for lower energy bills to offset the upfront investment. The payback results should therefore not be read as a forecast of future household energy expenditure. If future energy prices increase, measures that reduce purchased energy may become more attractive; if they decrease, the opposite may be true. In this study, simple payback periods are only provided as an additional indication, as the main economic performance indicator in the EU cost-optimality assessment is the net present value (TCO). Due to varying investment and energy cost levels across the assessed countries, payback times may vary significantly between packages with the same label (L, M, H) and therefore do not necessarily allow meaningful comparisons.

Finally, the analysis uses BEP-modelled energy demand rather than direct EPC before-and-after savings. EPCs are designed as asset-performance indicators and do not necessarily reflect actual user behaviour or measured consumption. As explained further in Appendix 5, calculated EPC-based consumption can be significantly higher than measured consumption in practice, particularly in Belgium. Using BEP therefore helps avoid overstating savings and provides a more credible basis for homeowner-relevant economic analysis.

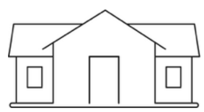
Assessing renovation measures across different building types

To assess the best economic performance, we analysed how different combinations of renovation measures perform across three representative owner-occupied residential building types in three case study markets: Belgium, Germany and the Netherlands (i.e. nine reference buildings overall). The BEP model applies country-specific cost data for renovation measures and simulates their impact on building energy performance over time. The modelling is based on reference buildings derived from the EU-wide TABULA–EPISCOPE framework, which defines typical building archetypes by age and size class using national building stock data. These reference buildings (shown below), developed by national research institutes (e.g. IWU, TU Delft, VITO), represent the most prevalent building types. Further details on the modelling approach and reference building characteristics are provided in Appendix 4: Reference building characteristics and assessed renovation measures.

Single family house (SFH) built between 1945 and 1990

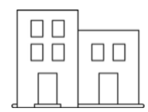
- Floor area: 110 to 126 m^2
- Low insulation standard
- Gas condensing boiler
- Single or cavity wall construction[5]

Single family house (SFH) built after 1990



- Floor area: 110 to 126 m^2
- Low insulation standard
- Gas condensing boiler
- Single or cavity wall construction[5]

Small apartment building (AB) built between 1945 and 1990



- Floor area: 400 to 500 m^2
- Low insulation standard
- Gas condensing boiler
- Single or cavity wall construction[5]

For each building type in each country, we assessed renovation options based on their TCO. This combines upfront investment costs with lifetime energy costs, allowing renovation measures to be compared on a like-for-like basis from a homeowner perspective. The aim is to identify combinations of measures that reduce total costs over time while significantly lowering energy consumption. The resulting cost-optimal package differs by building type and country, because starting conditions, technology costs and energy prices differ. This is why the analysis compares multiple reference buildings and markets rather than presenting one universal renovation package.

We assessed eight categories of renovation measures, covering improvements to the building envelope, upgrades to heating and domestic hot water systems, and the integration of renewable energy technologies. These renovation measures are described in Table 1 below.

[5] Single wall refers to single-leaf (solid) masonry construction, meaning an external wall consisting of one continuous layer of masonry material (for example brick, stone, or concrete block) without a cavity between inner and outer leaves. A cavity wall comprises two masonry leaves separated by an air gap or insulation layer. Both single-wall and cavity-wall constructions have been part of the cost-optimal analysis, depending on the country and age group.

Table 1: Categories of renovation measures

1-3. Envelope insulation (roof, wall, floors)

This includes insulation to walls, roof and floor. Three levels of renovation are considered: no renovation; renovation in line with minimum country-specific EPBD requirements, and renovation beyond these minimum standards.

4. Windows

Five levels of renovation are considered: no renovation, two double-glazing options, and two triple-glazing options.

5. Heating system

Six technology options for the heating system are considered: air-water heat pumps, ground-source heat pumps, hybrid heat pumps, biomass boilers, gas boilers, and district heating systems.

6. Domestic hot water system (DHW)

DHW includes two options: A dedicated electric heater that provides hot water generation only and a combi system, providing space heat and hot water.

7. Photovoltaic system (PV)

The installation of differently dimensioned PV on the roof is considered: 5 kWp (SFHs), 15-18 kWp (small ABs).

8. Battery storage

The installation of differently dimensioned PV battery systems on the roof is considered: 4 kWh (SFHs), 12-16 kWh (small ABs).

By applying different combinations of renovation measures, hundreds of combined renovation packages were assessed for cost-optimality and energy performance. Further details on the assessed renovation measures are provided in Appendix 4: Reference building characteristics and assessed renovation measures4.

Identifying cost-optimal renovation packages

Recognising that homeowners possess varying financial resources, we examined which renovation measures yield the greatest economic benefits across different levels of investment, in three steps:

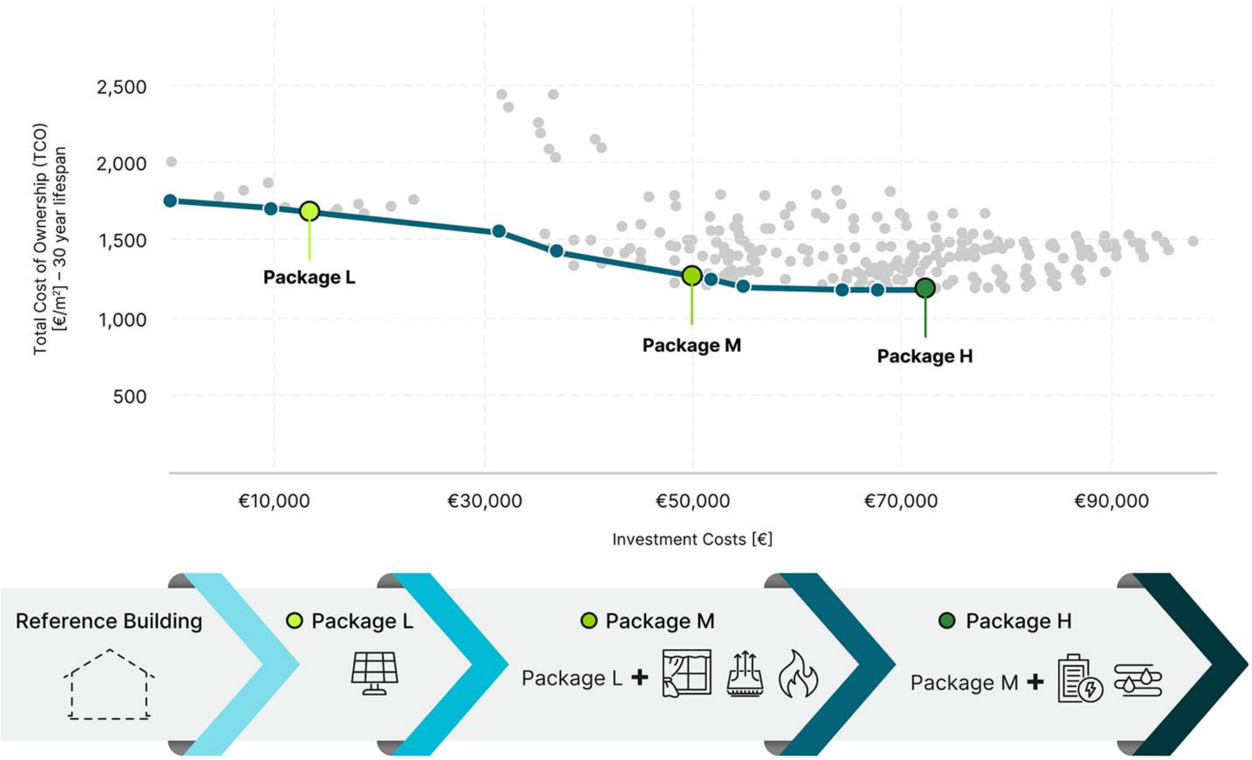
1. First, **all combinations of renovation measures** are modelled on a given reference building. A combination could be to install PV on an otherwise unrenovated building (one measure applied), or to install insulation measures and change the heating system (four measures applied). With each combination, the investment costs, TCO, energy performance and number of measures applied are recorded.
2. Second, we identify the combinations which have the lowest TCO for each given number of measures, resulting in a **cost-optimality curve**. For instance, for one measure, if PV yields

lower TCO than installing better windows, or a heat pump, this measure would be considered as part of the cost-optimality curve.

3. Finally, from the cost-optimality curve, we identify two or three recommended '**renovation packages**' that provide significant cost or energy savings at different investment levels[6]. Together, these packages define the economically meaningful options for each reference building, rather than prescribing one single solution.

These steps are illustrated in the graph below (Figure 5). The graph shows TCO as a function of invested amount. The grey dots show all combinations of renovation measures modelled on a given reference building. The cost-optimality curve is shown in blue and the renovation packages in different shades of green.

Figure 5: Illustrative scatter plot of methodology outputs



[6] The renovation packages selected in this section are generalised, and are meant to provide a common narrative across the three countries for each building type. They have been selected at points along the cost-optimality curve where either energy performance or TCO are minimised.

Cost-optimal renovation packages

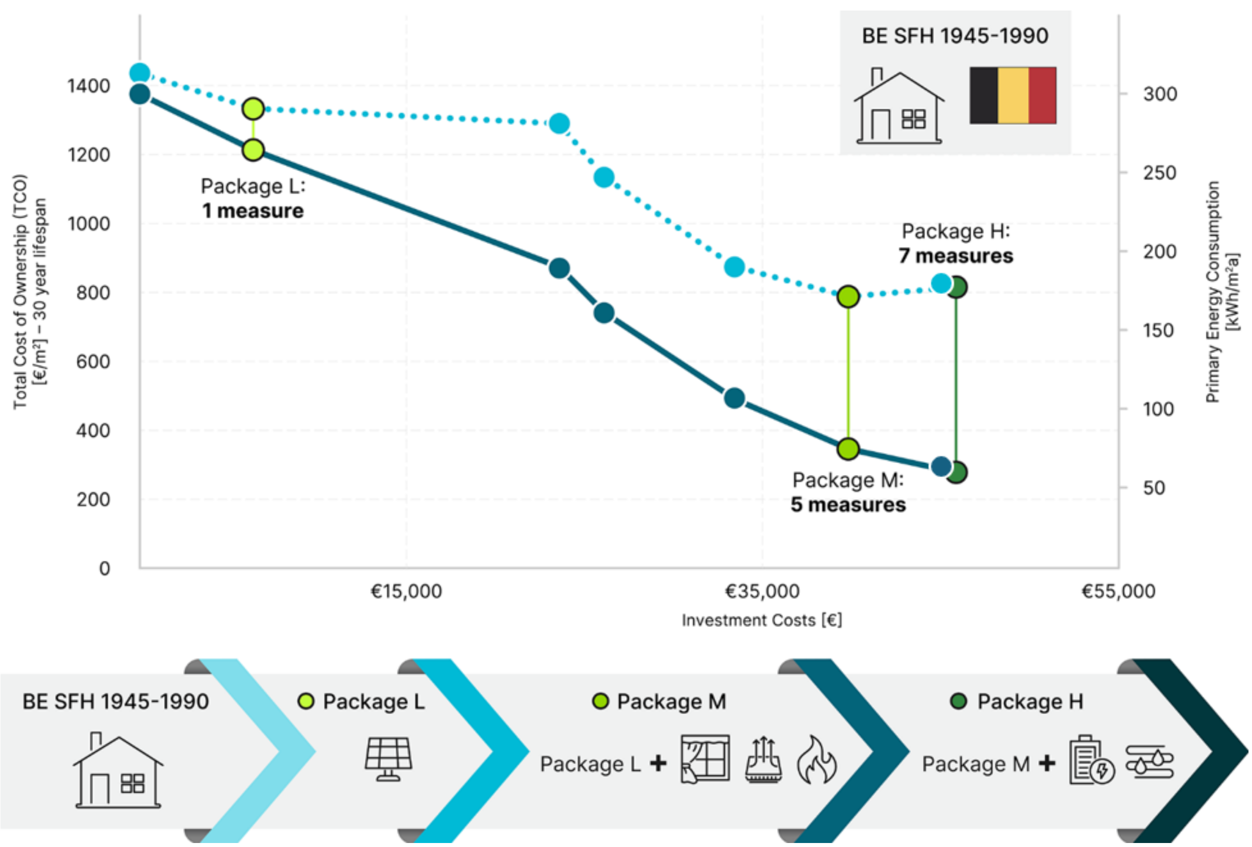
The following sections detail how these cost-optimal package structures materialise across the three building types, highlighting both consistent patterns and country-specific adaptations.

For each building type, we show the cost-optimality curve and energy performance for one country and then discuss renovation packages. The key economic performance indicator in the EU cost-optimality assessment is the so-called "global cost", which is the net present value used. As mentioned above, while the curves generally look different across the three countries, the overall packages are consistent.

SFH built between 1945 and 1990

This analysis compares a reference SFH with three renovation options. The reference building represents an older dwelling with limited insulation and a conventional fossil-based heating system, providing the baseline for assessing improvements in energy performance. The reference building shows high TCO, indicating significant ongoing energy-related costs (see Figure 6).

Figure 6: Illustrative cost-optimality curve and renovation packages for a 1945-1990 SFH in Belgium. The blue dotted line (left axis) shows TCO against investment costs, the dark blue solid line (right axis) shows primary energy against investment costs. Summarised renovation measures in each package are shown below.[7]



[7] Reasoning behind packaging in this example for Belgium: The 1st point at 1 renovation measure shows a

The three packages identified are as follows:

- **Package L** provides energy cost reductions for minimum investment. The payback period is minimal (5–14 years). Package L is achieved by an installation of PV only. While this package in theory provides good short-term economic benefits, there may be practical constraints to installing PVs on unrenovated roofs. However, if there are no such constraints, package L serves as a low-regret entry point into renovation, offering ease of implementation but only limited impact on overall energy demand and TCO.
- **Package M** combines building insulation improvements and a transition in the heating system and DHW. In Belgium and Germany, this takes the form of insulating walls, roofs and windows alongside installation of a heat pump. In the Netherlands, only the windows are insulated, together with heat pump installation, due to better insulations in the reference building. Package M consistently emerges as the cost-optimal solution, striking the best balance between investment levels and lifecycle cost reductions. The payback period of package M is slightly higher than that of package L, but with increased reductions in energy costs, the long-term savings will be higher.
- **Package H** represents a comprehensive renovation approach that combines full building insulation together with system electrification. This package delivers the lowest operational energy costs by maximising demand reduction and renewable energy use. However, the substantially higher upfront investment is typically not fully compensated by further decreasing energy costs, and thus, when compared to Package M, TCO is levelling off. This highlights a consistent cross-country insight for older SFHs: while deep renovations maximise energy performance, they don't necessarily represent the most cost-efficient pathway from a micro-economic perspective. The payback period of package H is again slightly higher than that of package M, however with increased reductions in energy costs.

For older single-family homes, cost-optimality is achieved at medium intervention levels, where the heating system is upgraded and building is insulated. Further investment may provide energy savings, but not cost savings.

SFH built after 1990

This analysis investigates renovation measures on a newer reference SFH built after 1990. Thanks to more stringent energy efficiency requirements by the time of its construction, the reference building already has good insulation on the roof, floor, walls and windows. It also has a conventional fossil-based heating system. Compared to older SFHs, the reference building starts from a lower TCO level, reflecting already improved insulation standards and building components, but still exhibits potential for further cost and energy savings (Figure 7).

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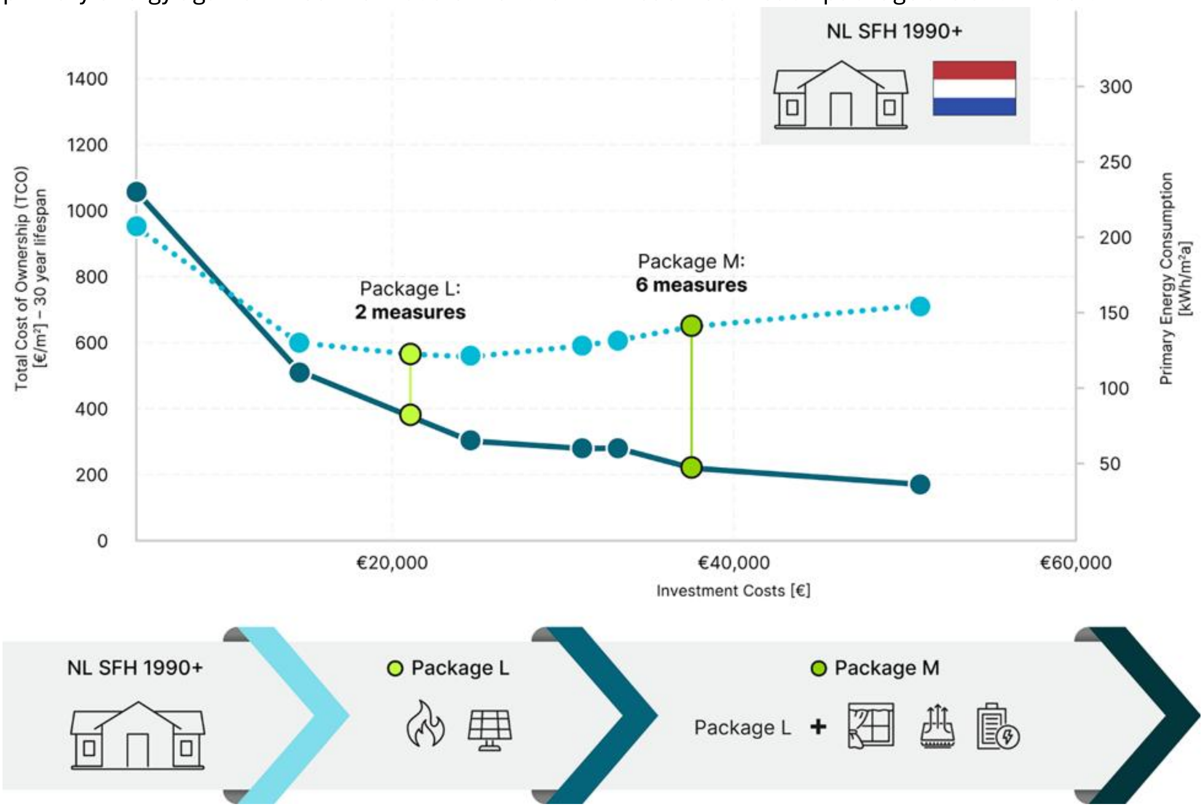
reduction in TCO, after which the 2nd point adds significant investment for little additional reduction, therefore the 1st point forms package L. The 5th point is the cost-optimal point (minimum TCO), therefore this is selected as package M. The 7th point minimises energy consumption, and is selected as package H. The icons in the graphics summarise the measures each package comprises of. While the details may differ across countries (e.g. which insulation measures are taken), at a high-level the packages are consistent.

Figure 7: Illustrative cost-optimality curve and renovation packages for a 1990+ SFH in the Netherlands. The blue dotted line (left axis) shows TCO against investment costs, the dark blue solid line (right axis) shows primary energy against investment costs. Renovation measures in each package are shown below.[8]



Similar to the previous figure, this graph illustrates the relationship between investment costs and TCO for different renovation packages, showing how increasing intervention levels affect economic performance for newer single-family homes. From the graph we see that cost-optimality is already reached after two measures, and that installing further measures increases TCO. However, energy consumption continues to decrease with further measures, and we therefore identify two packages, one with two measures installed (L), and one with six measures installed (M), for the SFH 1990+.

- **Package L** represents a change in the heating system and DHW (heat pump and combined water and space heating) and installation of PV (for the Netherlands, the reference building already has a combined water and space heating installed, therefore this package is at 2 measures). This package brings energy consumption down significantly for minimum investment, therefore reaching low TCO. The payback periods are also minimised, ranging

[8] Reasoning behind packaging in this example for the Netherlands: The 2nd point (2 renovation measures) shows a significant additional reduction in primary energy consumption compared to only 1 measure, with still further reduced TCO, forming package L. It includes PV, as a 1990+ building does not need additional roof insulation, which allows no-regret installation of PV. The 6th point combines all measures except the very costly additional wall insulation, forming package M.

between 8 and 16 years.

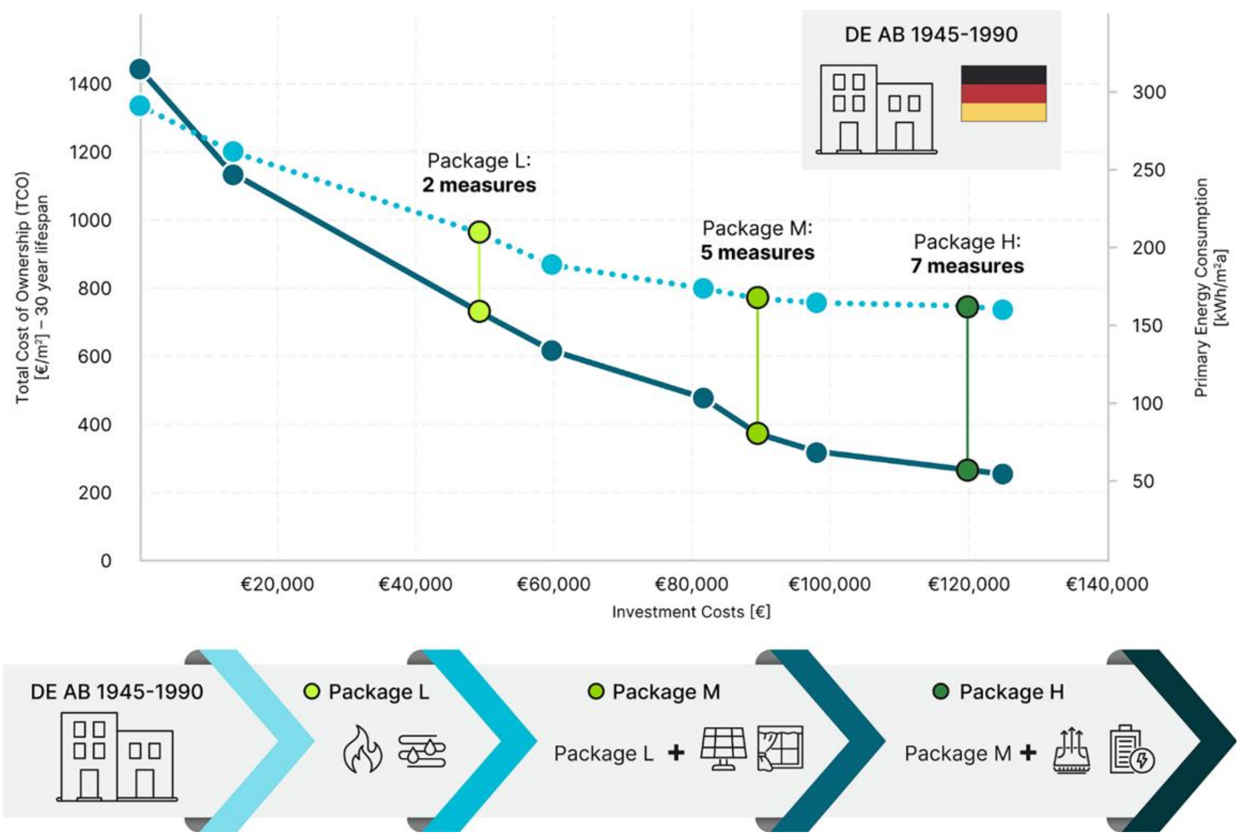
- **Package M** includes 6 measures, representing deep renovation with comprehensive insulation (roof, floor, windows), heat pump systems, and PV (plus battery in Germany). This package leads to lower energy consumption levels, but due to the very high investment costs, the TCO rises again, illustrating diminishing economic returns for each additional Euro invested at higher renovation depths. Payback periods are also higher than for package L.

This shows that for newer buildings, cost-optimal renovation strategies are often achieved at low intervention levels, while more ambitious packages provide energy and climate benefits rather than additional direct micro-economic benefits.

AB built between 1945 and 1990

This analysis shows the results for a small AB built between 1945 and 1990. The reference building has a floor area of 400-500 m^2 and is characterised by low insulation levels and a conventional fossil fuel–based heating system (Figure 8).

Figure 8: Illustrative cost-optimality curve and renovation packages for a 1945-1990 AB in Germany. The blue dotted line (left axis) shows TCO against investment costs, the dark blue solid line (right axis) shows primary energy against investment costs. Renovation measures in each package are shown below.[9]



[9] Reasoning behind packaging in this example for Germany: The 2nd point (2 renovation measures) shows the

Compared to SFHs, the reference building starts at a lower TCO level, primarily due to its greater compactness, which reduces heat losses through the building envelope and therefore leads to lower energy demand and associated energy costs. Across all three countries, increasing investment leads to noticeable reductions in TCO, although with differing slopes and levels of economic efficiency. The total investment costs of the building are naturally higher than for the smaller SFH buildings, but when viewed per unit of floor area, or per household, the costs are significantly lower. This, combined with the significant reductions in TCO achievable, results in short payback periods compared to the other buildings. We identify three renovation packages:

- **Package L** includes installation of a heat pump and an improved DHW, which delivers meaningful TCO reductions at relatively low investment levels, but has an impact which remains limited compared to more comprehensive approaches.
- **Package M** shows a balanced combination of insulation improvements and system upgrades. Package M achieves substantial reductions in TCO while maintaining moderate investment levels and typically is already close to the least-TCO combinations of measures.
- **Package H** represents a comprehensive upgrade of the building envelope combined with full system electrification. This package delivers the lowest energy consumption levels, and the lowest TCO.

Overall, the results for small ABs show that comprehensive renovations combining multiple measures are the most cost-effective as they provide significant energy savings for relatively low investment costs.

This building type also has the lowest payback periods, which never exceed 10 years in the renovation packages and countries considered. Payback periods also remain relatively constant with increased renovation depth.

Overall findings for economic and energy performances

Throughout all three case study countries, clear trends were observed from our findings.

01 | Applying renovation measures always lowers costs in the long term

While seemingly obvious, an important finding across our entire analysis is that applying renovation measures reduces TCO (i.e. investments are outweighed by energy cost savings over a 30-year timeframe). The cost saving depends on the number of measures applied and differs per building; however, the untouched reference building never remains the cost-optimal option.

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highest reduction in primary energy and is therefore included in the L package. The 5th point is the preferred M package, as it achieves most significant primary energy reductions at moderate investment costs. cost-optimal point (minimum TCO), therefore this is selected as package M. Compared to this, the H package only slightly reduces TCO further, but at significantly higher investment costs and rather moderate additional primary energy consumption. Measure 8 (ground floor insulation) was not included in H, as it only adds minor further primary energy reductions, but in many buildings faces practical restrictions (too low height of basement, or piping networks under the ceiling).

02 | Heat pumps are key – especially when combined with targeted insulation

Heat pumps are integral across all cost-effective renovation packages. While they entail higher upfront investment compared to conventional heating systems, their superior efficiency likely leads to substantially lower lifetime energy costs. As a result, heating system upgrades are present even in the least comprehensive cost-optimal packages across the analysed building types and remain the single most influential measure for reducing TCO.

03 | PV drives low-cost entry; supports deeper packages

PV and battery storage play a dual role in renovation strategies. At low intervention levels (Package L), PV frequently represents the standalone measure with the shortest payback period, especially in newer buildings. However, this also highlights an important limitation of payback-based decision-making: measures with short payback aren't necessarily those that deliver the best overall economic outcome when assessed over the full lifecycle. They can also complicate later renovation steps if they aren't sequenced well. For example, installing PV on a roof that requires renovation measures in the near future can create additional cost and disruption if the PV needs to be removed and reinstalled. From a TCO perspective, which includes investment, operation and replacement costs over time, more integrated renovation packages often provide a stronger overall value proposition.

Accordingly, for deeper renovation levels, the role of PV becomes more supportive, complementing core measures such as heating system upgrades and insulation rather than driving cost-optimality on its own. In the absence of subsidies or additional revenue streams, they enhance but don't replace the impact of demand reduction and system transformation measures.

04 | Cost-optimal renovation depth is driven by the age and typology of the building

A consistent pattern across the analysis is that cost-optimal renovation depth depends strongly on the initial building condition. For older buildings, medium-intensity packages (Package M), combining insulation improvements with heating-system upgrades, typically deliver the best balance between investment and TCO from the homeowner perspective. By contrast, for newer buildings, low-intensity measures (Package L) are often sufficient to capture much of the economically achievable benefit and to come close to the lowest possible TCO. This highlights that cost-optimal strategies are shaped by packages of measures rather than by individual technologies alone.

In addition, the size of the building matters: while single-family homes tend to reach cost-optimality at moderate intervention levels, apartment buildings can justify deeper renovations, as the total investment costs are lower relative to the energy savings.

05 | National context shapes specific outcomes, not overall conclusions

Differences in energy prices, technology performance and renovation cost structures affect which measures appear first in the cost-optimal sequence for a given building type and country. For example, heat pumps already emerge as attractive standalone solutions in the Netherlands, while PV often represents the most cost-effective entry point in Belgium and Germany, and window upgrades can play a stronger role in specific contexts such as Germany.

Overall, the results show that economically sound residential decarbonisation does not rely on uniform deep renovation across all building types. Instead, cost-effective pathways are achieved by aligning renovation depth with building characteristics, prioritising low-intensity measures for newer buildings and medium-intensity packages for older ones, and focusing on combinations of technical measures that deliver the strongest lifecycle cost performance.

The results in this section define the economically meaningful options for renovations from a homeowner cost perspective. They show which renovation packages can make sense in lifecycle-cost terms, but not which options homeowners are likely to choose in practice. That next question depends on financial capacity, perceived risk, disruption, motivation and decision context, and is addressed in the following section.

3. Understanding homeowner likelihood to renovate

A renovation journey only becomes relevant at scale if it is both economically sound to the homeowner and feasible for the homeowners expected to implement it. This section therefore examines homeowner preferences and renovation likelihood, while also considering the wider social dynamics, co-benefits and perceived barriers that shape renovation behaviour.

To capture this complexity, we analyse homeowners through a structured segmentation approach. There's no one-size-fits-all solution: motivations, constraints and decision drivers differ significantly across homeowners. At the same time, a purely household-by-household assessment is not feasible if the goal is to identify broader patterns and scalable interventions. The segmentation therefore categorizes homeowners into a defined set of five representative profiles. While these profiles cannot predict individual behaviour precisely and still allow for tailored support to help homeowners find solutions that fit their specific circumstances, they explain why homeowners do not choose uniformly from the same economic options and which types of intervention are likely to be most relevant for each group.

Process for segmenting homeowners

Across the case study countries of Belgium, Germany and the Netherlands, we drew on the most suitable national household segmentation studies and combined them with additional housing- and energy-relevant variables to develop a meaningful homeowner segmentation. These sources are presented in Table 2 below.

Table 2: National household segmentation studies

Country	Homeowner Segmentation	Variables
Belgium	Based on national household segmentation (created by Dividuals®), covering 10 segments	Additional data points linked to energy use and building characteristics to better match renovation decision-making[10]
Germany	Based on detailed homeowner segmentation study (16 personas) created by Sozial-Klimarat	Refined by focusing on renovation likelihood and affordability-relevant variables[11]
Netherlands	Based on national household segmentation (created by Whize), covering 11 segments	Additional indicators linked to building stock and energy-relevant characteristics[12]

The selected datasets provide a basis for identifying patterns in homeowner behaviour across countries. To tailor them for the purpose of this analysis, they were further refined through the integration of additional indicators related to energy use, building characteristics and renovation

[10] Source: Sirius Insight. *About Dividuals® - Dividuals® by SIRIUS Insight*
[11] Source: Sozial Klima Rat (2023). *Deutschlands Lebensrealität in 16 Personas*. Sozial Klima Rat. https://sozial-klimarat.de/personas/
[12] Source: TDA Analytics (2025). *Segmenten en Subsegmenten: Slim gebruik van data voor klantgesegmenteerde communicatie*. TDA Analytics. https://www.whize.nl/

context.

The resulting datasets consist of pre-defined homeowner segments, with data on key variables relevant to renovation behaviour, including:

1. Demographics (age, income, education)
2. Building characteristics (building type, construction year)
3. Energy performance (energy labels, energy consumption)
4. Renovation-related indicators (including stated willingness and measures already implemented)

Based on the pre-defined segments in each dataset, common characteristics across the country assessments could be identified and clustered into five overarching profiles used in this study. The datasets used were considered the most suitable national datasets available for capturing homeowner characteristics relevant to this study. The main limitation is that they studied both homeowners and tenants together as they were originally developed for broader market or household segmentation purposes, rather than specifically for energy renovation decisions. They nevertheless provide a useful basis for identifying meaningful patterns in homeowner decision contexts. In some cases, however, they don't fully distinguish between homeowners and tenants, which reduces the precision with which homeowner-specific behaviour can be captured, given the fundamental differences in decision authority, incentives and financial responsibility between homeowners and tenants. With access to raw household-level data on key variables, homeowners could be classified more precisely into renovation-relevant profiles. This would enable a more operational application of the framework, for example in portfolio segmentation or targeted customer engagement by financial institutions.

Analysing homeowner preferences based on their likelihood to renovate

Even if a renovation package is economically optimal over the long term, it may not be adopted if it is perceived as too expensive, disruptive, complex, unnecessary or risky. Understanding renovation outcomes therefore requires looking at how homeowners respond in practice and why. To understand this, we assessed renovation preferences for the identified homeowner profiles using a "likelihood to renovate" framework. This framework is built around three factors: need, ability and motivation to act, which are described in table 3.

Table 3: Likelihood to renovate factors

Factor	Description	Key indicators
Need to act	How urgent renovation is from an overall decarbonisation perspective, based on building and energy context. This reflects an objective assessment of renovation need which may or may not translate into action, as homeowners' subjective perception of urgency may differ.	- Energy source - Energy usage (or energy label) - Building age (construction year) - Prior renovation activity
Ability to act	Whether homeowners can realistically act, considering decision control and affordability constraints.[13]	- Household income - Household size

[13] In multi-owner buildings, this also depends on whether an individual owner can help secure the collective agreement required for whole-building measures.

		- Building type
Motivation to act	The incentives to renovate, including economic and environmental factors. Motivation pertains to how strong the case to renovate is, in theory. [14] Practical considerations, such as willingness to take on risk, trust in construction workers, priorities, etc. are described separately as these are not necessarily profile dependent.	- Environmental awareness - Education - Homeowner age - Property value[15] - Stated willingness to renovate

Indicators influencing likelihood to renovate

As described in Table 3, each factor is informed by multiple indicators. For example, the need to renovate is based primarily on building characteristics such as age and energy use, as well as previous renovations. The ability to renovate is mostly driven by household size and income as well as building type. The motivation to renovate is driven by various factors, including environmental awareness, education and homeowner age as well as the homeowners' property value and their stated willingness to renovate.

Despite key differences in the housing markets across countries, there are consistent patterns in how these variables relate to the "likelihood to renovate". For instance, a longer expected **time horizon of living in the property** increases the likelihood to renovate. Homeowners who anticipate living in their home for a longer period are generally more likely to invest in renovation measures, as they have more time to recover upfront costs and benefit from energy savings and comfort improvements. This long-term perspective tends to be weaker for homeowners with shorter planning horizons, which are often, but not exclusively, associated with later life stages.

One example of this is **homeowner age**: while older homeowners may be less inclined to renovate due to shorter investment horizons, age alone is not a decisive factor, and its influence depends on individual circumstances. Another example could be in markets with shorter homeowner occupancy duration, like the Netherlands - where decision making on renovation therefore can be focused on shorter payback periods, or on other factors such as any perceived value increase to the property based on an improvement of the EPC label.

Income primarily shapes the ability to act. Higher-income households are better positioned to finance more comprehensive renovations, while lower-income households often face affordability constraints, limiting them to smaller measures or preventing action without support.

Education plays a role in shaping motivation, but its influence is indirect. Higher levels of education are often associated with greater access to information, higher awareness of environmental and financial benefits, higher income, and a stronger ability to navigate complex

[14] The assessment of motivation is based on observable proxy indicators, such as environmental awareness and stated willingness to renovate. However, these variables provide only a partial representation of real-world motivation, which is also shaped by factors such as trust in contractors, perceived complexity, competing priorities, and expectations about future housing decisions. As a result, it is important to note that actual behaviour may diverge from the theoretically derived motivation scores.

[15] While property value was not included in the quantitative analysis described in section 2 due to the complexity in quantifying increases in property value from renovations, where available, we have included this indicator in the socio-economic analysis as part of the motivation to renovate.

decision-making processes. This can increase the perceived value of renovation and reduce hesitation related to uncertainty or lack of knowledge. However, education alone isn't a strong predictor of actual renovation behaviour, as it interacts with other factors such as financial capacity, competing priorities, and trust in the renovation process.

Other indicators further shape renovation likelihood through their interaction with these core dimensions. For example, building characteristics such as **building age** and **energy performance** influence the need to act, as poorly performing buildings create stronger economic and comfort incentives for renovation. At the same time, **household composition** and **life stage** (e.g. families with children, retirees) influence both available resources and competing priorities, thereby shaping both ability and motivation.

It is important to note that **physical constraints** and **technical feasibility** set the outer boundaries for renovation possibilities. Factors such as available space for a heat pump or suitable roof conditions for PV installation determine which measures can realistically be implemented at the building level. In this sense, they define what's technically feasible for a given property. However, unlike financial or behavioural factors, these constraints don't directly determine a homeowner's willingness or ability to act; rather, they establish the limits within which renovation decisions can be made.

Overall, these indicators should be understood as contributing factors rather than standalone predictors. Renovation decisions emerge from their combined effect, and from how they interact with practical constraints such as perceived risk, disruption, and complexity.

Defining distinct homeowner profiles

For the purposes of this white paper, we identify five indicative profiles that are most relevant for understanding homeowner decision contexts in relation to renovation uptake. These profiles are described in detail in Table 4 and illustrated in Figure 9.

The profiles are derived from detailed national segmentation datasets and reflect consistent patterns observed across the case study countries. While they simplify a more granular underlying dataset, they're grounded in empirical distributions of income, building characteristics, energy performance, and stated willingness to renovate. For the avoidance of doubt, any bank-level application would need to comply with applicable privacy, consumer protection, anti-discrimination, creditworthiness and product governance requirements.

The profiles therefore represent analytically derived groups rather than illustrative personas. Further details are provided in Appendix 6: Homeowner segmentation and demographics.

Figure 9: Homeowner profiles' likelihood to renovate

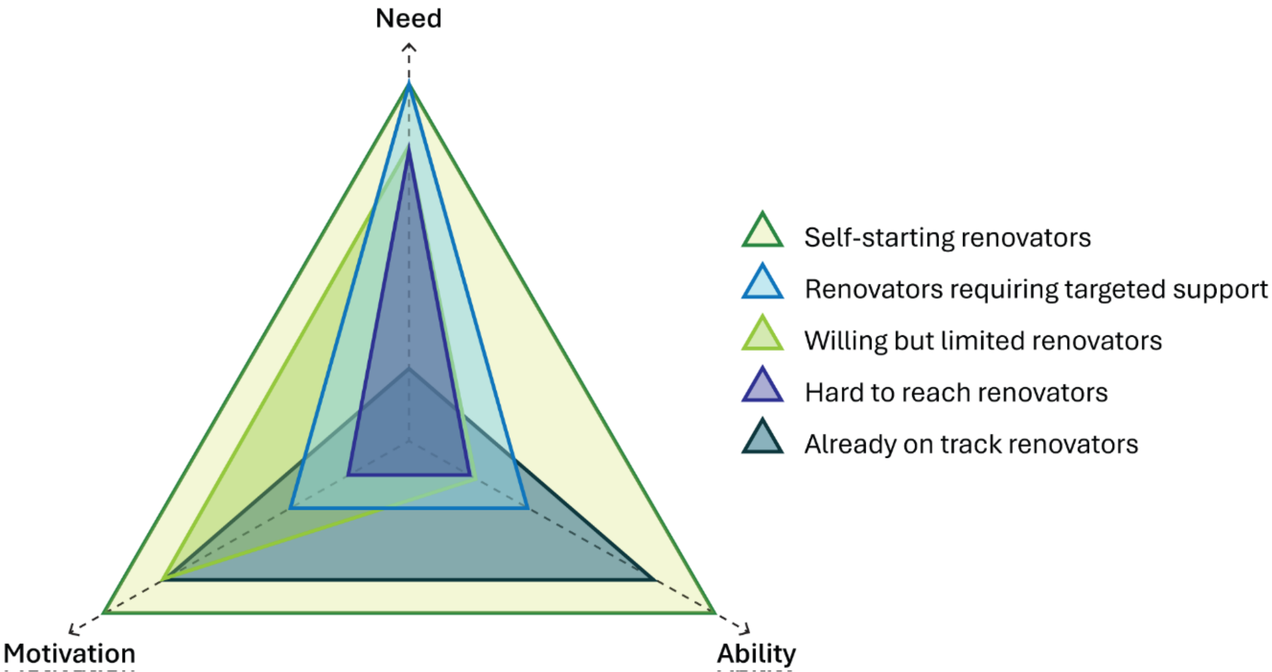
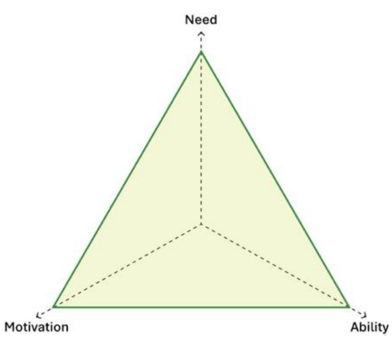
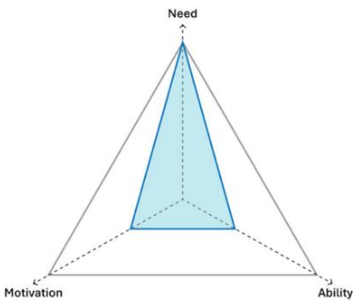
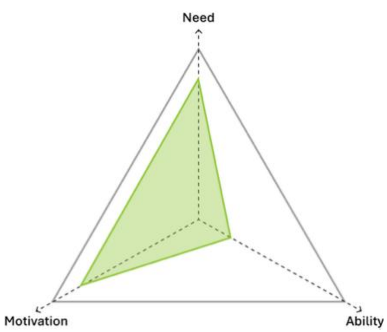
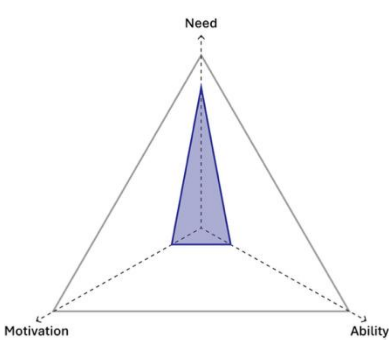
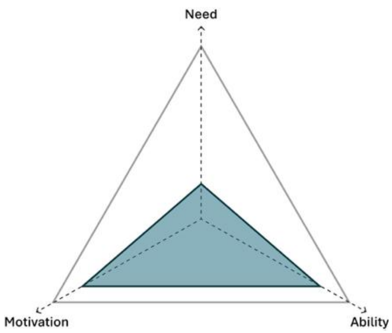


Table 4: Description of homeowner profiles

Homeowner profiles	Descriptions
Self-starting renovators  Need: Strong Ability: Strong Motivation: Strong	Self-starters are typically upper-middle-aged homeowners with above-average incomes, living in older SFHs with relatively poor energy performance. They combine a clear need to act with both the capacity and motivation to do so. Financial resources, full decision-making authority and confidence enable them to undertake renovations. However, they may still underestimate the benefits of shifting from isolated measures to a more integrated renovation approach. In practice, they are one of the profiles most likely to act: the priority isn't to build willingness from scratch, but to translate existing readiness into more comprehensive and better-sequenced renovation decisions.

Renovators requiring targeted support  Need: Strong Ability: Medium Motivation: Medium	Renovators requiring targeted support are often small families or older homeowners with low to middle incomes and moderate environmental awareness, typically living in SFHs. While they have a strong need for renovation, their ability or motivation is constrained by one or two key barriers such as misaligned household budgets, competing family priorities, limited access to contractors in their area, or more technically complex starting points (e.g., challenging heating system replacements). They aren't disengaged per se; rather, they are conditional actors whose decision to renovate depends on whether the relevant obstacle is clearly identified and effectively addressed, and interventions should be targeted to address these bottlenecks
Willing but limited renovators  Need: Medium/Strong Ability: Weak Motivation: Medium/Strong	Willing but limited homeowners are typically middle-aged, lower-income residents of small ABs in urban settings. They often exhibit a strong need to renovate and a reasonable level of motivation but have limited ability to act. This constraint is primarily structural rather than purely financial: many live in apartments, row houses, or small multi-unit properties where renovation decisions depend on collective agreement, governance frameworks, or building-level coordination. As a result, they may be individually open to renovation but lack the authority or practical means to initiate it on their own. The priority is to create mechanisms that facilitate coordination, collective action, and decision-making among multiple stakeholders.
Hard-to-reach renovators  Need: Medium/Strong Ability: Weak Motivation: Weak	Hard-to-reach homeowners are often upper-middle-aged or older, have low to moderate incomes and lower education levels, show limited environmental awareness, and live in older, energy-inefficient SFHs. This profile combines a high need for renovation with low ability and low motivation to act. Financial constraints, shorter planning horizons, and more complex life circumstances reduce the perceived urgency and feasibility of renovation. For these homeowners, renovation isn't simply a technical or financial decision, it competes with more immediate priorities, and the perceived effort and burden can outweigh even a compelling long-term case. The priority is therefore not only to improve affordability, but also to reduce complexity, address competing priorities, and demonstrate clear and tangible benefits

Already-on-track renovators  Need: Weak Ability: Medium/Strong Motivation: Medium/Strong	Already-on-track homeowners are typically middle- to upper-middle-aged, with moderate to high incomes and education levels, and strong environmental awareness. They tend to live in newer SFHs or have already implemented significant renovation measures. This profile has a relatively low remaining renovation need but maintains high ability and motivation to act. Their homes are already comparatively energy-efficient, meaning they aren't a priority segment for increasing overall renovation uptake. The focus should instead be on the primary group limiting overall renovation uptake. Their core challenge is more targeted: assessing whether further improvements are still worthwhile and identifying the most sensible next step, if any.

General trends influencing homeowners

While this analysis focuses on distinctions between homeowner profiles, several structural trends influence renovation behaviour across all groups. These factors primarily act as determinants of homeowner ability and motivation to renovate. However, their impact is not uniform: depending on the specific homeowner profile, they may be more or less constraining and can be perceived as more or less manageable at a given point in time.

01 | Workforce and supply chain constraints

Systemic constraints, such as skilled labour shortages, combined with bottlenecks in materials, equipment and supply chains, limit the pace and scale of renovation required to meet EU climate and energy targets. Capacity constraints across the value chain can increase costs, extend timelines and reduce access to key technologies, with more pronounced effects for segments that are already financially or logistically constrained. In addition, grid capacity constraints can limit the ability to electrify homes. Without sufficient grid capacity, the electrification of homes cannot scale, making grid congestion a critical bottleneck for the energy transition.

02 | Capability gaps

Homeowners may lack the knowledge, tools and support needed to make informed renovation decisions, particularly for deeper, more complex upgrades. The disruption and organisational effort involved can reduce willingness to act, especially for profiles with lower confidence or fewer available resources.

03 | Perceived risk and uncertainty

Renovations are often associated with uncertain financial returns and unclear performance outcomes. This can discourage action, particularly for segments that are more risk-averse or have limited financial buffers.

04 | Policy and market fragmentation

Complexity in policy frameworks and implementation requirements as well as market fragmentation can increase perceived effort and uncertainty. As a result, homeowners may favour simpler, incremental measures over more comprehensive renovations, particularly where administrative or coordination burdens are significant.

05 | Timing misalignment

Renovation decisions are often triggered by specific events (e.g. equipment failure, property transactions). Outside these moments, uptake remains lower, even where the economic case is favourable. The relevance of such triggers varies across segments depending on life stage, financial flexibility and decision context.

The findings highlight that renovation uptake is not uniform across homeowners: targeted, profile-specific solutions are essential to effectively scale both the uptake and depth of renovations. Despite the limitations in the datasets used, segmentation offers a valuable lens for understanding how differences in need, ability and motivation shape renovation behaviour in practice.

Building on this, the next section links these profiles to suitable renovation packages, providing insight into which segments are most likely to adopt which measures, and how targeted support can accelerate both renovation uptake and depth in the respective homeowner groups.

4. Closing the decision gap: Matching solutions to homeowner realities

This section links the representative renovation packages (L, M, H) to these indicative homeowner profiles. The objective is not to define a single optimal pathway, but to show which renovation approaches are most plausible for different types of homeowners, where uptake is likely to stall, and which targeted policy, finance and market instruments could help increase uptake and renovation depth. This includes financial support, advice, sequencing and implementation support, but also recognises that the wider policy framework is not built on incentives alone: phased requirements, minimum performance expectations and fossil-heating phase-out pathways can all create clearer direction for homeowner decisions when combined with adequate support.

The result is a practical mapping that contributes to discussions around how stakeholders could move from general renovation ambition to targeted intervention design. It shows, for each homeowner profile:

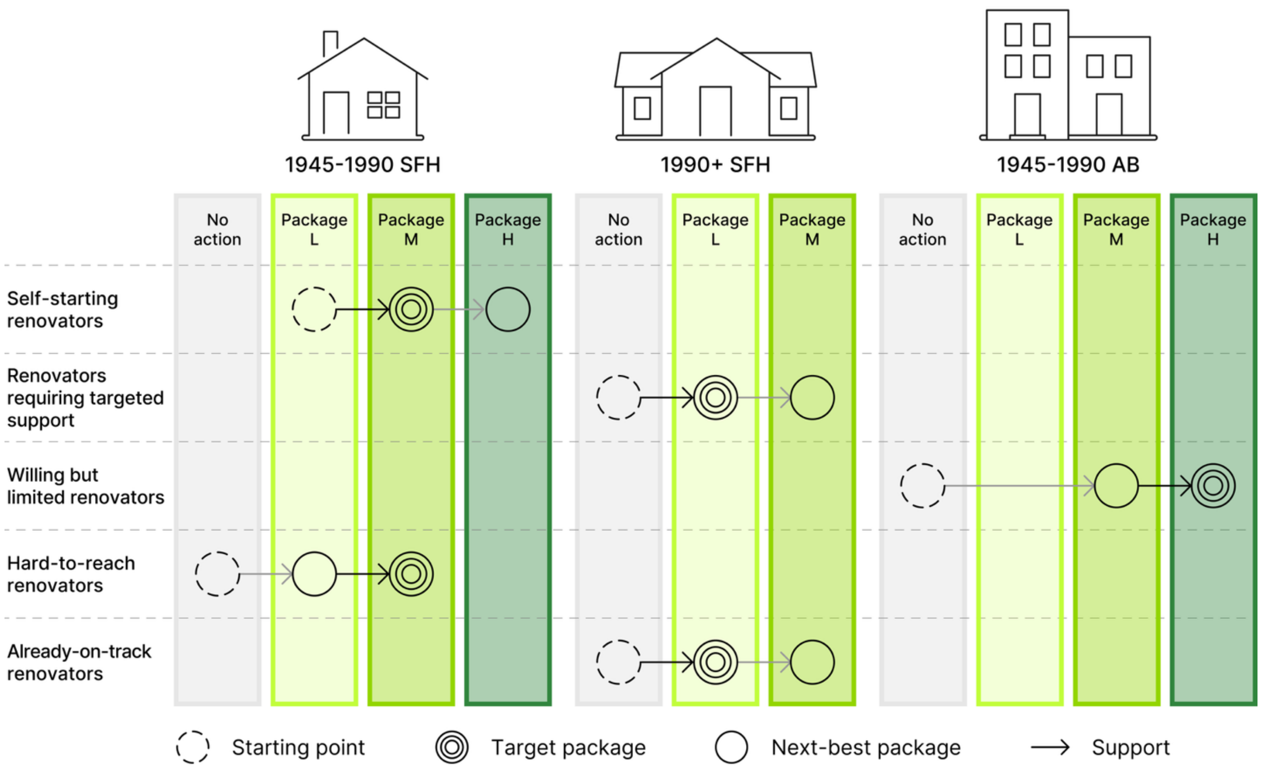
(i) Which renovation approaches are most relevant
(ii) What the main barriers are likely to be
(iii) What kinds of solutions could address them

Mapping renovation packages to homeowner profiles

Figure 10 illustrates how different homeowner profiles across markets align with different renovation packages, taking into account both the typical building context associated with each profile and their likelihood to act. While some variation exists across countries, the analysis identified a set of common homeowner archetypes and renovation pathways that are relevant across markets, enabling the development of a single cross-market mapping. For each profile, the mapping distinguishes between a likely starting point and a target package. The target package represents a more attractive yet still plausible outcome compared with the status quo, assuming key barriers to renovation are addressed.

Importantly, the target package is not simply the package with the lowest energy use or the lowest lifecycle cost. It represents the most plausible higher-impact approach for a given homeowner profile once relevant barriers are addressed. In this sense, it combines the renovation options that make the most sense economically with the decision reality of the homeowner. The starting point represents what is most likely to happen under current conditions, based on each profile's likelihood to renovate. For some, this involves only limited action and for others, it may mean no action at all. The next-best package reflects an alternative approach that may still be attractive but is lower priority because it either delivers weaker energy and cost outcomes or is less likely to be adopted in practice.

Figure 10: Mapping renovation packages to homeowner profiles



It is worth noting that higher intensity renovation packages are less likely to be attractive for 1990+ SFHs from a strict TCO perspective, as they tend to increase TCO compared to lower-intensity packages. Homeowners in these properties–renovators requiring targeted support and those already on track–therefore mostly start from a baseline of no action, since their homes are often already relatively energy-efficient or have previously been renovated. Willing but limited and hard-to-reach renovators also mostly start from a point of no action, but for different reasons: their likelihood to act is so low that they are unlikely to adopt these measures without support.

This mapping shows that viable renovation packages are not equally accessible, attractive or actionable for all homeowners. The core challenge is therefore not to identify a single optimal package, but to align renovation depth, support and delivery models with the decision conditions of each homeowner profile.

Understanding the barriers and triggers to renovate

The gap between economically viable and actually realised renovation is shaped by affordability constraints, perceived risk, complexity, timing and structural limitations. Because these barriers differ by homeowner profile and building type, the same renovation package may require different types of support depending on who is in a certain type of house. The main barriers and triggers to renovate are summarised below for each profile, showing which packages they would select under current conditions and how deeper renovation packages could be triggered through targeted intervention strategies.

Barriers and triggers for homeowners

Self-starting renovators

Among the readiest to act, typically owning older SFHs with clear renovation needs and sufficient financial capacity to undertake upgrades. This profile is likely to begin renovating but not always prepared to choose the most optimal cost.

What are the barriers and willingness to renovate?

The complexity of renovating older buildings, including coordination with installers and temporary disruption, often slows progress and leads to partial rather than optimal implementation. The main barrier isn't inability, but follow-through: without clear sequencing, they may choose lower-intensity options over better-performing ones.

How to trigger these homeowners to renovate?

Targeted, decision support rather than purely financial incentives can help move this group towards medium- and, where appropriate, high-intensity renovation packages. Clear roadmaps, transparent cost insights, and access to trusted installers enable confident choices. Solutions like one-stop-shops are particularly successful at providing such targeted support (see Appendix 7: Solution offerings for details). Standard renovation loans can still be useful, but mainly as enabling tools rather than must-haves. Together, these elements reduce perceived risk and complexity.

Renovators requiring targeted support

Represent a heterogeneous but highly promising group, often living in relatively energy-efficient homes (built after 1990) where further renovation is economically viable but not always obvious or urgent. The most suitable pathway isn't necessarily the deepest renovation, but rather a tailored or staged approach that reflects specific constraints.

What are the barriers and willingness to renovate?

The key challenge lies in the gap between economic rationality and practical feasibility: they're unlikely to act on their own, and renovation may be postponed because it feels too costly at a given moment, poorly timed relative to household priorities, or administratively complex. Their willingness is therefore conditional rather than absent.

How to trigger these homeowners to renovate?

Priority-targeted support as well as subsidies and blended finance can help address specific bottlenecks and make action more likely. Effective support includes personalised advisory services, staged renovation plans, targeted financial incentives, complemented by improved contractor matching where needed. Impact is highest when measures are targeted toward segments and buildings with the highest need and lowest ability to renovate. Examples include income-linked loans geared towards lower-income households (see

Appendix 7: Solution offerings for details).

Willing but limited renovators

Characterised by relatively high motivation but constrained ability to act, typically living in apartment buildings (ABs) where renovation requires collective decision making. This profile has potential for significant cost and energy savings but lacks implementation capacity: the mismatch isn’t between motivation and value, but between collective benefit and individual agency.

What are the barriers and willingness to renovate?

The core barrier isn’t limited interest but fragmented ownership and decision-making structures. Deeper, building-level renovation packages are often economically attractive, as they unlock economies of scale and deliver significant energy and cost savings. However, these opportunities remain largely unrealised due to structural barriers: individual homeowners can’t act independently; they depend on agreement between multiple stakeholders.

How to trigger these homeowners to renovate?

Unlocking progress requires collective-action mechanisms such as homeowners’ association support, block-level renovation planning, shared technical advice, standardised decision packages, and financing approaches that help multiple owners act in parallel around the same building-level renovation plan. It is less about persuading homeowners one by one and more about enabling individual owners to participate in a coordinated building-level decision, supported by governance arrangements, standardised information and financing approaches while still recognising individual borrower circumstances.

Hard-to-reach renovators

Facing the greatest gap between renovation need and practical ability to act, often living in older, energy-inefficient homes but constrained by affordability pressures, low motivation or short-term planning horizons. While deeper renovation packages may be economically justified over the long term, they’re typically not actionable without substantial support. As a result, this profile is among the least likely to engage in renovation and requires a fundamentally different approach.

What are the barriers and willingness to renovate?

This profile is unlikely to respond to offers focused solely on optimisation and long-term efficiency. Even where the technical and economic case for renovation is strong, the homeowner case may still feel weak due to affordability constraints, low trust, disruption concerns or limited perceived relevance.

How to trigger these homeowners to renovate?

Solution offerings for this profile should be simple, low-upfront-cost and highly accessible, focusing on incremental progress rather than optimisation. Concessional finance, subsidised loan schemes, blended finance and practical handholding that reduce paperwork and perceived risk are most relevant. The objective isn’t to push the deepest package immediately, but to create realistic low-threshold action for a profile that's otherwise very unlikely to engage.

Already-on-track renovators

Typically live in newer or already renovated homes and have both the ability and motivation to act. For this group, most economically meaningful gains have already been realised, and further renovation often doesn't yield a strong additional return from a pure cost perspective. Cost-optimal strategies therefore tend to focus on limited, technical system-focused improvements–such as replacing an existing gas boiler with a heat pump or installing PV–rather than undertaking comprehensive building upgrades such as full insulation of walls, roof and floors.

What are the barriers and willingness to renovate?

The key challenge isn't to discourage further action, but to guide it in a way that maximises impact. Additional investments can still deliver meaningful decarbonisation–even when they go beyond the strictly cost-optimal pathway–however, their effectiveness depends on making the right choices and sequencing measures appropriately.

How to trigger these homeowners to renovate?

This group benefits more from light steering and guidance rather than active intervention. This implies supporting well-informed decision-making in subsequent steps, ensuring that investments are well sequenced. A lighter-touch approach focused on information and guidance can help homeowners refine their renovation plans and get the most value and impact from additional investments, while allowing resources to be prioritised towards segments with greater untapped potential.

In response to the identified barriers, a broad set of interventions are needed, addressing not only affordability but also the wider "decision gap" between technically and economically viable options and what homeowners are willing and able to implement in practice. The profile mapping helps clarify how these interventions could be combined: some homeowners mainly need clearer information, trusted advice, better sequencing or suitable finance, while others may require more direct affordability support, practical handholding or phased regulatory expectations to overcome delay, short planning horizons or persistent inaction.

The interventions can be grouped into four complementary categories (further details can be found in Appendix 7: Solution offerings):

- **Loans and other financial instruments** help address the upfront renovation costs and improve investment attractiveness. Products such as green mortgages, green mortgage top-ups, concessional renovation loans, and cashback schemes can make renovation options more accessible by providing dedicated capital, lowering borrowing costs, and rewarding completed energy upgrades. These solutions are particularly relevant for homeowners who are willing to renovate but require financing to spread costs over time.
- **Subsidies and blended finance** help to provide visible upfront incentives and address financing needs where private financing alone is not appropriate, particularly for deeper

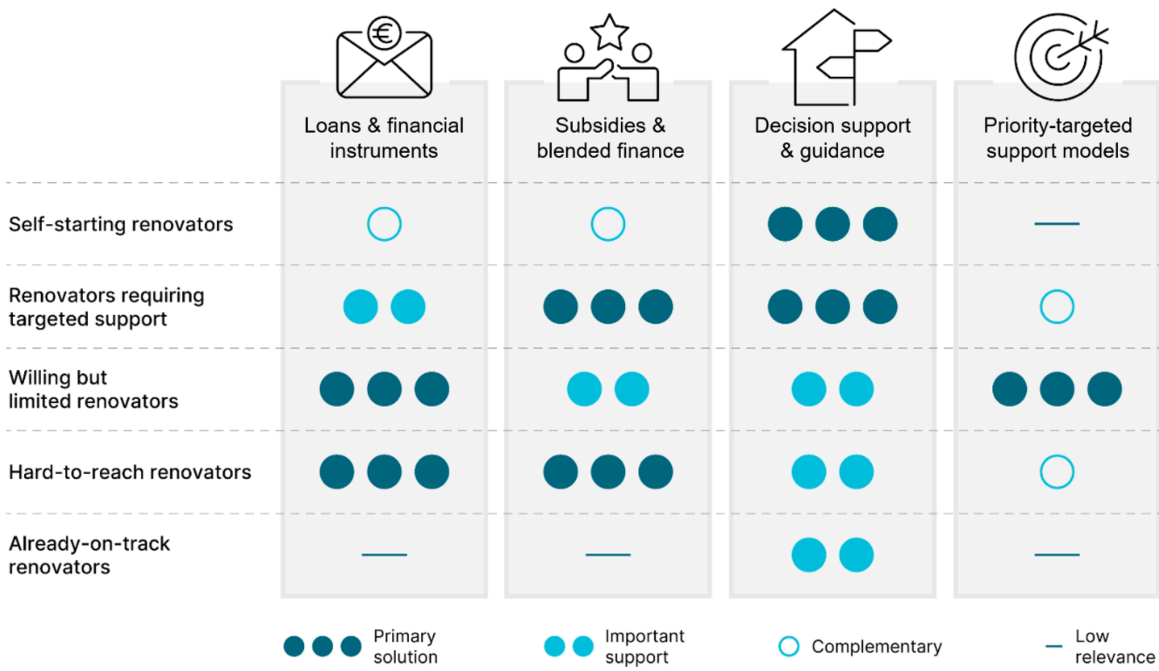
renovations with high upfront costs but strong economic benefits in the long-term. Grants, subsidised public loans (“soft loans”), and combinations of public support and private financing serve an important de-risking function as they can reduce uncertainty around payback, performance, and timing. These interventions are especially important for homeowners facing affordability constraints or undertaking comprehensive renovation projects.

- **Decision support and guidance** help homeowners navigate the complexity of the renovation process. Integrated platforms such as one-stop-shops combine energy assessments, renovation advice, financing options, contractor access, and support with subsidy applications reduce effort, uncertainty and administrative burden. By providing a single point of contact throughout the customer journey, these solutions make it easier for homeowners to move from intention to action. While banks can be a facilitator to access such information tools, technical advice, installation quality, energy-performance outcomes and subsidy eligibility should remain subject to qualified third-party assessment and applicable terms.
- **Priority-targeted support models** direct resources towards homeowners and buildings that face the highest need and lowest ability to renovate. Examples include zero-interest loans or income-linked loans for lower-income households, enhanced subsidies for vulnerable groups, and programmes focused on the least energy-efficient homes. Targeting support in this way helps address affordability challenges while maximising renovation impact.

On top of the above, as a policy option, a shadow regulation can complement the targeted incentives, support schemes, and market-based instruments by establishing a clear long-term regulatory framework that defines future minimum performance requirements. With “shadow” regulation we mean obligations to implement certain no-regret low-cost measures or to achieve certain building energy efficiency standards at a certain point in time if until then no voluntary action has taken place, in spite of targeted interventions. These obligations may be triggered by transactions like selling or inheriting a building. While financial incentives and carbon pricing encourage voluntary action in the near term, the shadow regulation provides a credible signal that progressively higher standards will become mandatory over time. This combination strengthens investment certainty, encourages early adoption of efficient and low-carbon solutions, and helps ensure that short-term incentives contribute to a predictable and cost-effective long-term transition pathway. Of course, any such measures would need appropriate safeguards for affordability, proportionality, vulnerable households and national legal frameworks.

The effectiveness of these interventions depends on how well they are combined and tailored to different homeowner needs. Therefore, we matched them with the distinct barriers and contexts of each homeowner profile to maximise renovation uptake and depth. This is synthesised in Figure 11 below. While implementation should reflect national market conditions and policy environments, the underlying homeowner needs and barriers are broadly consistent across countries. The result is a set of intervention strategies that can be applied across markets.

Figure 11: Key intervention strategies across homeowner profiles



5. Aligning net zero ambition with real world feasibility

The 2025 white paper showed that current and policy-driven decarbonisation rates remain insufficient to align the residential building stock with a net zero pathway. Its policy scenario assumed full compliance with national measures in place up to 2026, without factoring in the 2024 EPBD revision. Even under that policy scenario, with renovation rates increasing to around 2% annually by 2030, mainly through medium-depth upgrades, limited deep renovations and a heat pump share of roughly 45% of new heating systems by 2030, the pathway still fell short of the net zero scenario used in that publication.

This paper provides an indicative quantification of what targeted homeowner interventions could potentially add in the three case-study markets, drawing on preliminary insights from draft National Building Renovation Plans, building-level cost-optimal modelling and the homeowner profiles developed in sections 2-4. This is aligned with the purpose of this study: to assess the part of the transition where renovation outcomes are directly shaped by homeowner decisions. The segmentation-based renovation package mapping is therefore applied to owner-occupied SFH and, more cautiously, to SMFH where engagement with owner-occupiers could help secure a collective whole-building decision. The remainder of the residential stock continues to follow the policy assumptions referenced in the 2025 white paper.

To estimate the potential impact on CO_2 efficiency, we defined annual renovation uptake rates for each homeowner profile and renovation package under two cases: “no additional targeted action” and “additional targeted action”. These rates are expert assumptions, not outputs from a behavioural model. They reflect an expert assessment of what uptake could plausibly look like if current decision patterns broadly continued, compared with what could become feasible if a really well-functioning, targeted intervention system addressed the specific barriers of each homeowner profile. Implementing such a targeted intervention system will need substantial effort and collaboration between different stakeholders, as elaborated in the 2025 white paper. The “additional targeted action” case therefore builds on the intervention strategies described in Figure 11, translating them into indicative uptake assumptions for Packages L, M and H. These are inherently optimistic, as they assume a well-functioning targeted intervention system. The resulting rates are used as inputs for the BEAM tool, whose application and wider assumptions remain aligned with the 2025 white paper.

The assumed renovation rates are presented in Table 5. The higher rates in the additional targeted action case are driven mainly by increased uptake of low- and medium-intensity packages, rather than by a broad shift towards Package H. This is important for interpreting the results: more floor area is addressed, but through a renovation mix that remains realistic in terms of investment needs, construction activity and disruption. The rates should therefore be read as transparent scenario assumptions, not as forecasts or values calibrated to obtain alignment with the 2025 net zero pathway.

The difference between the two cases indicates the potential additional impact of better-targeted homeowner interventions within the part of the stock where the segmentation-based approach can be meaningfully applied. Since this targeted assessment is not a full update of the 2025 stock-level pathway, the results should not be interpreted as a like-for-like update of the trendlines from the previous paper.

Table 5: Assumed annual uptake rates of the unrenovated building stock of the identified renovation packages for "no additional targeted action" and "additional targeted action" cases, by homeowner profile, used as an input to the BEAM model

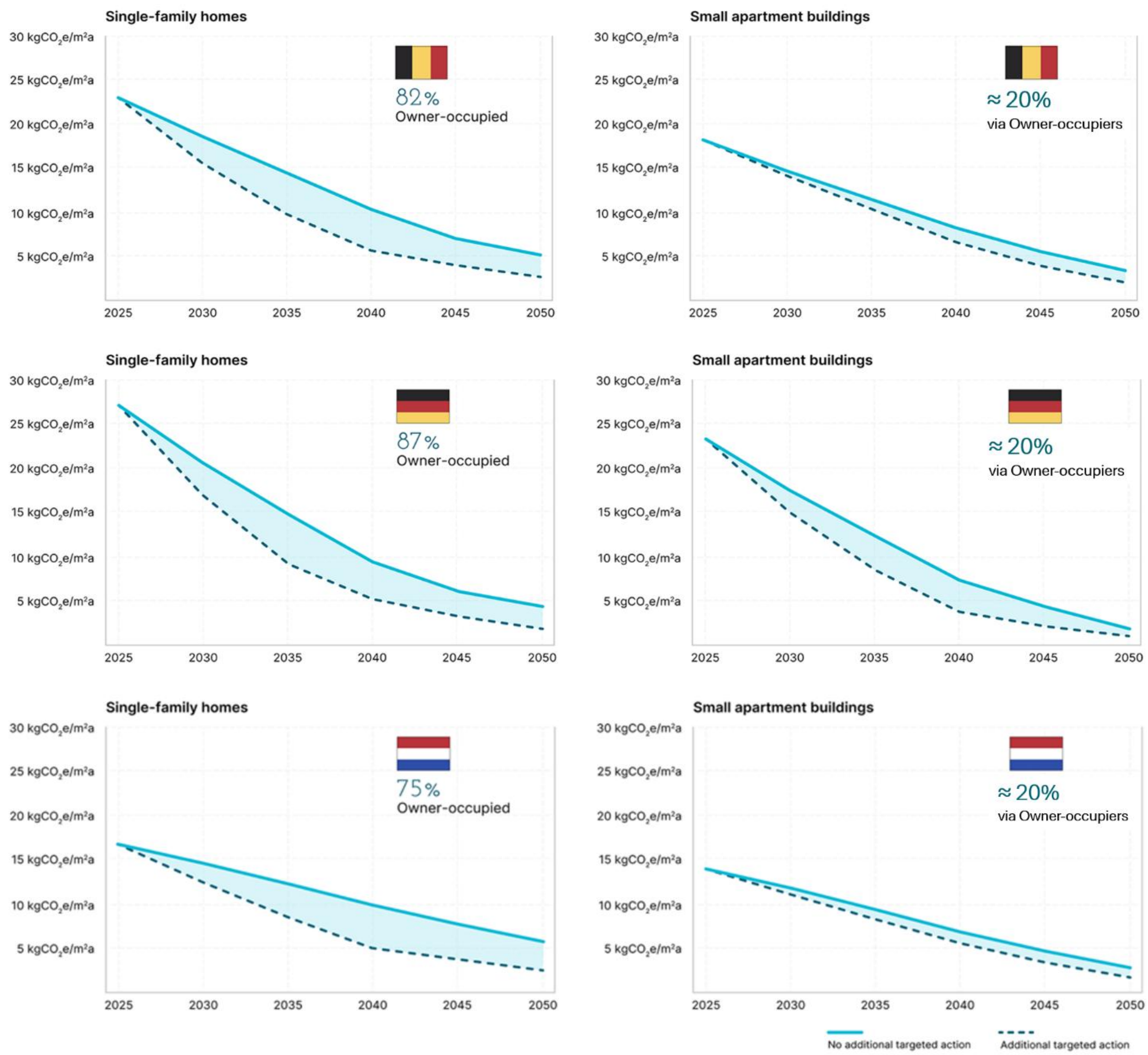
Homeowner profile	No additional targeted action	Additional targeted action
Self-starting renovators	• Package L: 5% • Package M: 2% • Package H: 0.5%	• Package L: 2.5% • Package M: 5% • Package H: 1%
Renovators requiring targeted support	• Package L: 1.5% • Package M: 0.25%	• Package L: 4.5% • Package M: 0.5%
Willing but limited renovators	• Package L: 1% • Package M: 0.5% • Package H: 0.1%	• Package L: 0.5% • Package M: 5% • Package H: 1%
Hard-to-reach renovators	• Package L: 0.5% • Package M: 0.25% • Package H: 0%	• Package L: 2% • Package M: 2.5% • Package H: 0.1%
Already-on-track renovators	• Package L: 3% • Package M: 0.5%	• Package L: 6% • Package M: 1%

The results are shown separately for each case-study country and for two building categories: single-family homes and small apartment buildings. These categories are shown because they are the building types assessed in the package analysis and because the segmentation-based intervention logic is applicable to part of each category. The graphs show emission-intensity pathways for the share of each building category that can be reached through segmentation-based interventions, while the percentages indicate the size of that reachable share within the full building category. In Figure 12, the blue line represents the "no additional targeted action" case, while the green line shows the "additional targeted action" case. The vertical axis indicates annual emissions intensity per unit floor area, and the horizontal axis covers the period from 2025 to 2050.

The potential impact of targeted solution offerings is represented by the difference between the "no additional targeted action" and "additional targeted action" curves. The curves show the emissions-intensity pathways for the share of each building category considered reachable through homeowner-targeted interventions. For SFH, this share comprises all owner-occupied dwellings. For SMFH, it comprises the estimated share of all dwellings in buildings where targeted engagement with owner-occupiers can help secure a collective whole-building renovation decision.

The size of this effect depends on two factors: the assumed renovation uptake rates by homeowner profile and package shown in Table 5, and the energy and emissions impact of applying these packages to the building archetypes.

Figure 12: Indicative emission-intensity pathways for the share of single-family homes and small apartment buildings that can be reached through targeted engagement with owner-occupiers, comparing scenarios with and without additional homeowner profile-based interventions by country and building category[16]



[16] Dwelling and owner-occupancy shares are derived from Eurostat Census 2021 data. For SFH, the percentages represent all owner-occupied dwellings. For SMFH, a cautious estimate of 20% of all dwellings is used across the three countries. This includes rented dwellings in buildings where targeted engagement with owner-occupiers is assumed to help secure a collective whole-building renovation decision. The 20% value is a scenario assumption, not an observed statistical share, and is considerably more uncertain than the SFH percentages.

The analysis demonstrates that targeted interventions for distinct homeowner profiles have the potential to unlock substantial additional decarbonisation. This impact materialises early in the transition pathway, with the curves diverging soon after the intervention assumptions take effect, highlighting the importance of timely engagement. If homeowner decisions are not supported early enough, part of the available impact may be lost because homeowners either do not act or choose less effective renovation steps.

The higher pre-renovation emission intensity of SFHs, together with the much larger number of dwellings and floor area that can be addressed directly through owner-occupiers, supports a strong focus on this segment. For small ABs, the results underline the need for dedicated collective-action solutions as individual homeowners cannot decide on whole-building renovations alone.

Comparing these findings with the policy scenario from the 2025 white paper provides additional context. The “no additional targeted action” case decarbonises more slowly than the earlier policy scenario, which is plausible because the earlier scenario assumed full implementation of policy measures, while the new scenario introduces a more granular view of homeowner uptake. The “additional targeted action” case generally improves on the policy scenario, showing that well-designed solution offerings can potentially unlock additional progress beyond what would be expected from policy implementation alone. The results should therefore be interpreted as indicative scenario evidence of the value of better aligning renovation packages with homeowner realities and intervention strategies.

6. Putting people first: Feasible renovation approaches

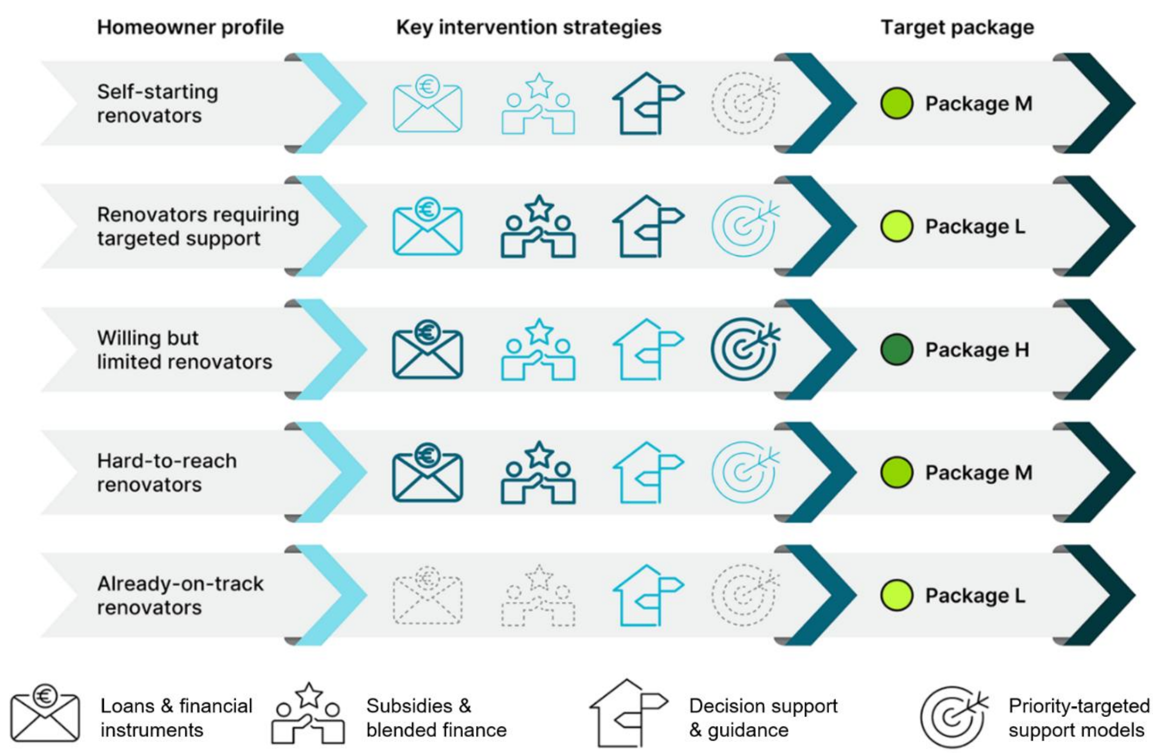
This white paper addresses a fundamental challenge in residential decarbonisation: the gap between policy ambition, technical potential and real-world action. The analysis shows that this gap cannot be closed by technical optimisation alone. Scaling residential decarbonisation depends on aligning viable renovation solutions with how homeowners make decisions in practice, and what they are able and willing to act on. Since renovation decisions are shaped by financial and affordability constraints, risk perceptions, competing priorities and implementation complexity, even economically viable solutions remain underused when they do not fit real-world decision contexts.

Grounding residential decarbonisation in homeowner realities

This paper shows that economically meaningful renovation packages already exist across building types and markets. For older buildings, medium-intensity packages often deliver the strongest balance between investment and lifecycle costs, while for newer buildings, more limited interventions capture most benefits. These findings define the renovation options that make the most sense economically but do not determine uptake.

What determines uptake is homeowner diversity. Homeowners differ significantly in their need, ability and motivation to act, as well as in structural constraints such as collective decision-making. Linking economic performance with these realities reveals a persistent "decision gap": a disconnect between viable renovation options and their adoption in practice.

Figure 13: Key intervention strategies to connect homeowners and renovation packages



The scenario analysis confirms that closing this gap, through targeted intervention, can materially accelerate emissions reductions. **The implication is clear: the route to scale is not to optimise solutions further, but to improve the conditions under which different homeowner groups choose and implement them.**

Figure 13 depicts how different homeowners require distinct combinations of solution offerings to move to effective renovation outcomes. The relative importance of these intervention strategies is illustrated through shades of blue, highlighting that the target renovation packages differ across homeowner profiles.

This does not reduce the need for ambitious building-stock decarbonisation; it clarifies how ambition can be translated into action. The revised EPBD and national renovation frameworks create a stronger direction of travel for improving building performance over time. The question is how these expectations can be implemented in ways that homeowners can realistically respond to. Segmentation helps identify where deeper renovation is justified and feasible, where staged or medium-intensity packages are more likely to unlock action, and where today's measures need to be sequenced so that future decarbonisation steps remain possible. **It is therefore not a case for lower ambition, but a way to make ambitious policy, finance and implementation strategies more actionable.**

Consideration should nevertheless be given to the long-term implications of staged renovation approaches. While commencing with "no-regret" measures may improve affordability and increase initial uptake, there is a risk that buildings requiring substantially higher energy performance levels in the future may ultimately face higher overall renovation costs if deeper interventions are deferred. Future labour and material cost inflation, repeated mobilisation costs, and additional disruption associated with multiple renovation cycles may reduce the economic benefits of a purely incremental approach. Policymakers should therefore consider how short-term affordability objectives can be balanced against the potential long-term benefits of undertaking more comprehensive renovations at an earlier stage.

Turning ambition into action: what policymakers and financial institutions can do

The key point is not to introduce entirely new instruments, but rather to deploy existing ones more effectively. Policies, subsidies, financing instruments and advisory services are widely available, yet their impact remains limited when applied in a generic, one-size-fits-all manner. What is required instead is a more precise, targeted and integrated use of these tools, grounded in how homeowners actually make decisions.

For policymakers, this means moving beyond uniform policy design towards approaches that explicitly account for differences in financial capacity, risk tolerance and decision context. Success should not be defined by whether governments design renovation pathways that are cost-optimal in theory, but by whether they are adopted in practice based on homeowners' financial and technical constraints. In this context, policymakers should:

- Direct support to the homeowner segments where barriers are most pronounced.
- Design and enable staged renovation pathways for various building types and homeowner segments that can be shared in policy frameworks that align with real-life triggers such as equipment replacement or life-cycle events.
- Such pathways should commence with no regret measures, that improve the TCO, energy

savings, and environmental impact. They should become more ambitious over time, for example including minimum energy performance standards.

- Addressing structural constraints, particularly in multi-family buildings where decision-making is shared, is equally critical.
- Sustain consistent subsidies and scale blended finance instruments, as public support remains essential to reduce investment risk and to mobilise private capital at scale.

Financial institutions can play a complementary role in enabling action at the customer interface. In many cases, financing availability is not the primary constraint; rather, complexity, uncertainty and process-related frictions prevent action. Increasing uptake therefore depends on financial institutions:

- Combining financing with guidance, sequencing and delivery support, and embedding lending within more integrated customer journeys.
- This also requires moving away from standardised products towards solutions that are tailored to distinct homeowner situations, ensuring that financial offerings are closely aligned with individual decision contexts.
- Continue to engage with governments and multilateral organisations on the design of blended finance instruments that can benefit the market.
- Share best practice and challenges in terms of which solutions and aspects of solutions are proving most effective.

Enabling homeowner decisions at scale

Taking these insights together, the key implication is clear: accelerating residential decarbonisation depends on enabling decisions, not just defining solutions. Existing tools and instruments need to be deployed more precisely and efficiently, aligned with how different homeowners make decisions in practice. This implies three shifts:

- From optimisation to adoption
- From generic solutions to targeted interventions
- From one-off transactions to staged renovation journeys

By recognising the diversity of homeowner situations and tailoring instruments to these realities, policymakers, financial institutions and market actors can move from identifying potential to enabling uptake. The practical message is clear: cost-optimality helps identify which renovation packages make economic sense; homeowner segmentation helps identify who is likely to act on them, under what conditions and with which barriers; and targeted policy, finance, guidance and delivery models help close the remaining decision gap. Delivering residential decarbonisation at the required pace and scale will depend on converting viable solutions into widespread action — helping homeowners move from awareness to decision, and from decision to implementation.

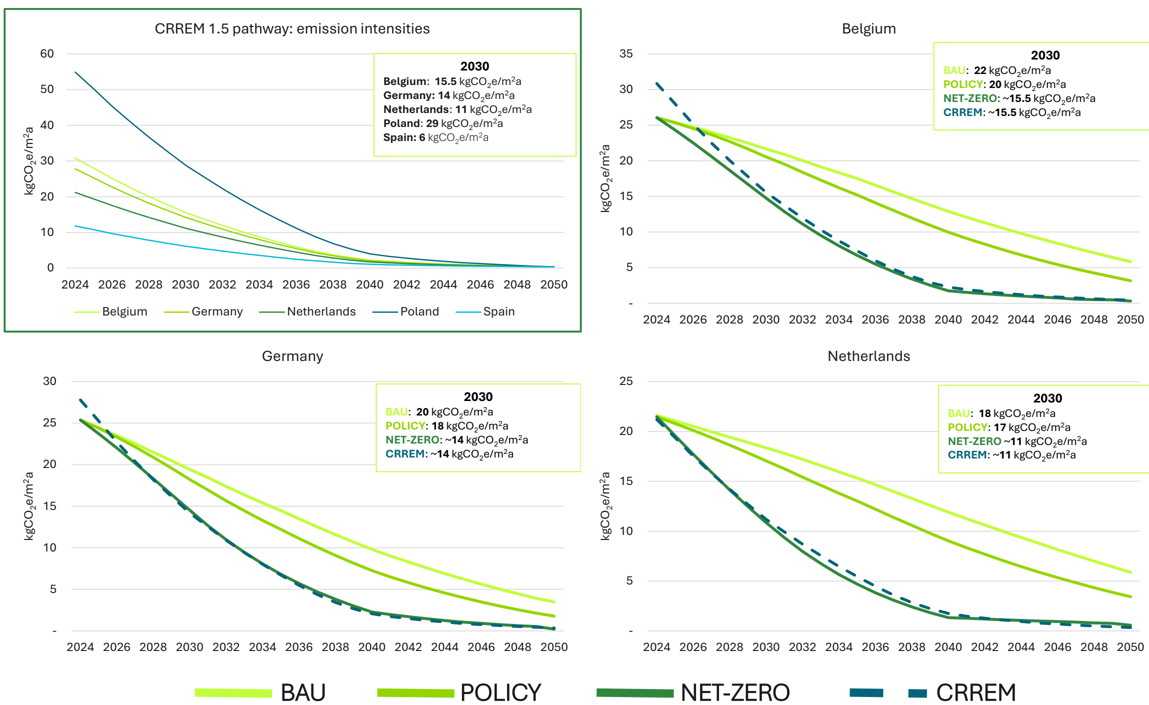
Appendix 1: Summary of the 2025 white paper

The 2025 publication highlighted that progress isn't constrained by a lack of solutions, but by the complexity of delivering them at scale across a fragmented and highly diverse residential sector.

In particular, the publication focused on three decarbonisation scenarios for residential building stock across five European markets as depicted in Figure 14:

1. A **business-as-usual scenario** reflecting current trends
2. A **policy scenario** assuming full implementation of existing national policies
3. A **net-zero scenario** aligned as closely as possible with a 1.5-degree pathway

Figure 14: GHG-emission intensities per scenario, modelled against the CRREM 1.5 decarbonisation pathway[17]



Comparing these scenarios revealed a growing gap between current trajectories and what would be required to reach climate neutrality by 2050. Closing this gap would require faster progress across four technical levers:

- Greening the energy supply
- Deeper renovation of building insulation
- Rapid replacement of fossil-fuel heating systems with low-emission alternatives
- Higher performance standards for new buildings

[17] Source: Decarbonising residential buildings: A multi-stakeholder journey, 2025

Appendix 2: Understanding the boundaries of the analysis

Several key assumptions shape the analysis of the best economic performance. Firstly, TCO is driven by the interaction between upfront investment costs and ongoing energy costs. Implementing more renovation measures increases the initial investment required, but it also reduces energy consumption (and, in many cases, energy costs) substantially. The resulting TCO reflects the balance between these fixed, often high upfront costs and the variable costs that decline over time as energy demand falls. Looking at both elements together is essential to understanding the real economic trade-offs that homeowners face.

Secondly, the time horizon over which costs and savings are assessed plays an important role. In line with common practice in building policy and comparable studies, the analysis considers TCO over a 30-year lifespan. This long-term perspective provides a consistent foundation for comparing renovation options across building types and countries. At the same time, it's important to recognise that individual homeowners may not remain in the same home for the full 30-year-period–in fact, across the case study countries, homeowners only live in the same home for 10-22 years on average, although this figures is significantly longer for owner-occupiers (22-35 years).[18] In addition, the analysis does not quantify potential increases in property value resulting from renovation, although these may be relevant to homeowners with shorter expected occupancy periods.

To reflect these realities, the analysis also considers simple payback periods: the point at which reduced energy costs offset the upfront investment. This provides a more intuitive indication of when homeowners may start to see direct financial benefits. For this simple payback calculation, energy costs are held static over time. This reflects a simplified homeowner decision logic and keeps the payback comparison transparent across renovation packages. Financing costs, such as interest on renovation loans, are not included. The resulting payback periods should therefore be read as simplified indicators, not as forecasts of future household energy expenditure.

While these results identify economically-optimal renovation scenarios, they do not indicate whether these scenarios will be adopted in practice. This depends on how different homeowners perceive costs, benefits and implementation challenges.

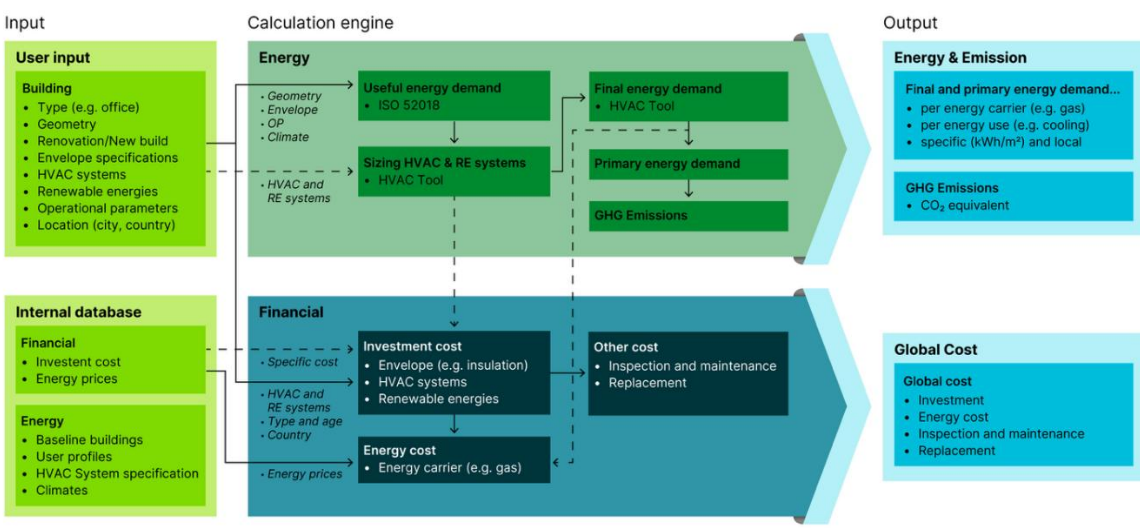
[18] Source: OECD (2021). *Housing Policy Toolkit – Country Housing Profiles (Germany, Belgium, Netherlands)*. OECD. https://housingpolicytoolkit.oecd.org

Appendix 3: The Building Energy Performance (BEP) Tool

The Building Energy Performance (BEP) Tool is an integrated energy, environmental and economic assessment model for the assessment of individual reference buildings developed by Guidehouse. It's part of the Built Environment Analysis Model (BEAM2) suite and has been applied extensively in EU-level analytical work, including studies supporting the revision of the Energy Performance of Buildings Directive (EPBD) and related impact assessments conducted for the European Commission. The BEP tool combines detailed information on building configuration with an internal, harmonised database to assess building performance across three dimensions: energy use, GHG emissions and global costs. Outputs are provided in a structured and transparent format, enabling consistent comparison across building types, scenarios and Member States.

Energy performance calculations follow internationally recognised standards, notably ISO 52016-1:2017 for the determination of useful energy demand for space heating and cooling. Based on key parameters related to building characteristics, technical systems and climatic conditions, the tool derives policy-relevant energy demand and performance indicators in a consistent manner. Final energy demand is calculated by modelling the performance and sizing of HVAC systems and on-site renewable energy technologies in line with established efficiency and operational assumptions. Primary energy demand is derived using country-specific, dynamic primary energy factors, while GHG emissions are calculated by applying corresponding dynamic emission factors, with results expressed in CO_2-equivalent terms. The economic module assesses energy-related costs over the calculation period, including energy and GHG-related expenditures as well as investment, maintenance, inspection and replacement costs. Investment costs for on-site renewable energy systems are based on harmonised assumptions, including full system costs for relevant on-site renewable technologies, ensuring consistency across building types and Member States.[19]

Figure 15: Visualisation of BEP tool, showing inputs, calculation steps and outputs



[19] Main sources for investment costs: BKI, baupreise.de, Kostenkentallen, Livios, JRC: Assessing Nearly Zero Energy Buildings (NZEBs) development in Europe

Appendix 4: Reference building characteristics and assessed renovation measures

The following tables summarise the main characteristics of the reference buildings and the renovation measures assessed in the modelling.

Table 6: Reference building characteristics

Country	Building type	Floor area (m^2)	U-value: Wall (W/m^2K)	U-value: Roof (W/m^2K)	U-value: Window (W/m^2K)	U-value: Floor (W/m^2K)	Heating	DHW
BE	SFH 1945-90	126	1.6	1.3	3.5	1.0	Gas cond.	Electric
BE	SFH 1990+	126	0.6	0.6	3.5	0.7	Gas cond.	Electric
BE	Small AB 1945-90	503	1.7	1.9	5.0	0.9	Gas cond.	Electric
DE	SFH 1945-90	111	1.4	1.3	3.7	1.3	Gas cond.	Electric
DE	SFH 1990+	111	0.4	0.3	2.0	0.4	Gas cond.	Electric
DE	Small AB 1945-90	405	0.6	1.2	3.0	1.0	Gas cond.	Electric
NL	SFH 1945-90	126	0.6	0.6	5.2	0.6	Gas cond.	Combi
NL	SFH 1990+	126	0.4	0.4	2.9	0.4	Gas cond.	Combi
NL	Small AB 1945-90	503	0.6	0.6	5.2	1.3	Gas cond.	Combi

Table 7: Assessed renovation measures

Country	Building type	U-values: Wall (W/m^2K)	U-values: Roof (W/m^2K)	U-values: Window (W/m^2K)	U-values: Floor (W/m^2K)	Heating and DHW	PV	Battery storage
BE	SFH 1945-90	1: 0.24 2: 0.20	1: 0.24 2: 0.20	1: 1.5 2: 1.3 3: 0.9 4: 0.7	1: 0.30 2: 0.24	A-W-HP Biomass DH Gas Hybrid-HP	5 kWp	n/a
BE	SFH 1990+	1: 0.24 2: 0.20	1: 0.24 2: 0.20	1: 1.5 2: 1.3 3: 0.9 4: 0.7	1: 0.30 2: 0.24	A-W-HP Biomass DH Gas Hybrid-HP	5 kWp	n/a
BE	Small AB 1945-90	1: 0.24 2: 0.20	1: 0.24 2: 0.20	1: 1.5 2: 1.3 3: 0.9 4: 0.7	1: 0.30 2: 0.24	A-W-HP; Biomass DH Gas Hybrid-HP	18 kWp	n/a

Country	Building type	U-values: Wall (W/m^2K)	U-values: Roof (W/m^2K)	U-values: Window (W/m^2K)	U-values: Floor (W/m^2K)	Heating and DHW	PV	Battery storage
DE	SFH 1945-90	1: 0.24 2: 0.20	1: 0.24 2: 0.20	1: 1.3 2: 1.1 3: 0.9	1: 0.30 2: 0.24	A-W-HP Biomass DH Gas Hybrid-HP	5 kWp	4 kWh
DE	SFH 1990+	1: 0.24 2: 0.20	1: 0.24 2: 0.20	1: 1.3 2: 1.1 3: 0.9	1: 0.30 2: 0.24	A-W-HP Biomass DH Gas Hybrid-HP	5 kWp	4 kWh
DE	Small AB 1945-90	1: 0.24 2: 0.20	1: 0.24 2: 0.20	1: 1.3 2: 1.1 3: 0.9	1: 0.30 2: 0.24	A-W-HP Biomass DH G-HP Gas Hybrid-HP	15 kWp	12 kWh
NL	SFH 1945-90	1: 0.21 2: 0.15 3: 0.30	1: 0.16 2: 0.10	1: 1.3 2: 1.1 3: 0.9	1: 0.27 2: 0.24	A-W-HP Biomass DH G-HP Gas Hybrid-HP	5 kWp	4 kWh
NL	SFH 1990+	1: 0.21 2: 0.15 3: 0.30	1: 0.16 2: 0.10	1: 1.3 2: 1.1 3: 0.9	1: 0.27 2: 0.24	A-W-HP Biomass DH G-HP Gas Hybrid-HP	5 kWp	4 kWh
NL	Small AB 1945-90	1: 0.21 2: 0.15 3: 0.30	1: 0.16 2: 0.10	1: 1.3 2: 1.1 3: 0.9	1: 0.27 2: 0.24	A-W-HP Biomass DH G-HP Gas Hybrid-HP	18 kWp	16 kWh

Legend:
1 = Renovation in line with minimum country-specific EPBD requirements
2–4 = Renovation beyond these minimum standards
A-W-HP = Air-to-water heat pump
Biomass = Biomass boiler
DH = District heating
G-HP = Ground-source heat pump
Hybrid-HP = Hybrid heat pump
Gas = Gas condensing boiler
Electric = Electric DHW system
Combi = Combined space-heating and DHW system

Appendix 5: Comparing actual energy use with EPC-based estimates

EPC ratings are based on asset-based calculations that reflect the building's theoretical "as built" performance, rather than actual user behaviour. As a result, calculated energy consumption is often significantly higher than measured consumption in practice. This discrepancy is particularly pronounced in Belgium. When renovation measures are evaluated against inflated baseline values, the resulting savings can become unrealistic. In some cases, calculated savings may even exceed the building's real energy use, making the results misleading and unsuitable for investment or policy assessment.

The BEP tool addresses this issue by applying more realistic consumption patterns that are better aligned with observed usage. By calibrating demand assumptions to typical operational behaviour, the tool derives energy savings that more closely reflect what can realistically be achieved in practice, rather than overstated theoretical potentials.

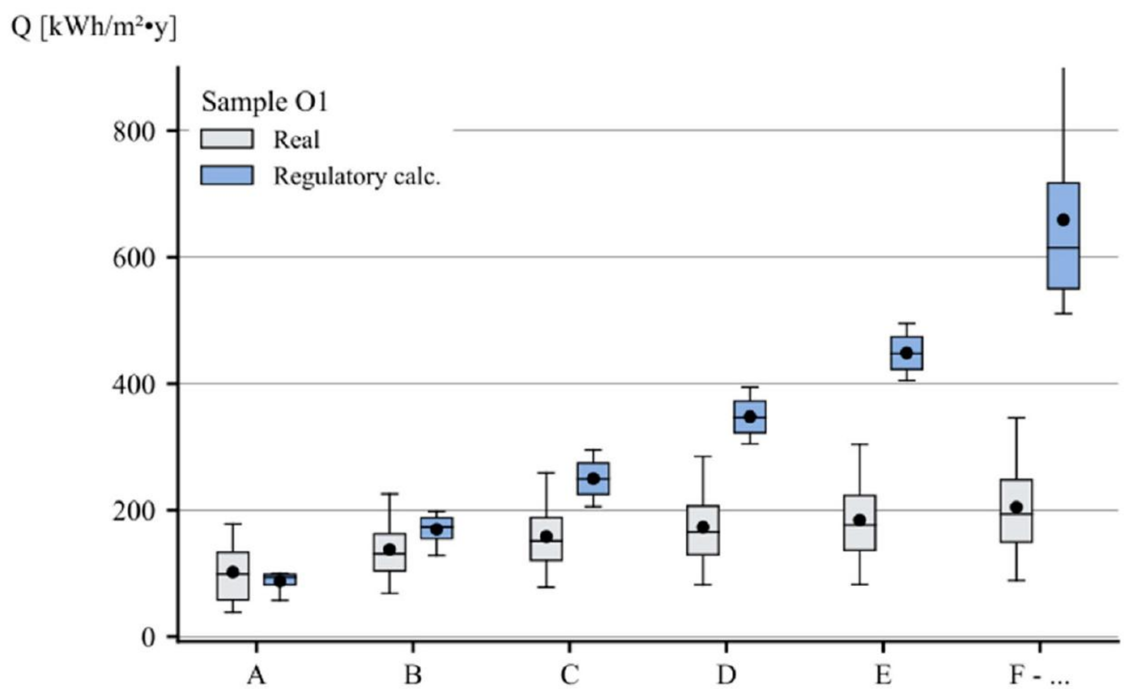
Importantly, these calibration parameters are only applied at higher demand levels, where the discrepancy between EPC-based demand and real consumption is most pronounced. Once buildings are renovated and energy demand is reduced, the BEP tool no longer applies this adjustment, as the calculated demand already falls within a realistic range. This ensures that post-renovation consumption isn't artificially suppressed.

Without the BEP upper-boundary constraints, savings derived from asset-based EPC calculations would remain systematically overestimated. The BEP methodology therefore provides a more credible and investment-relevant assessment of renovation impacts by preventing the calculation of unrealistically high savings, and aligning results with actual building use.

The discrepancy between real and calculated energy use is well-known. For example, a 2022 paper, *Large-scale statistical analysis and modelling of real and regulatory total energy use in existing single-family houses in Flanders*, finds that the energy use corresponding to an individual energy label is generally overestimated, in some cases by up to 200%.[20] Their findings are presented in the figures below, and may be used to connect energy labels to the energy consumption values in this report.

[20] Large-scale statistical analysis and modelling of real and regulatory total energy use in existing single-family houses in Flanders: Building Research & Information: Vol 51 , No 2 - Get Access

Figure 16: Real and regulatory calculated annual total primary energy use per m2 in Flemish single-family houses in function of the EPC-label.



It should also be noted that, by using values more closely aligned with real energy use, the analysis finds lower cost and energy savings for renovation measures than it would if EPC-based values were used directly. This was also quantitatively shown in a publication by the German Environment Agency[21]. Nonetheless, the analysis still shows that substantial renovation packages can deliver significant real-world energy and emissions reductions, while the cost-effective depth of renovation depends on building type, starting condition and package composition.

[21] Realitätsnahe Berechnung des Energiebedarfs, 2022. www.umweltbundesamt.de

Appendix 6: Homeowner segmentation and demographics

The following tables provide country-specific demographic evidence for the five homeowner profiles used in this report. The data draws on the three national segmentation datasets described in section 3.

Each dataset contains 10 or 11 underlying homeowner segments, which were classified into one of the five homeowner profiles through a holistic assessment of their characteristics. The demographic values presented in the tables are aggregated from the underlying segments assigned to each profile. The variables differ slightly across countries, depending on data availability.

Belgium homeowner profile demographics

Table 8: Demographics of the Belgian dataset (Dividuals®, Sirius Insights) consisting of 10 segments. Homeowners and renters are not separated in the segmentation.

Variable	Unit	Self-starting renovators	Requiring targeted support	Willing but Limited	Hard-to-reach	Already-on-track
% of population	% of total population	12%	18%	23%	21%	26%
% homeowners	% of segment	78%	66%	49%	61%	71%
Household income	EUR per month	€3,768	€3,474	€2,859	€3,144	€3,595
Age (0-39)	% of segment	43%	47%	53%	47%	47%
Age (40-59)	% of segment	27%	27%	25%	25%	27%
Age (60+)	% of segment	29%	26%	22%	27%	26%
Dominant building type(s)		SFH	RH / SFH	AB / RH	AB / RH	SFH / 2FH
Dwelling surface	m^2	171	139	108	113	150
EPC labels A-B	% of segment	3%	19%	30%	16%	6%
EPC labels C-D	% of segment	18%	38%	43%	38%	30%
EPC labels >E	% of segment	79%	43%	27%	46%	64%
Central heating	% of segment	75.0%	76.1%	67%	76%	73.5%
Heat pump	% of segment	16.1%	13.3%	12%	10%	16.3%
Solar panels	% of segment	47.3%	35.3%	20%	24%	38.8%

SFH = Single-family home
2FH = Two-family home
RH = Row home
AB = Apartment building

Germany homeowner profile demographics

Table 9: Demographics of the German dataset (Sozial Klimarat) consisting of 16 segments, of which 10 are homeowner segments. Renters are not included in the analysis.

Variable	Unit	Self-starting renovators	Requiring targeted support	Willing but Limited	Hard-to-reach	Already-on-track
% of population	% of total population	6%	4%	10%	10%	13%
Income	EUR per month	€4325	€2127	€2361	€1858	€3165
Age (18-39)	% of segment	13%	14%	14%	11%	14%
Age (40-59)	% of segment	31%	34%	32%	30%	31%
Age (60+)	% of segment	56%	53%	55%	59%	55%
Dominant building type(s)		SFH / 2FH	SFH / 2FH	RH / AB	SFH / 2FH	SFH / 2FH
Construction year: 1945-1990	% of segment	100%	43%	72%	100%	33%
Construction year: 1990+	% of segment	0%	57%	28%	0%	67%
Urban	% of segment	50%	43%	73%	36%	38%
Rural	% of segment	50%	57%	27%	64%	62%
Energy source	% of segment	61% gas/ 39% oil	31% gas / 11% oil / 57% night storage	82% gas/ 18% oil	56% gas/ 44% oil	31% gas/ 9% oil/ 25% HP/ 34% pellet
Energy demand	kWh/m^2	131	111	121	135	102

Netherlands homeowner profile demographics

Table 10: Demographics of the Dutch dataset (Whize, TDA Analytics) consisting of 11 segments, of which seven are predominantly homeowner segments. Segments that are predominantly renter segments are not included in the analysis.

Variable	Unit	Self-starting renovators	Requiring targeted support	Willing but Limited	Hard-to-reach renovators	Already-on-track
% of population	% of total population	3%	15%	5%	27%	9%
% homeowners	% of segment	88%	88%	67%	100%	97%
Income	Annual salary in EUR	€203,072	€131,643	€91,752	€104,231	€181,436
Age (18-39)	% of segment	16%	6%	50%	10%	38%
Age (40-59)	% of segment	16%	9%	28%	13%	37%
Age (60+)	% of segment	68%	84%	23%	70%	25%
Dominant building type(s)		SFH / 2FH	SFH / 2FH / AB	AB	RH	SFH / 2FH / RH
Construction age: <1945	% of segment	40%	29%	41%	14%	18%
Construction age: 1945-1990	% of segment	21%	33%	35%	61%	26%
Construction age: 1990+	% of segment	39%	37%	23%	25%	56%
Floor area	m^2	207	151	80	128	155
EPC labels A-B	% of segment	47%	42%	37%	31%	63%
EPC labels C-D	% of segment	20%	27%	33%	47%	22%
EPC labels E-H	% of segment	34%	31%	30%	22%	15%
Average energy consumption	Total kWh	4234	3274	2062	2794	3366
Heat Pump	% of segment	19%	15%	2%	7%	14%
Solar panels	% of segment	50%	48%	18%	48%	64%
Willingness to renovate	% that report to be 'willing'	34%	27%	44%	33%	30%

Appendix 7: Solution offerings

Loans and other financial instruments

Financial instruments to improve affordability help address upfront renovation costs and improve investment attractiveness. They aim to make renovation options more accessible by improving financing conditions and aligning financial terms with energy performance improvements. Common approaches include:

- **Green mortgages**, where preferential terms, such as lower interest rates or improved affordability, are linked to the energy performance of a property.[22]
- **"Green top-ups"**, which provide additional borrowing specifically earmarked for energy-efficient home improvements at better rates than standard consumer credit.[23] For instance, Nationwide offers a "0% Green Additional Borrowing" mortgage top-up at 0% fixed interest. This additional financing is strictly conditional on being used for energy-efficiency improvements, such as solar panels, insulation, or heat pumps.[24]
- **Cashback and reward schemes**, where homeowners receive funds back after completing eligible renovation measures.[25] For example, Halifax's "Green Living Reward" provides cashback linked to specific home improvements, such as heat pumps, solar installations, and other eligible measures.[26]
- **Concessional finance**, offering below-market terms such as low-interest rates or deferred repayments for specific segments.[27]

Subsidies and blended finance

In many cases, private financing alone isn't sufficient to unlock renovation uptake, particularly for homeowners with limited borrowing capacity. Public support and blended financing mechanisms therefore play a critical role in closing funding gaps and enabling investment, especially in cases where deeper renovation is economically viable in the long term, but difficult to realise due to upfront affordability constraints. They also serve an important de-risking function which can reduce uncertainty around payback, performance and timing. Key mechanisms include:

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[22] Source: Green Finance Institute, Green Mortgages: https://www.greenfinanceinstitute.com/products-solutions/green-mortgages/
[23] Source: Which, Green mortgages: https://www.which.co.uk/money/mortgages-and-property/mortgages/types-of-mortgage/green-mortgages-aHAck0T6dCr8
[24] Source: Nationwide, Green Additional Borrowing: https://www.nationwide.co.uk/mortgages/borrowing-more/green-additional-borrowing/
[25] Source: Halifax, Green living offers: https://www.halifax.co.uk/mortgages/help-and-advice/green-living/green-living-offers.html
[26] Source: Creara energy experts, How to accelerate home renovations through innovative financing: https://www.beuc.eu/sites/default/files/publications/BEUC-X-2023-038_How_to_accelerate_home_renovations_through_innovative_financing.pdf
[27] Source: Vereniging Eigen Huis, Extra mortgage for sustainability: https://www.eigenhuis.nl/verduurzamen/verduurzamen-financieel/extra-hypotheek-voor-verduurzaming

- **Grants and subsidies** that reduce upfront investment–e.g. through tax relief or grants for energy-efficient renovation measures–and significantly improve payback periods.[28] An example is the MaPrimeRénov' scheme, France's main state aid for energy renovation, which is based on the renovation and the homeowner's income.[29] Germany's federal BEG scheme is another example of grants and subsidised loans for energy-efficient buildings and renovation projects.[30]
- **Subsidised public loans**, often with longer maturities and favourable conditions, such as fixed-rate lending for energy-saving measures. As an example, the Dutch government offers public interest-free loans for energy-saving measures to low- and middle-income homeowners.[31]
- **Grant + loan "stacking"**, where banks complement public subsidies with additional financing to cover residual costs.[32] For instance, both the MaPrimeRénov' in France and the BEG scheme in Germany are designed to be combined with other public aids, allowing lenders to structure complementary products to cover remaining financing needs.

Decision support and guidance

Even when financially viable, renovation is often still constrained by complexity and lack of clarity. Simplifying the customer journey is therefore essential. This is where integrated platforms are key: by combining advice, cost estimates, financing options, and access to contractors in a single, coherent offering, they reduce effort, uncertainty and fragmentation, and make renovation more manageable from the homeowner perspective. Effective approaches include:

- **One-stop-shop models**, integrating technical, administrative, and financial services in a single hub for homeowners to help navigate everything from cost estimates to contractor coordination and subsidy applications.[33] Examples include the FOSSTER LIFE project in

[28] Source: Economidou, M. et al. (2019), Accelerating energy renovation investments in buildings: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC117816/accelerating_energy_renovation_investments_in_buildings.pdf
[29] Source: France Rénov, MaPrimeRénov' L'aide à la rénovation énergétique: https://france-renov.gouv.fr/aides/maprimerenov
[30] Source: KFW, Bundesförderung für effiziente Gebäude (BEG): https://www.kfw.de/inlandsfoerderung/Bundesf%C3%B6rderung-f%C3%BCr-effiziente-Geb%C3%A4ude/
[31] Source: Government of the Netherlands, €750 million extra for National Heat Fund: https://www.rijksoverheid.nl/actueel/nieuws/2025/05/19/%E2%82%AC-750-miljoen-extra-voor-nationaal-warmtefonds
[32] Source: ING, Federal Funding for Efficient Buildings (BEG): https://www.ing.de/wissen/bundesfoerderung-fuer-effiziente-gebaeude/
[33] Source: Economidou, M. et al. (2019), Accelerating energy renovation investments in buildings: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC117816/accelerating_energy_renovation_investments_in_buildings.pdf

Flanders and the municipal energy advisers in Denmark, which guide citizens through their first steps and connect them with certified professionals.[34] [35]

- **Bundled offers**, combining financing with assessments or services, for example by offering free or discounted EPC or energy assessments together with other financing support and contractor coordination to reduce transaction efforts.
- **Process facilitation**, such as banks or intermediaries handling grant applications or administrative steps. For instance, in Germany, ING applies for KfW funding on behalf of the customer and handles the entire administrative process, including the paperwork.[36]
- **Advisory services**, which help identify the most suitable renovation package and financing support.[37]

Priority-targeted support models

Solution offerings must be targeted toward segments and buildings with the highest need and lowest ability to renovate. This is particularly relevant for homeowners facing binding affordability constraints, and buildings that are the least energy-efficient and can address both high decarbonisation potential and elevated barriers. Relevant approaches include:

- **Segment-targeted offerings**, such as income-linked loan conditions or enhanced support for low-income households (e.g. zero-interest loans for households up to a stated income threshold). For example, the Dutch National Heat Fund offers a zero-interest loan for low- and middle-income households to finance energy-saving home improvements.[38]
- **Programmes focused on worst-performing buildings**, with higher support levels for the least efficient homes. For instance, under the BEG, higher funding levels are provided for deeper renovations, thereby directing more support toward buildings requiring more substantial energy upgrades.[39]

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[34] Source: Build Up, Supporting Consumers Through Renovation: The Growing Role of One-Stop-Shops: https://build-up.ec.europa.eu/en/resources-and-tools/articles/supporting-consumers-through-renovation-growing-role-one-stop-shops
[35] Source: Euroconsumers, HORIS One Stop Shops: https://www.euroconsumers.org/horis-one-stop-shops/
[36] Source: ING, Federal Funding for Efficient Buildings (BEG): https://www.ing.de/wissen/bundesfoerderung-fuer-effiziente-gebaeude/
[37] Source: UK Calculator, Green Mortgage Calculator UK 2026: https://ukcalculator.com/green-mortgage-calculator.html
[38] Source: Government of the Netherlands, €750 million extra for National Heat Fund: https://www.rijksoverheid.nl/actueel/nieuws/2025/05/19/%E2%82%AC-750-miljoen-extra-voor-nationaal-warmtefonds
[39] Source: KFW, Federal Funding for Efficient Buildings (BEG): https://www.kfw.de/inlandsfoerderung/Bundesf%c3%b6rderung-f%c3%bcr-effiziente-Geb%c3%a4ude/