Literature review of the energy efficiency gap

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Executive Summary

The European Commission aims at making the European society and economy climate neutral by 2050. Improving the energy efficiency of the European building stock is a cornerstone in this transformation. Hence, the Commission has proposed a *renovation wave.* To reduce greenhouse gas emissions by 40% in all sectors of the European economy by 2030, requiring investments of up to EUR 180 billion.[1,2]

For households and companies these energy renovations can often be financially interesting; future savings due to a reduced energy bill can compensate to a certain extent the lending costs of borrowing funds to carry out the renovation. Furthermore, studies find that households often also are motivated to conduct energy renovation due to idealistic reasons, i.e. to reduce CO2 emissions caused by the household. Nevertheless, renovations rates in Europe are low, around 1% per year[3] – this dichotomy is known as the "*energy efficiency gap*".

Reviewing relevant literature, we have identified six barriers that prevent renovation rates in EU from increasing:

1. **Behavioural barriers**: First, many households and companies are simply not aware of the potential benefit of conducting an energy renovation. Integrating awareness of the benefits of energy renovations into decision processes regarding general renovations is therefore a key step. Not least because many energy renovations only become profitable when carried out together with other renovations. Roof insulation e.g. could only become profitable with a general roof renovation. Furthermore, consumers perceive the decision-making process towards energy renovations as complex and uncertain regarding the cost-effectiveness (i.e. the future reduction in energy bill and the property value increase), which further blocks renovations.
2. **Transaction costs:** The majority of these costs are related to the time spent by the consumer in relation to the organisation of the renovation, which can be a troublesome process involving many stakeholders. These include finding the right renovation solution, the right company to carry out the solution, getting the necessary approval, acquiring a loan to finance the renovation, and monitoring the company while the renovation is in process. Reciprocally, financial institutions suffer from high transaction costs as well.
3. **Financial barriers:** It is not always possible to acquire competitive finance for the renovation project – even if the renovation is profitable from a financial perspective. A common issue is that the increase in the value due to the renovation cannot be used as collateral for the loan. This gives rise to more expensive financing costs than necessary. In some cases, customers cannot even use the existing equity in the home as collateral. This means that an unsecured consumer loan is the only option, making the renovation an expensive endeavour, even though the size of such loans is usually not extraordinarily large when benchmarked against median disposable income.
4. **Data insufficiency:** There is often a lack of reliable data, both in terms of identifying for which buildings a renovation would be profitable (identifying the energy efficiency gap) but also lack

[1] EU Commission, available at https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en (accessed 28 January 2021)

[2] EU Commission Communication (2020), *A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives*

[3] See e.g. for Germany: UBA (2013), *Der Weg zum klimaneutralen Gebäudebestand. Available at https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/hgp_gebaeudesanierung_final_04.11.2014.pdf (accessed on 09.12.2020)*

of data to verify the impact of the improvement, once the renovation is completed (e.g. to acquire an updated EPC label). The lack of data is both observed at the consumer level, but also at the institutional level in advising customers, e.g. within financial institutions.

5. **Regulatory barriers:** The process of acquiring an energy efficiency label can be troublesome and not transparent in some regions. Also, the criteria for obtaining a certain rating differ widely across countries.
6. **Conflicting interests between landlord and tenant:** Whereas tenants typically favour an energy renovation in expectation of a reduced energy bill, landlords often lack incentives to renovate as normally they bear the mortgage burden. Rent regulation is often a key barrier: while tenants might benefit from a lower energy bill, the owner of the building may not be able to increase rental payments to pay for the additional investment costs. Hence, contrary to the other identified barriers, this can often be a policy failure than a market failure.

Many of these barriers are known by regulators, private market stakeholders, and a range of different initiatives are being undertaken. For example:

- Different institutions are working on providing targeted information to consumers on the benefits of renovation concretely for their building.[4]
- Several initiatives are in place to enhance data availability for consumers and lending institutions, including central national registers, real-time data on energy consumption from energy companies and the EU-funded Energy Efficiency Data Protocol & Portal (EeDaPP) under the Energy Efficient Mortgages Initiative (EEMI).
- Financial institutions and financial regulators are working to incorporating green factors in credit and capital framework, e.g. through the EEMI.

[4] See e.g. Denmark, iNudgeyou (2020), *Adfærdsindsigter inden for energimærkningsordningen*

1. MOTIVATION: THE ENERGY EFFICIENCY GAP

The European Commission aims at making the EU climate neutral by 2050.[5] Improving the energy efficiency of the European building stock is a cornerstone in this transformation. 85-95 per cent of the buildings in the EU that exist today will still be standing in 2050.[6] And most of these buildings (almost 75 per cent) are not energy efficient. Hence, the EU Green Deal proposes a *renovation wave* of the EU's public and private building stock to boost renovation investments and reduce the energy efficiency gap.[7]

Buildings' energy renovations can be broadly understood as:[8,9]

- Renovations that reduce the energy use of buildings
- Electrification of heating
- Smart energy systems

The first aspect, energy-reducing renovations such as insulation improvements or solar panels, is typically the first association to energy renovations and will likely be the focus for the next decade or so. Increased energy efficiency paves the path towards carbon neutrality. The second aspect of energy renovations, electrification of heating or shift to district heating will enable heating to be based on renewables and thus contribute to eventually achieve carbon neutrality. Finally, smart energy systems will allow for a precise monitoring of the heat and electricity consumption and reveal the energy savings potential of a building. Over the next decade, we expect that the focus will shift from energy efficiency to electrification (e.g. individual heat pumps fuelled by green energy) and smart energy systems as fossil fuel-based energy production is gradually phased out.[10]

For both households and companies such energy renovations can often be financially profitable. Future savings due to a reduced energy bill can compensate to some extent for the lending costs of borrowing the funds to carry out the renovation. However, we do not observe a level of energy renovations that matches its potential, neither in Europe[11] [12] nor globally[13]. This dichotomy is known as the *"energy efficiency gap"* and has been identified plentiful in financial and academic literature.[14] [15] [16] [17]

In the years to come, many policies targeting climate change incentivise energy efficiency investments. This means that energy renovations are expected to gradually become even more attractive going forward, and therefore, the energy efficiency gap is expected to grow. This highlights the importance to understand the energy efficiency gap and develop mitigation policies.

[5] Climate neutrality is aimed to be achieved through reduction of greenhouse gas emissions, increased use of renewable energies and increased energy efficiency.

[6] EU Commission Communication (2020), *A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives*

[7] High-Level Expert Group on Sustainable Finance, *Final Report 2018*

[8] Bertoldi et al. (2020). *How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU*

[9] Nadel (2019). *Electrification as an energy efficiency and decarbonization strategy*

[10] Nadel (2019). *Electrification as an energy efficiency and decarbonization strategy*

[11] Frauenhofer Institute (2009), *Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries. Final Report.*

[12] Statens Byggeforskningsinstitut (SBi), Aalborg Universitet (2017), *Varmebesparelse i eksisterende bygninger: Potentiale og økonomi*

[13] Worrell et al. (2009), *Industrial energy efficiency and climate change mitigation*

[14] Jaffe & Stavins (1994), The energy-efficiency gap. What does it mean?

[15] Brown (2001), *Market failures and barriers as a basis for clean energy policies*

[16] Thompson (2002), *Consumer Theory, Home Production, and Energy Efficiency*

[17] Golove & Eto (1996), *Market barriers to energy efficiency: A critical reappraisal of the rationale for public policies to promote energy efficiency*

Simultaneously, future political initiatives that increase the incentive to conduct energy renovations – e.g. subsidies, tax incentives, or fees on fossil fuel-based heating – will have a larger impact in the absence of barriers that prevent such profitable investments.

The rest of this paper is structured as follows. Drivers of consumer demand are presented in section **Error! Reference source not found.**. Barriers to energy renovations are presented in section **Error! Reference source not found.**.[18] Section **Error! Reference source not found.** lists suggestions and policies as to how to overcome the identified barriers.

2. DRIVERS OF CONSUMER DEMAND

Overall, we have identified numerous drivers for private consumers as well as companies to conduct energy renovations. These drivers can be organised in three categories: financial incentives, idealistic reasons, or simply as a by-product of other renovations.

Financial incentives

Financial incentives are often the most addressed driver for energy renovation and relate directly to the energy efficiency gap.

Energy renovations typically provide three types of financial incentives:

Firstly, energy renovations reduce energy consumption of the building leading to a reduced energy bill. Some studies find that comprehensive energy renovations typically can deliver energy savings of more than 60 per cent.[19] The financial incentive kicks in when the cost savings from reduced energy consumption outweigh the capital costs of the investment, and the undertaking is thus cost-effective.[20] [21] [22]

Secondly, an energy renovation increases the value of the building.[23] [24] A study by Copenhagen Economics on Danish data from 2016 shows that increasing the EPC label one notch typically increases the value of the building by around 4 per cent.[25] Furthermore, studies from Switzerland have shown that consumers are willing to pay 13 per cent more than the current home price for new windows, and around 7 per cent more for façade insulation.[26] Three drivers are at play here:

- The lower energy bill reduces the future cost of living in the building. Future expected cost savings have a discounted present value. This value is reflected in a higher price of the building.[27]
- Energy renovations not only improve the energy efficiency of a building but can also improve the aesthetic value as such.[28] For example, new windows provide improved insulation and simultaneously enhance the aesthetics of a building.

[18] Sorrell et al. (2004), *The Economics of Energy Efficiency: Barriers to Cost-Effective Investment*
[19] Bertoldi et al. (2020). *How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU*
[20] Halme et al. (2005), *Business from Sustainability: Drivers for Energy Efficient Housing*
[21] Häkkinen & Belloni (2011), *Barriers and drivers for sustainable building*
[22] Beillan et al. (2011), *Barriers and drivers to energy-efficient renovation in the residential sector. Empirical findings from five European countries*
[23] Jakob (2006), *Marginal costs and co-benefits of energy efficiency investments: The case of the Swiss residential sector*
[24] Ramseier (2013), *Essays in energy economics and policy: An empirical analysis of the determinants of energy efficiency investment decisions*
[25] Copenhagen Economics (2016), *Do homes with better energy efficiency ratings have higher house prices?*
[26] Banfi et al. (2008), *Willingness to pay for energy-saving measures in residential buildings*
[27] Copenhagen Economics (2016), *Do homes with better energy efficiency ratings have higher house prices?*
[28] Sunikka-Blank & Galvin (2016), *Irrational homeowners? How aesthetics and heritage values influence thermal retrofit decisions in the United Kingdom*

- Finally, energy renovations make buildings future-proof. Reduced energy use makes the energy expenses for a building more robust to increasing energy prices as well as future requirements on energy standards.

Thirdly, and looking outside pure private market terms, there could be financial incentives in the form of tax deductions and subsidies. For example, in Switzerland, private individuals can deduct value-increasing investments from their taxable income.[29] Similarly, a benevolent subsidy policy, for example subsidies for solar panels, incentivises to invest in energy renovations.

Idealistic reasons

Research indicates that homeowners and companies also pursue energy efficiency investments because of more idealistic reasons – with environmental considerations being a main driver,[30] concretely, concerns over resource conservation,[31] and becoming more energy self-sufficient, are two reasons mentioned in previous consumer research from Switzerland.[32] As a side effect, energy efficiency improvements that are visible can also grant social approval for building owners for their environmental considerations.[33]

Finally, expectations of tighter future regulation regarding the tolerated levels of energy consumption are mentioned as a reason to renovate from a consumer study conducted in France.[34]

By-product of other renovations and other reasons

At last, energy renovations can simply be a "by-product" of other, often larger, renovations. A general refurbishing of a building would often improve the energy efficiency, e.g. as a result of new windows, heating system, etc. In Switzerland building owners report to consider an energy renovation when a related renovation has been decided on. The insulation of the roof for example is debated when the building's roof covering is renewed.[35]

In similar fashion, the comfort of a home is perceived to increase upon an energy renovation.[36] Better insulation for example reduces the need for thermal energy to heat and creates more comfort. A study from Slovakia, for example, shows large effects of energy renovations on the indoor air quality.[37]

The degree of complexity of an energy renovation also determines whether an energy renovation is considered during another, larger renovation process.[38]

Despite these drivers for energy renovations, and as outlined above, we observe a gap between potential for energy renovations and conducted renovations. Several barriers cause this gap. We present these barriers in the next section.

[29] Jakob (2007), *The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners*
[30] Wilson et al. (2015), *Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy*
[31] Beillan et al. (2011), *Barriers and drivers to energy-efficient renovation in the residential sector. Empirical findings from five European countries*
[32] Ramseier (2013), *Essays in energy economics and policy: An empirical analysis of the determinants of energy efficiency investment decisions*
[33] Beillan et al. (2011), *Barriers and drivers to energy-efficient renovation in the residential sector. Empirical findings from five European countries*
[34] Beillan et al. (2011), *Barriers and drivers to energy-efficient renovation in the residential sector. Empirical findings from five European countries*
[35] Jakob (2007), *The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners*
[36] Copenhagen Economics (2016), *Do homes with better energy efficiency ratings have higher house prices?*
[37] Földváry et al. (2017), *Effect of energy renovation on indoor air quality in multifamily residential buildings in Slovakia*
[38] Thomsen et al. (2009), *Innovative retrofit to improve energy efficiency in public buildings*

3. BARRIERS TO ENERGY RENOVATIONS

In this section, we investigate the barriers behind the energy efficiency gap, i.e. the discrepancy between the level of energy renovations that would be profitable from an economic perspective and the level of energy renovations actually carried out. We have categorised the barriers into six main blocks: Behavioural barriers, transaction cost, financial barriers, data insufficiency, regulatory barriers, and conflicting interests between landlord and tenant. We will outline each barrier in the following.

Behavioural barriers

Research has shown that consumers are prone to behavioural flaws that distort their decision-making processes. These flaws are for example caused by limited available information and limited capacity to foresee all potential benefits and costs (bounded rationality), high perceived complexity, or high perceived uncertainty (prospect theory (the expected losses overweight the expected gains) and myopia (excessive focus on short term).

First, energy efficiency investments are often simply not considered in the range of renovation options.[39] This can often be the result of a lack of credible information regarding energy renovations.[40]

Besides the lack of credible information, conducting an energy renovation is also perceived as a complex and irreversible decision. And processing the information around such a decision is perceived as mentally challenging.[41] [42] Thus, consumers tend to prefer simple solutions and favour the status quo.[43]

Concretely, we have identified four areas, where consumers typically experience high uncertainty, either due to lack of credible information or due to high perceived complexity:

Cost-effectiveness: Consumers struggle to assess whether an energy efficiency investment is cost-effective, i.e. whether the cost of borrowing the required funds from a financial institution is fully covered by the expected benefit through a reduced energy bill or an increased value of the building.[44]

Heavy discounting of future earnings: People tend to discount future earnings heavily, i.e. the incurred immediate costs of an energy renovation weigh heavier than potential benefits that only accrue in the future.[45]

Increase in value of building: Energy renovations increase the value of the building. However, consumers perceive uncertainty as to how exactly the value of their building changes due to the renovation and how much the value increase covers the lending costs of capital necessary to conduct the renovation.

[39] Weiss et al. (2012), *Improving policy instruments to better tap into homeowner refurbishment potential: Lessons learned from a case study in Germany*
[40] Jakob (2007), *The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners*
[41] Entranze project (2012), *Working paper: Literature review of key stakeholders, users and investors*
[42] Phillips (2012), *Landlords versus tenants: Information asymmetry and mismatched preferences for home energy efficiency*
[43] Banfi et al. (2012), *An Analysis of Investment Decisions for Energy-Efficient Renovation of Multi-Family Buildings*
[44] Golove & Eto (1996), *Market barriers to energy efficiency: A critical reappraisal of the rationale for public policies to promote energy efficiency*
[45] Cabinet Office: Behavioural Insights Team (2011), *Behaviour Change and Energy Use*

Environmental impact: Relating to the "idealistic driver" of energy renovations, consumers perceive uncertainty regarding the actual environmental benefits of energy renovations.[46] The level of environmental impact is hard to measure, and consumers struggle to assess their impact correctly.

Herd mentality could also be a behavioural barrier in relation to energy renovations. Social norms, for example, lead individuals to behave according to their peers.[47] As the decision to energy renovate is not widespread yet in many European countries, the uptake of such renovations is hindered by the mere fact that consumers do not energy renovate yet on a large scale.

Transaction cost barrier

Transaction costs form a second barrier to energy efficiency investments. The majority of these costs relate to the time spent by the consumer in relation to carrying out the renovation, which can be a troublesome process involving many stakeholders.

At the start of an energy renovation decision-making process, numerous search cost aspects arise. A very first hurdle is to search for and acquire the relevant information on the different energy renovation solutions.[48] Once consumers have decided on a solution, they must find adequate service providers, which is often not a straight-forward undertaking.[49] In how far governments' financial incentives offset the cost of prospecting remains difficult to grasp.

During the renovation process, other transaction costs arise: The building owner faces uncertainty about the contractor's reliability and thus must monitor the contractor.[50] Moreover, if the building owner uses the building themselves, it can be challenging to live in the building during the renovation work and they may even relocate themselves during the renovation period.

In total, transaction costs can amount to a substantial share of the total costs of an energy renovation. In an earlier study, Copenhagen Economics finds that transaction costs can range between 1 and 60 per cent,[51] depending on the on the size of the project, whereas smaller projects, mostly conducted by private customers, tend to exhibit higher transaction costs.

Financial barriers

An energy renovation often requires the building owner to take on a loan. Depending on the magnitude of the renovation, the loan is often significant, e.g. compared to income.[52] Limited capital availability poses a considerable barrier to energy efficiency investments. Especially building owners with restricted financial means might encounter severe restrictions in accessing necessary funds.[53] [54] [55] [56] [57]

[46] Häkkinen & Belloni (2011), *Barriers and drivers for sustainable building*

[47] Cabinet Office: Behavioural Insights Team (2011), *Behaviour Change and Energy Use*

[48] Brown (2001), *Market failures and barriers as a basis for clean energy policies*

[49] Uhilein & Eder (2009), *Towards additional policies to improve the environmental performance of buildings*

[50] Banfi et al. (2012), *An Analysis of Investment Decisions for Energy-Efficient Renovation of Multi-Family Buildings*

[51] Copenhagen Economics (2018), *Gevinster ved anvendelse af data og digitalisering til screening af bygninger for EE: Kortlægning af mekanismer*

[52] Uhilein & Eder (2009), *Towards additional policies to improve the environmental performance of buildings*

[53] Brown (2001), *Market failures and barriers as a basis for clean energy policies*

[54] Golove & Eto (1996), *Market barriers to energy efficiency: A critical reappraisal of the rationale for public policies to promote energy efficiency*

[55] Wilson et al. (2015), *Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy*

[56] Linares & Labandeira (2010), *Energy efficiency: Economics and Policy*

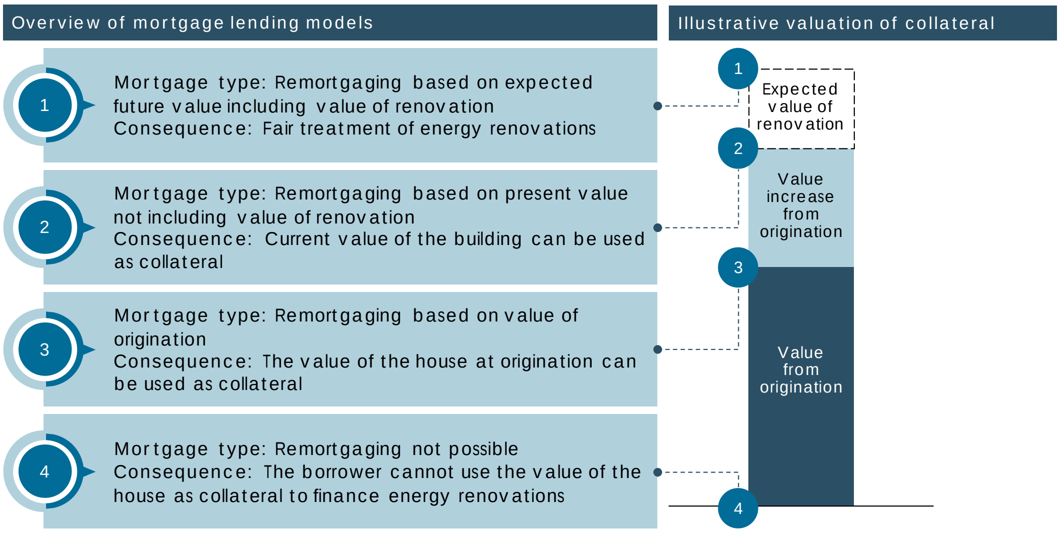
[57] Gillingham et al. (2009), *Energy Efficiency Economics and Policy*

The financial barriers for the actual energy efficiency investment are compounded by mortgage lending practices. These influence how energy renovation loans can be collateralised and therefore determine the cost of the loan, i.e. the interest rate the borrower must pay.

Based on forthcoming work within the EeMMIP, we have identified four general mortgage lending models that are applied by European credit institutions (see Figure 1 for an overview). Since regulation of mortgage lending differs across European countries and since lending practices can vary between credit institutions, these mortgage lending models are applied to a different degree in the various European countries.

In the following, we will go through each of the four mortgage models and highlight any barrier associated with it.

Figure 1
Mortgage lending models and associated collateral value



Source: Copenhagen Economics based on interviews with national financial institutions and banking associations, ECBC (2019) and EMF (2019)

In the first lending model, the energy renovation loan can be collateralised using the current value of the property *and* the expected value of the energy efficient renovation.[58] Since a higher collateral value reduces the risk of the loan, the interest rate for the renovation will be lower than the one without the inclusion of the value of the renovation. Given that the collateral value increases with the energy renovation, it is furthermore less likely that the borrower exceeds the limits of the so-called loan-to-value (LTV) ratio in which case (part of) the renovation loan would have to be financed with a more expensive consumer loan.[59] We consider this a fair treatment of energy renovations since it takes into account the positive impact higher energy efficiency has on property prices.[60] However, based on

[58] The expected value of the renovation is linked to future cost savings due to a lower energy consumption. Not taking into account other potential benefits of energy renovations (such as health benefits), a rational investor will therefore typically not pay more for a renovation than the future energy cost savings due to the renovation.

[59] The LTV ratio is given as the ratio of the mortgage loan to the value of the property with which it is collateralised.

[60] See, for instance, Copenhagen Economics (2016) and Brocklehurst (2017). For an overview of studies analysing the link between energy efficiency and property values see EeDaPP (2020).

interviews with credit institutions, we find that the expected value of the energy renovation is rarely included in the collateral.

In the second lending model, credit institutions also use the current value of the property as collateral but do *not* incorporate the positive impact of the energy renovation on the property value. The lower collateral value compared to a fair treatment results in a higher interest rate for the energy renovation. Moreover, it is more likely that the loan for the energy renovation leads to an LTV ratio above the set LTV limit. In that case the energy renovation must be financed through private savings or a more expensive consumer loan. This amplifies the financial barriers that borrowers face when considering energy renovations. Many European credit institutions allow using the current property value as collateral and this seems to be the most used approach in Europe.

In the third lending model, credit institutions use the property value at the origination of the initial mortgage loan as collateral. The property value is not updated at all, which typically means that the collateral value used for the renovation loan is lower. The result will typically be a higher interest rate. This mortgage lending model is applied in some countries and its application varies between credit institutions.[61]

Lastly, some credit institutions do not allow for subsequent collateralised lending for an energy renovation at all. No matter what the LTV ratio of the mortgage loan is, the energy renovation loan then must be financed by private savings or a consumer loan. This results in a significantly higher cost of an energy renovation because lending is much more expensive. No European country prohibits refinancing of mortgages, but some credit institutions chose to do so because mortgage products are typically less profitable.

Data insufficiency

Private and commercial building owners, as well as financial institutions are confronted with a lack of appropriate data to make meaningful energy efficiency investment decisions. The lack of data becomes apparent at various stages along the energy renovation decision-making process:

First, financial institutions lack information as to which customers could be eligible for and might be interested in an energy renovation. The lack of this information constitutes a first barrier for financial institutions to approach the relevant customers or stakeholders.

Second, during the energy renovation decision-making process, consumers and lending institutions alike want to have a coherent overview over the actual energy consumption of a building. Measurement and verification of energy use of a building can be challenging.[62]

Third, customers and lending institutions do not always have access to a full overview of possible energy renovation solutions. Different energy renovation solutions have different predicted energy savings, as well as different comfort perceptions by consumers. The lack of data on the long-term improvement of an energy renovation creates a large barrier to engage in such an undertaking.[63]

[61] In Germany, for instance, the collateral value for Germany covered bonds (*Pfandbriefe)* is calculated as the *mortgage lending value* which attempts to correct for speculative elements in the market price.

[62] Beillan et al. (2011), *Barriers and drivers to energy-efficient renovation in the residential sector. Empirical findings from five European countries*

[63] Palm & Reindl (2017), *Understanding barriers to energy-efficiency renovations of multifamily dwellings*

Regulatory barriers

Inadequate or missing regulation constitute barriers to the uptake of energy efficiency investments. Although European Energy Performance Certificates, EPCs, are a legal requirement in all EU Member States, other certified energy efficiency labels are not introduced everywhere to promote transparency around the actual energy consumption and ultimately the value of a building, especially for old buildings.[64] Where such a label has been introduced, recurring reforms to update the label are essential and not always pursued.[65]

Besides existing regulation, building owners have historically perceived uncertainty about future, potential regulations, and consumers have reported receiving confusing political signals as to what energy renovation solutions are encouraged and supported.[66] Today, policy instruments vary in their maturity and hence in their high profile. Long standing policies are well-known which reduces the uncertainty.[67]

Conflicting interest between landlord and tenant

Finally, when the building is not used by the owner themselves, but rented to a tenant, interest of landlord and tenant can conflict. The tenant could be in favour of an energy renovation which reduces their energy bill, whereas the landlord would be against such a renovation to avoid the investment costs if the associated costs cannot be passed on to the tenant with a higher rent.[68] This policy failure stops investment that could provide net benefits to society.

As many buildings in the EU are rented out to tenants, this conflicting interest constitutes a significant barrier for the uptake of energy renovations.

4. OVERCOMING THE BARRIERS

To take advantage of the potential advantages of energy renovation described above, effective energy efficiency policies need to mitigate the barriers and allow consumers to reap the financial and idealistic benefits. The magnitude of the barriers varies for individual consumers, and the collective nature of decisions calls for an integrated approach that tackles multiple barriers.[69] Below, we have briefly outlined some of the most prominent initiatives currently in place.

Guidance on energy renovations to bring down behavioural barriers

Various instruments have been suggested to guide and nudge private consumers and commercial companies alike to consider energy renovations, see for example research by the Danish[70] and British[71] behavioural insights teams and a study by Abrardi that tackles varies behavioural barriers separately.[72]

For example, information should be made available around lending possibilities and the range of energy renovation solutions, their approximate costs, the available financial incentives, and potential

64 Jakob (2007), *The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners*
65 Cabinet Office: Behavioural Insights Team (2011), *Behaviour Change and Energy Use*
66 Beillan et al. (2011), *Barriers and drivers to energy-efficient renovation in the residential sector. Empirical findings from five European countries*
67 Bertoldi et al. (2020). *How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU*
68 Phillips (2012), *Landlords versus tenants: Information asymmetry and mismatched preferences for home energy efficiency*
69 Matschoss et al. (2013), *Energy renovations of EU multifamily buildings: do current policies target the real problems?*
70 iNudgeyou (2020), *Adfærdsindsigter inden for energimærkningsordningen*
71 Cabinet Office: Behavioural Insights Team (2011), *Behaviour Change and Energy Use*
72 Abrardi (2019), *Behavioral barriers and the energy efficiency gap: a survey of the literature*

benefits. Moreover, consumers must be made aware of the impact of energy renovations on the comfort of the building.[73] Such measures jointly and additionally reduce the information barrier.

As mentioned, consumers perceive energy renovations as a large and complex undertaking. It logically follows that targeted technical and organisational guidance could reduce the complexity and thereby mitigate the barrier.[74] As such, research finds that a so-called *situated approach* which is adjusted to the respective situation of the building owner promises more success than a standard approach. This approach integrates an energy renovation into broader support for general renovations through e.g. respecting residents' differentiated desires regarding the use of spaces in a building.[75] For example, a one-pager that financial institutions can hand out to potential customers for energy renovations is found to be an effective format to provide such information.[76] Energy consultants also compose an important channel to diffuse such targeted information, although the cost for such consulting augments the financial barrier.[77]

Data availability for consumers and lending institutions

Data availability is an often-discussed challenge. Studies suggest that energy efficiency policies should aim at improving and enlarging data availability regarding e.g. who could be eligible for an energy renovation, various renovation solutions, as well as energy and cost savings. This would facilitate consumers' informed decision-making and will provide grounds for sophisticated guidance from financial institutions. A study in the Netherlands, for example, uses comprehensive datasets to monitor the renovation rates and advocates for a wider use of big data to drive the rate of energy renovations.[78]

Copenhagen Economics has analysed the use of data and digitalisation in the assessment of buildings' energy efficiency.[79] The study finds that the use of data can severely reduce transaction costs in energy renovation processes. Specifically, the study identifies efficiency gains from data-driven tools and digitalisation for energy renovations in three dimensions: Better data availability and a higher digitalisation support i) a more precise and less expensive identification process of the best potential renovation projects; ii) a more accurate verification of the value of a renovation; and iii) enhanced possibilities to use mortgages to finance a renovation.

Researchers have developed data-driven tools to facilitate decision-making for energy renovations. For example, local municipalities in Italy have been supported with GIS-based tools.[80] Slovenian researchers have explored the potential of building information modelling (BIM) and energy simulations to facilitate informed decision-making for office buildings.[81] More, more accurate, and more real-time data as inputs to such tools enhances their effectiveness.

[73] Ebrahimigharehbaghi et al. (2019), *Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making?*

[74] Matschoss et al. (2013), *Energy renovations of EU multifamily buildings: do current policies target the real problems?*

[75] Wilson et al. (2015), *Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy*

[76] iNudgeyou (2020), *Adfærdsindsigter inden for energimærkningsordningen*

[77] Beillan et al. (2011), *Barriers and drivers to energy-efficient renovation in the residential sector. Empirical findings from five European countries*

[78] Filippidou (2017), *Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing using the national energy labelling database*

[79] Copenhagen Economics (2018), *Gevinster ved anvendelse af data og digitalisering til screening af bygninger for EE: Kortlægning af mekanismer*

[80] Caputo & Pasetti (2017), *Boosting the energy renovation rate of the private building stock in Italy: Policies and innovative GIS-based tools*

[81] Stegnar & Cerovšek (2019), *Information needs for progressive BIM methodology supporting the holistic energy renovation of office buildings*

Addressing financial barriers

From a risk perspective, higher energy efficiency has two positive effects on the borrower's solvency: it increases the property value of the building and additionally leads to a smaller monthly energy bill. However, these risk mitigating factors are currently not fully incorporated in interest rates that are charged, making energy efficiency investments more expensive than warranted by the riskiness of the associated loan. This disincentivises borrowers from taking out a loan to carry out an energy renovation.

The forthcoming work within the EeMMIP aims at alleviating this disincentive by suggesting a capital framework in which risk mitigating factors of energy efficient buildings can be appropriately considered. In that way, the costs for an energy renovation are lower because the improvement in energy efficiency has a positive impact on the riskiness of the loan. In this respect, in its Action Plan on Sustainable Finance, the European Commission commits to exploring the feasibility of reducing capital charges for banks' exposure to green assets (such as green mortgages), where justified from a risk perspective.[82]

Other market initiatives aim at reducing costs for green assets directly through lower interest rates. Among the financial institutions that already incorporate a beneficial treatment of green assets is the French commercial bank Natixis, which implemented a so-called *green weighting factor* that allocates capital charges internally based on the environmental impact of each financial transaction.[83] This weighting factor makes lending for non-sustainable activities more costly. Some German banks, such as the Münchener Hypothekenbank and Commerzbank, provide an interest rate discount for certain green mortgages directly.

For a correct treatment of energy efficiency, the future impact of climate change (i.e. more extreme weather conditions) must also be considered because it will increase the advantages of owning an energy efficient property. Several initiatives have provided recommendations on how such risks can be incorporated within the financial sector. The Network for Greening the Financial System (NGFS), for instance, has provided a guide for central banks and supervisors on how to measure climate risks' impact on financial stability.[84] The Bank of England is currently working on a climate stress tests for banks. The regulatory treatment of energy efficient mortgages can build on the results of these studies. As an example of an implementation of this logic, the Hungarian central bank has recently introduced a preferential prudential treatment for lenders that offer energy-efficient mortgages to reduce risks stemming from climate change.[85]

Lastly, existing financial barriers can also be addressed directly through public support: A current example is that of the recently introduced Italian Superbonus, which represents massive public intervention in the process of energy efficiency.[86] It allows 110 per cent of fiscal rate deduction in 5 years for energy efficiency and earthquake resilience retrofitting interventions as well as installations of photovoltaic panels and electric charging systems for vehicles. Additionally, the interventions must result in an improvement of two EPC classes. Among all the novelties introduced by the Superbonus scheme, a crucial element is represented by the option of transferring the fiscal credit to other

[82] See Action 1 in the Action Plan (COM(2018) 97)

[83] This is not a risk-based preferential treatment of green assets but is mainly driven by the goal to incentivize investments in green activities. See, for instance, I4CE (2020) for details

[84] See NGFS (2020)

[85] See, for instance, Laidlaw (2020)

[86] See, for instance, https://www.italy-uk-law.com/italian-news/superbonus-the-new-tax-credit-for-italian-property-improvements/

subjects as other individuals, companies, intervention's suppliers, credit and financial Institution and intermediaries. In Germany, the CO2 Building Renovation Programme (*"CO2 - Gebäudesanierungsprogramm"*) provides low-interest loans combined with repayment grants and investment grants. Similar schemes exist in France and other European countries.[87]

[87] Economidou et al. (2019), *Accelerating energy renovation investments in buildings*

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