Energy Efficient Mortgages Initiative

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Copenhagen Economics

APPROPRIATE PRUDENTIAL FRAMEWORK FOR ENERGY EFFICIENT MORTGAGES

Energy Efficient Mortgage Market Implementation Plan

May 2021

Preface

The Energy Efficient Mortgages Initiative (EEMI) aims at incentivising building owners to invest in energy efficiency of their property to reduce energy consumption and emissions. A central aspect of the initiative is that investments in energy efficiency entail risk mitigating factors that should be included in the prudential framework.

This paper is part of the Energy efficient Mortgage Market Implementation Plan (EeMMIP)

- Building on previous projects, the EeMMIP has the main objective to implement energy efficient mortgages (EEM) as a product and develop the market for EEMs. In doing so, the EeMMIP will establish an EEM label, identify and test interventions necessary for a successful implementation of the EEM and develop an appropriate regulatory capital framework for EEM. This latter part of the EeMMIP is what Copenhagen Economics is mainly involved in.
- In order to develop an appropriate regulatory capital framework for EEM, we, in this report, analyse identified risk mitigating factors of EEMs and estimate how they would impact capital requirements from a risk perspective.
- We then benchmark the results from this exercise with the current treatment of EEM in the EU in order to identify shortcomings in the regulatory capital framework. These shortcomings will provide the basis for recommendations for financial institutions, supervisory authorities and regulators in order to appropriately account for energy efficiency aspects in the existing capital requirements framework.

This report contains our analysis of the treatment of EEM in the regulatory capital framework

The current report presents our results from this exercise and provides the foundation for a separate note on the regulatory implications that can be drawn from this. Our main conclusions are:

- For an appropriate regulatory treatment of energy efficient mortgages (EEM), so-called risk mitigating factors should be accounted for. This is possible without a complete overhaul of the regulatory framework and hinges on the availability of technical solutions to provide the necessary data.
- Transition risks, on average, seem manageable, but are very country- and portfolio-specific. Transition scenario analysis is therefore an important extension to the current framework.

Executive summary: A risk-based approach to regulating green assets

Motivation:

- The financial sector plays a crucial role in financing the investments needed in a transition to a carbon neutral economy.
- Consequently, removing any financial or regulatory barrier to financing the transition has increasingly gained the interest of policy makers and regulators.
- In particular, it is discussed, whether there are any grounds for a preferential regulatory treatment of green assets.
- This debate can simplistically be portrayed in two different approaches:

1) Green regulatory discount

One approach is simply to give a regulatory discount to green assets, i.e. to incentivise green investments, in line with the overall societal aim of reducing CO2 emissions. However, many, both public and private stakeholders, argue that this is in contrast with the very aim of financial regulation; to ensure financial stability – not to pursue broader societal goals.

2) Our approach: Risk-based

Another approach is that green assets should only have a preferential treatment to the extent that it can be justified from a risk perspective; that there exist certain risk mitigating factors that, if considered, entail lower capital requirements.

This analysis departs from the second approach, analysing whether energy efficient mortgages (EEM) entail risk mitigating factors that could have consequences for capital requirements.

Executive summary: Risk mitigating factors of energy efficient mortgages have a significant impact on capital requirements

From a theoretical perspective, EEMs could entail lower risks

Concretely, we test two previously identified risk mitigating factors for EEM:

1. Decrease the energy bill: which, in turn, leads to lower risk of default, giving rise to lower capital requirements.
2. Increase housing prices: which increases the underlying collateral, giving rise to lower capital requirements.

To test the significance of these factors, we implement them in a generic (IRB) regulatory capital model.

1	First, we test this from a current portfolio perspective, using average EU values as a case, as well as existing research on the correlation between collateral values and energy renovations.
2	Second, we will test this in a climate risks scenario analysis, to analyse if green mortgages are better guarded against future climate risks currently not apparent in data (compared to normal mortgages).

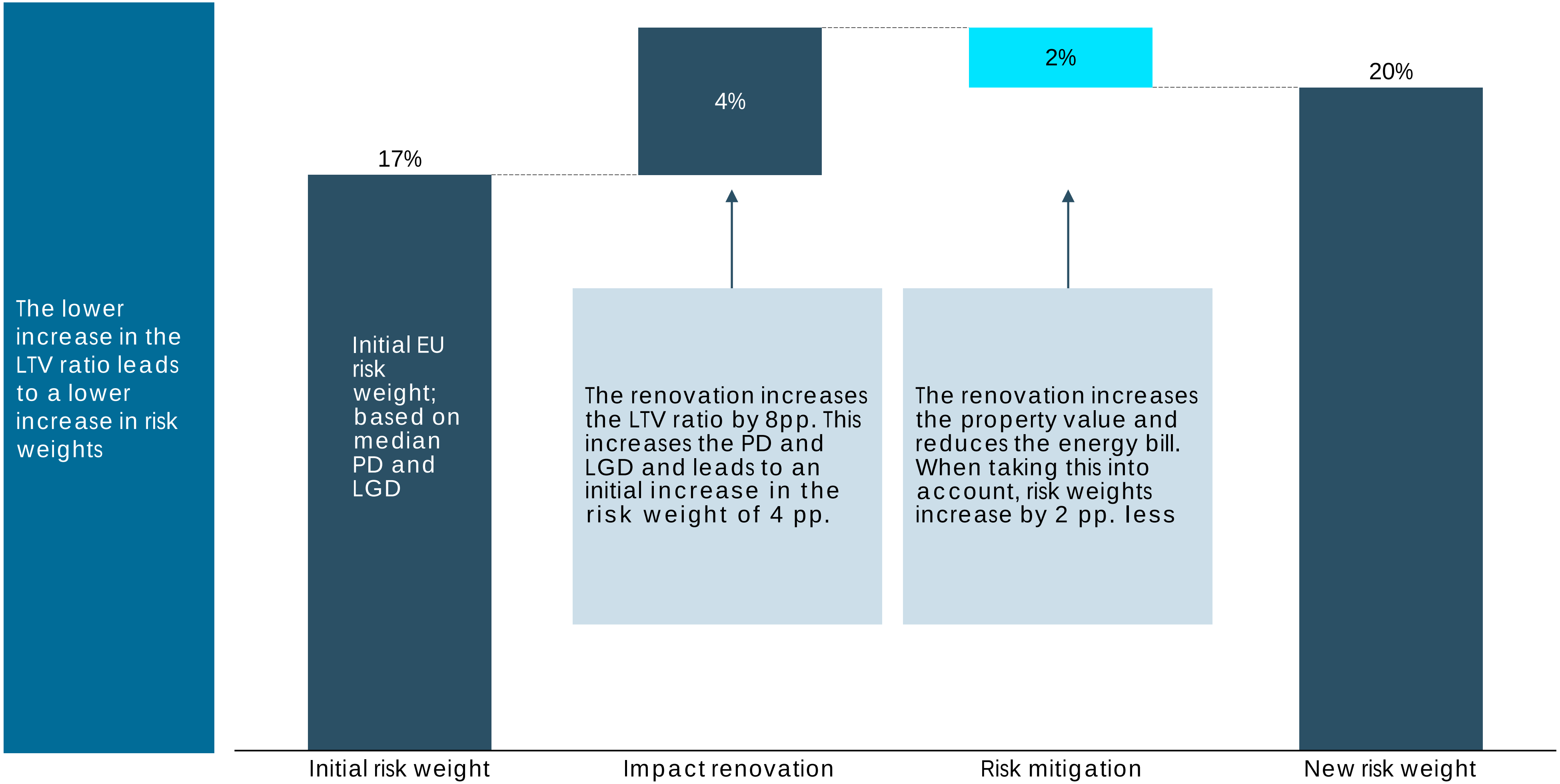
We find evidence that risk mitigating factors of EEMs can have significant impact on capital requirements

- Examining the current portfolio of mortgages, we find that in particular **a higher collateral value could have a significant impact on capital requirements.**
- In our main case, a loan-financed renovation for a household, **that moves the energy efficiency from EPC level D to B, entails risk mitigation corresponding to a decline in risk weights of around two percentage points (see next page)**. This is entirely an effect of private market mechanisms, i.e. excluding any public incentivising such as subsidies.
- Note that this is an **"everything else equal"** consideration; a loan-financed renovation will increase the leverage of households, leading to higher risk weights – but by less if the risk mitigating factor is included.
- We find that the risk mitigating factors are very **case-specific**: in our main case, we assumed that the household could use the existing value of the house as collateral for the renovation. However, this is not always the case, e.g. for new homeowners that have reached the LTV limit. This means that a renovation will have to be financed unsecured, i.e. through a consumer loan. In that case, the risk mitigating factor will then have a larger impact.
- We have also analysed the **effects of a lower energy bill**. Here we find that the impact on risk weights is negligible; the energy bill is typically small compared to the entire household income (around 4%). Even if a renovation managed to remove the entire energy bill, risk weights will only decrease by around 0.1 percentage point.
- However, for other reasons an energy renovation could lead to lower PD as EeDaPP has demonstrated, i.e. due to behavioural effects. Including this could enhance the mitigating effect with an additional 20%-40%, depending on the degree to which collateral values can be updated upon renovation.

EEMI

Causal link between LTV ratio and risk weights

Impact of lower LTV on risk weights
Percent; percentage points



Executive summary: Risk mitigating factors are currently not included in capital adequacy assessment of European institutions

Are the risk mitigating factors, described on the previous page, currently included in the regulatory capital assessment of European financial institutions?

The short answer is: not really

Collateral is rarely updated with the value of the renovation

In terms of collateral, we find that the collateral included in the capital requirement estimation is often not updated with the value of the renovation.

A minority of institutions update the collateral value, and typically only in case of:

- Large energy renovations that significantly increased the value of the home (e.g. 10%-20% increase in value).
- When customers are restricted by the LTV limit (i.e. existing collateral not sufficient).

There are several barriers preventing updating the collateral with the value of the renovation:

- Often, it is simply not included in the lending practice, or not possible within the current credit risk systems.
- In addition, the process is not automated, but requires physical visits sometimes before and often after a renovation to assess the value of the renovation – which is administratively costly.

Forward-looking scenario analyses not used to determine capital requirements

In terms of forward-looking scenario analysis, we find that this is only to a limited extent carried out at financial institutions – and if it is carried out, it does not impact capital requirements.

Often lending to renovations are unsecured loans

In other jurisdictions lending to energy renovations are simply treated as unsecured lending, i.e. neither the renovation nor the original housing value is recognised as collateral – not even when the LTV is below the current limit.

Not recognising any collateral obviously means that the capital requirements would be too stringent from a risk perspective (more or less the difference between risk weights of unsecured consumer loans of e.g. around 70% and mortgages of e.g. around 20%. Again, the reason for this practice is multifold:

- Some institutions do simply not allow remortgaging; lending for renovation cannot use the house as collateral. Or it is allowed but not common practice.
- In other cases, there are significant costs involved with remortgaging, both administrative and financial, meaning that there are lower net costs of issuing an unsecured loan, which is a less compliance-heavy procedure.

Executive summary: EEMs outperform ordinary mortgages in a transition scenario, although risks overall seems manageable

A cornerstone in the green transition is that the costs of emitting greenhouse gases (GHG) need to increase in order to incentivise green investments. Therefore, to fully understand the risk properties of EEMs, we can evaluate their performance in a scenario with increasing costs of emitting CO_2[1] – this is often referred to as a transition risk scenario.

- The dynamics of the scenario analysis can be summarised as follows: for energy-inefficient buildings, the higher price for CO_2 emissions increases the cost of heating[2] and cooling, increasing the living costs of that building. This will reduce the housing value, i.e. the collateral of the mortgage. This lower collateral value increases risk weights and hereby the capital requirements for that given mortgage. For EEMs, the cost of heating does not increase as much, thus leading to a better relative performance.
- The methodology behind our scenario analysis is explained in more details in our [forthcoming] Transition risk scenario analysis blueprint report.
- In our simulations, we find that the above-mentioned transition risks – on average – seem manageable. In the case of average EU values, we find that risk weights for an energy label D building increase by around 1.1 percentage points. Risk weights for lending to a building with an energy label B increases by some 0.6 percentage points, thus outperforming the average by some 0.5 percentage points.
- This estimated average impact includes a large heterogeneity among customers. For example, for an energy label G building with an oil boiler as a heating source risk-weights could increase by around 4.5 percentage points.
- Also, the above analysis is based on a CO_2 price scenario by the Network for Greening the Financial System (NGFS) , i.e. assuming a one-size-fits-all scenario for all EU countries. However, many countries already today have an implicit CO_2 price on heating, meaning that a realistic (and needed) CO_2 price scenario will diverge significantly between countries.

All in all, this suggests that transition risks on average are manageable but also very portfolio-specific, requiring a portfolio-specific analysis.

1) Typically, emissions of other greenhouse gases are expressed in CO_2 equivalents to make them comparable to CO_2 emissions. / 2) Space and water heating: In this report, the term "heating" refers to both space and water heating.

Table of contents

1
Conceptual framework

Our mission: A risk-based approach to a regulatory treatment of green assets

The regulatory treatment of energy efficient mortgages (EEM) should be risk-based

Policy approach: Green supporting factor (GSF), i.e. a preferential treatment for green loans due to a political aim of incentivising green lending.

Regulatory treatment of EEM

Risk-based approach, i.e. a purely risk-based treatment of EEM that incorporates all potentially risk mitigating factors in regulatory capital models

1

A GSF would decouple risk assessment and capital requirements related to EEM, potentially **counteracting financial stability goals**. We therefore do not pursue this option.

2

The treatment of EEM is only based on their risk. Evidence[1] suggests that EEM indeed entail risk mitigating factors that are currently not fully included in the credit risk frameworks.
This is our starting point.

> "Some argue that regulation should feature a green supporting factor [...] From my point of view as a supervisor, it is not as easy as that. Our mandate is to make banks safer and sounder. Thus, the treatment of exposures to certain assets should be based on their risks."
>
> – *Speech by Andrea Enria, Chair of the Supervisory Board of the ECB, at the Retail Banking Conference, November 2019*

1) Guin & Korhonen (2020) find that mortgages against energy efficient properties are less frequently in payment arrears than mortgages against energy-inefficient properties. Moreover, tentative evidence from the previous projects within the Energy Efficient Mortgage Initiative also suggests that EEM entails risk mitigating factors (see e.g. Final report D5.4 on the correlation between energy efficiency and probability of default within the EeMAP initiative).

EEM entail risk mitigating factors

		Risk mitigating factors inherent in EEM	
Current perspective	Both loans for purchases of energy efficient buildings and renovations to improve energy efficiency of existing buildings entail risk mitigating factors.	Lower loss given default (LGD) due to higher collateral value	After an energy renovation, the property value will be higher than before. The associated increase in the collateral value that the bank can use, if the borrower default, reduces the loss given default (LGD). A higher property value could also reduce the PD because the equity stake in the loan is larger, thus decreasing the incentive to default on the mortgage.
Forward-looking perspective	These dynamics will compound over time. Taking a forward-looking perspective; the transition risks associated with a higher energy bill when heating is fossil fuel based or when stricter building regulation affect the risk of mortgage loans today. This is relevant both for the PD and the LGD.	Lower probability of default (PD) due to lower energy bill	Higher energy efficiency implies lower energy expenses in the future. The associated increase in disposable income leaves the borrower more funds to service the debt, thus reducing the probability that the customer defaults on the loan (PD).

The risk mitigating factors translate to lower risk weights, incentivising energy renovations

These risk mitigating factors has the potential to incentivise more green renovations

Note: This is an 'all else equal' perspective: Risk weights will increase banks increase lending – but less if risk mitigating factors are included.

Lower risk weights:
Lower PDs and LGDs will lead to lower risk weights for EEM.

Lower capital requirements:
This will reduce the capital banks have to hold for such loans

Lower mortgage rates:
If passed on to customer, this will reduce the cost of lending for energy renovations.

Higher demand for energy renovations:
Lower costs of lending could incentivise green renovations.

In the entire analysis, we compare the impact of including these risk mitigating factors to a situation where they are not included, but where the loan is still issued. That is, we take an all else equal perspective. Issuing an additional loan for an energy renovation will most likely still make the loan riskier (and more expensive) because the size of the loan is larger. But the risk (and the interest rate) increases by less if the risk mitigating factors associated with EEM are taken into account.[1]

It follows that the impact on the demand for EEM will most likely work through a relative effect: Since the additional loan is cheaper than it would be without the inclusion of risk mitigating factors in the credit risk framework, more customers will consider taking out a loan to invest in the energy efficiency. In other words, more of such loans will become profitable when taking into account the reduced energy expenses and the positive impact on the property value.

1) Consider, for instance, the impact on the LTV ratio of an energy renovation worth EUR 50,000. If the initial value of the property is EUR 500,000, and the loan taken out is half of that, the LTV ratio without the energy renovation would be 50% (250,000/500,000). Assuming that the energy renovation increases the value of the property one-to-one, the LTV ratio after including the renovation in the loan would be around 55% (300,000/550,000), which is still larger than without the renovation loan. However, the LTV increases by less than when the increase in collateral is not included, in which case the LTV ratio would increase to 60%.

Recent development within sustainable finance allows for the targeted risk assessment of EEMS, as we propose

Including green risk mitigating factors in capital adequacy assessment is new	Previous, barriers have prevented the inclusion of green risk mitigating factors	However, recent advancements are allowed for the targeted approach we suggest
Our proposed framework includes metrics, such as energy expenses, that enable banks to capture the risk mitigating factors related to energy efficiency. These metrics are currently not utilised widespread among European banks and there are no requirements from legislators to take them into account.[1] And if they are used, they are not based on a harmonised approach.[2]	Barrier: Challenging to single out green assets	Recent advancement: A common taxonomy (p. 49)
	Barrier: No data to establish link between energy performance and default risk	Recent advancement : Data collection and reporting initiatives (pp. 50 and 51)
	Barrier: Current risk framework do not capture forward-looking risks	Recent advancement Current progress in climate risk scenarios (p.52)

1) NGFS (2020) / 2) To our knowledge, no studies have so far succeeded to establish a causal relation between default risk and energy performance, though studies have shown a correlation, even after correcting for factors that typically explain default risk. See EMF (2019) / 3) BoE (2020)

What is a green mortgage?

Green buildings are classified by their energy efficiency

Green buildings differ from non-green buildings by being more energy efficient. In other words, they have a better energy performance than most other properties which, all things equal, reduces the energy-related expenses of the homeowner.

The EEMI and the EU taxonomy provides two different, but overlapping classifications of green buildings.

Classification requirements for green properties

	Construction	Purchase	Renovation
EEM classification	An EEM must have energy performance which meets or exceeds relevant market best practice standards in line with EU legislative requirements	An EEM must have energy performance which meets or exceeds relevant market best practice standards in line with EU legislative requirements	EEM requires an improvement in energy performance of at least 30%
EU taxonomy	Eligible if the Primary Energy Demand (PED) is at least 10% lower than the PED target implied by national Near Zero-Energy Buildings (NZEB) regulations, which is based on the Energy Performance of Buildings Directive (EPBD).	Buildings constructed after 2021 are eligible if the construction of them was eligible. Buildings constructed before 2021 are eligible if they have at least an EPC class A, or if they are within the top 15% of national or regional building stock with regards to PED.	Renovations are eligible if they comply with national requirements for 'major renovation' as defined in EPBD, *or* renovations ensure at least 30% savings in PED.

Source: Energy Efficient Mortgage Initiative, EU Taxonomy Report Technical Annex p. 369-370 and Annex I of the Delegated Act, pp. 166 ff

EU and EEM taxonomies are different, but overlapping

For constructions and purchases of buildings, both classifications suggest that a building is benchmarked against the top performing buildings to be labelled green. The EU taxonomy defines a *best practice* relative to the PED[1] target levels mandated by national regulations, while the EEM does not set any explicit requirements for best practice.[2] The threshold value should over time be set to an absolute measure, to reflect actual energy performance instead of a relative.

For renovations, the two classifications are aligned in their requirement of a 30% improvement in energy performance. Importantly, in case a building becomes top-performing after an energy renovation, the entire asset will be considered a green asset, and hence eligible for lower capital charges on the entire mortgage.

1) PED is Primary Energy Demand associated with energy use for heating, ventilation, cooling and utility water / 2) *EU Taxonomy Report Technical Annex p. 369* / 3) https://eemap.energyefficientmortgages.eu/eem-definition/

2
How green risk mitigating factors impact capital requirements

Purpose of the chapter: What is a fair regulatory treatment of EEM?

Purpose of this chapter

- In this chapter, we analyse what a fair regulatory capital treatment of energy efficient mortgages (EEM) would be.
- This can be benchmarked against the actual treatment of EEM – identified in chapter 3 – to assess any regulatory deficiencies.

The chapter is structured as follows

2.1 **Theoretical perspective:** We identify, which energy efficiency factors could be important in the regulatory capital framework, from a theoretical perspective. We call them "risk mitigating factors".

2.2 **Current perspective:** We then present the results from our generic regulatory capital model for a mortgage bank. Based on data of an average EU mortgage portfolio, we test how the identified risk mitigating factors impact capital requirements.

2.3 **Forward-looking perspective:** We analyse how the identified factors would impact capital requirements in a transition risk scenario, with increasing costs associated with emitting CO_2.

2.1
Theoretical perspective

Energy efficiency and risk weights for mortgage loans

Previous research through EeMAP has, from a theoretical perspective, identified, which factors that could impact the capital requirements for mortgages:

1 Collateral value (housing price):
An energy renovation could increase the value of the house

2 Disposable income:
A lower energy bill increases disposable income

Loan-to-value (LTV) ratio:
A higher collateral value implies a lower LTV, which reduces the LGD. A lower LTV ratio implies less risk, as it is more likely that the bank can recover the entire loan by selling the collateral. A lower LTV ratio also reduces the PD because a higher equity stake in the loan reduces the incentive to default on the loan

Loan-to-income (LTI) ratio:
Higher disposable income reduces the leverage of the loan, expressed relative to income. This leads to a lower risk that the customer cannot service the debt: All else equal a lower LTI ratio will reduce the PD and with it the risk weight

To ensure a correct regulatory treatment of EEM, we take a look at which fundamental factors that:

1) are likely to be impacted by energy efficiency
2) can impact the two fundamental parameters decisive for risk weights, namely LGD and PD (see figure).

Loss-given-default (LGD):
How much can the bank expect to lose if the customer defaults?

Probability of default (PD):
What is the risk of a customer going into default?

Risk weights:
Cover unexpected losses

EEMI

2.2
Current perspective

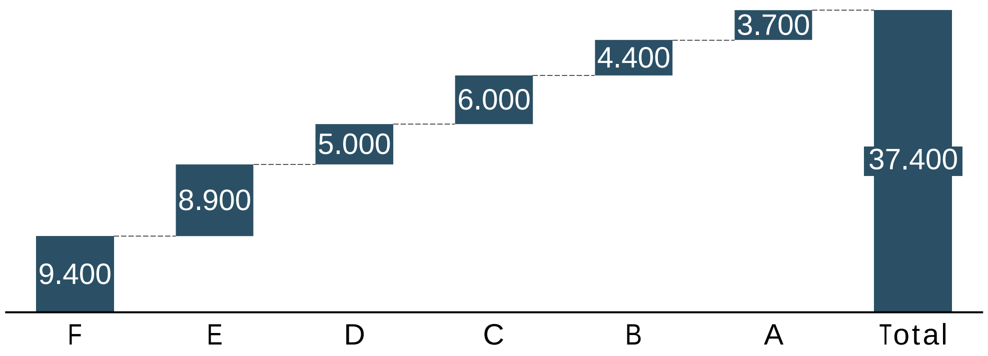
The correct regulatory treatment of EEM: Looking at the current portfolio

Methodology: How we estimate the impact on risk weights

- To analyse the impact of the identified risk mitigating factors – disposable income and collateral value – we set up a generic regulatory capital model for mortgages.
- We calibrate the model using estimates from papers by ECB (2019) and Bundesbank (2017). The ECB study provides estimates on how LTV and LTI ratios affect the PD and uses data from 2000-2016 for a subset of euro area countries. The paper by the Bundesbank infers the impact of the LTV ratio on the LGD from two different studies that use US and Finnish data, respectively, to estimate the correlation between the LTV ratio and the LGD.[1]
- How the change in PD and LGD translates into risk weights is based on a standard formula given in CRR/CRD IV. This takes into account that the impact on risk weights is not linear but depends on the initial EPC, PD and LGD.
- To assess the impact on risk weights, we consider an energy renovation that moves the energy label **from the median energy label (D) to label B** for a **100m² house**. We assume that an average family takes out the additional renovation loan when buying the house. The average price of a label D 100m² house in the EU is assumed to be around EUR 130,000 and the cost of the renovation around EUR 11,000.[2]
- Higher energy efficiency is associated with **lower energy expenses** and **higher property prices**, see figures to the right. We base the impact of an energy renovation on the property value and energy bill on the average impact found in six studies estimating the effect of energy efficiency ratings on house prices in European countries, see appendix for details. The impact on energy expenses is based on the relative difference in energy consumption between labels from a previous study by Copenhagen Economics and country-specific data on the energy mix and energy prices.

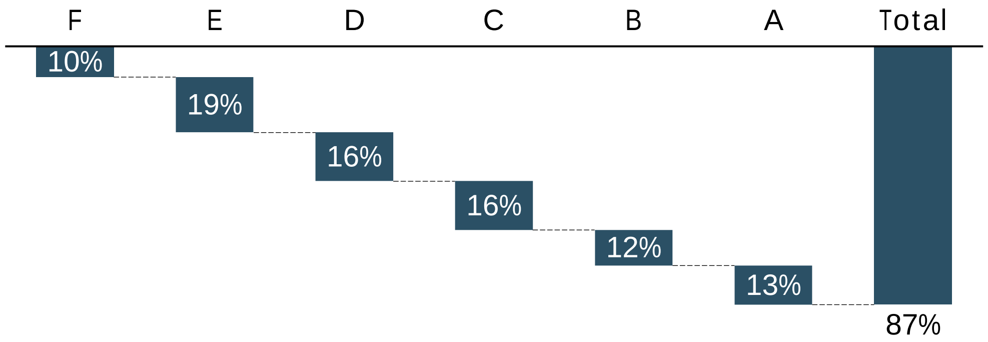
Increase in property price by reaching the next better energy label

Relative to label G average pre-renovation house price, EUR



Decrease in energy expenses by reaching the next better energy label

Relative to label G average pre-renovation energy expense, percent, percentage points



Source: Copenhagen Economics (2016), Fjärrsyn (2016), Heat Roadmap Europe (2018), European Commission (2019) and Eurostat

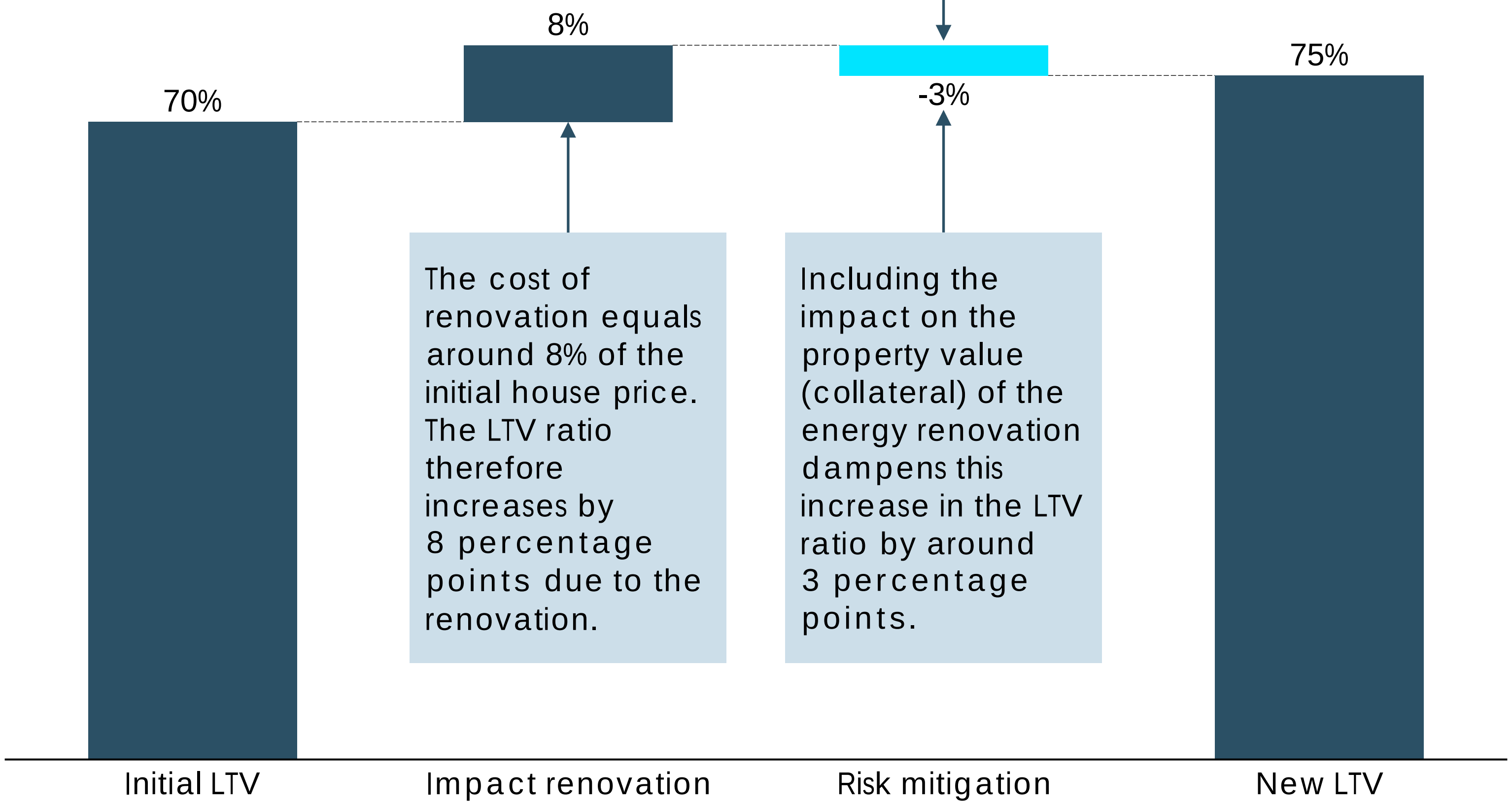
1) In the ECB study, the authors find that, evaluated at the mean of all variables, a percentage point increase in the LTV ratio increases the probability of default by 0.02 percentage points. An increase in the LTI ratio by 1 is estimated to increase the probability of default by around 0.001 percentage points. In the Bundesbank discussion paper, the authors find that the LGD increases by around 0.3 pp. for every increase in the LTV ratio. See full description in the appendix. / 2) This average house price is based on Copenhagen Economics (2016) covering Danish sales prices and Deloitte's property price index covering average new house prices in different European countries; see appendix for details.

EEMI

Higher collateral value means lower LTV ratio

We first analyse how the higher collateral value from an energy renovation impacts risk weights: When a loan for a renovation is issued, the LTV increases. This will increase the risk weight for the mortgage. However, considering the risk mitigating factor of a higher collateral value will almost halve the increase in LTV.

Impact of risk mitigating factors on the LTV
Percent; percentage points



Which kind of renovation do we consider?

We assume that the energy renovation is just exactly profitable, i.e. the renovation investment costs exactly equate the discounted savings in energy consumption over the average lifespan of the renovation.[1]

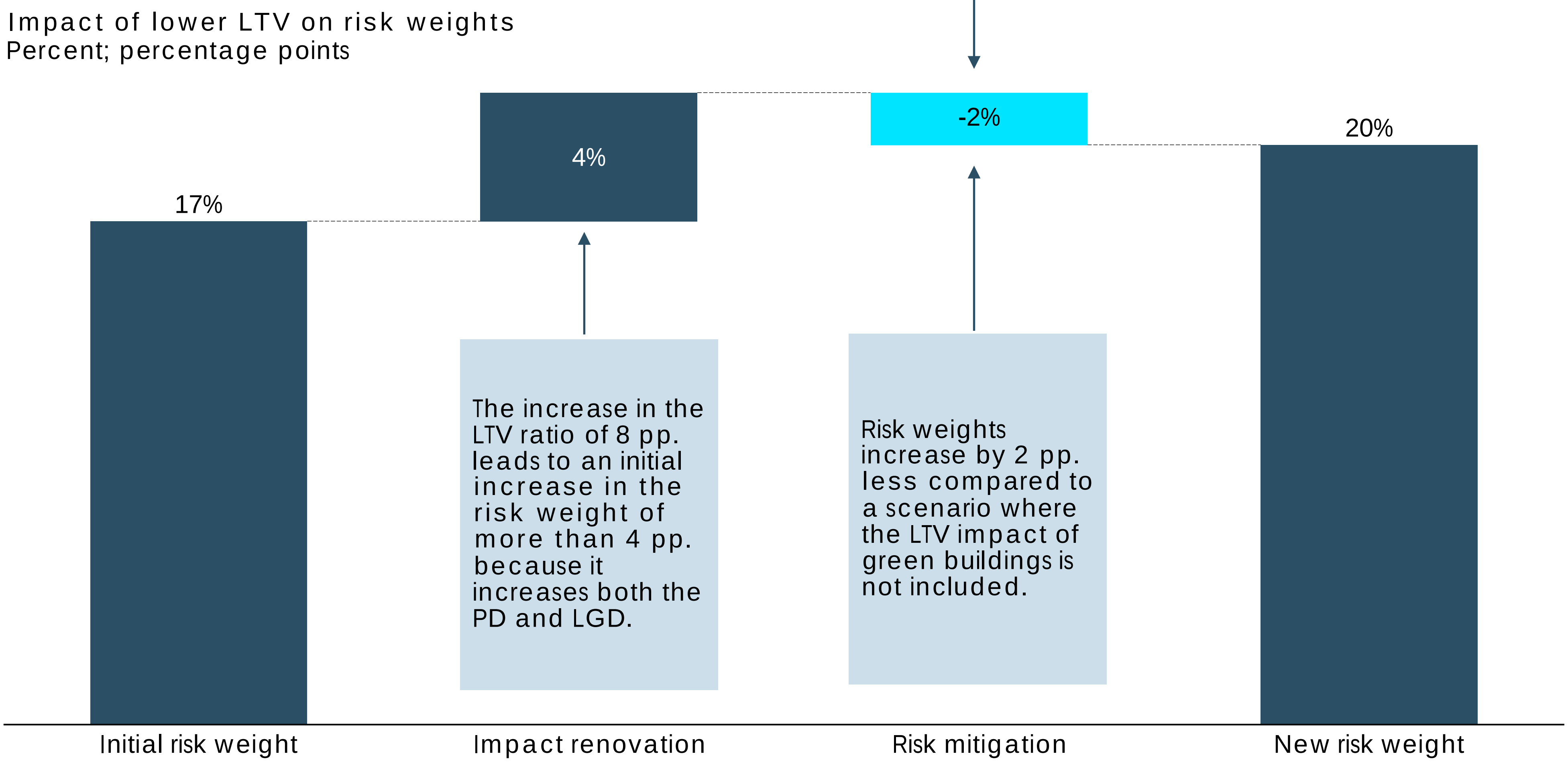
The investment costs could also be smaller than the future saved energy expenses due to high-impact energy renovations.

The marginal impact of the risk mitigating factors on the LTV ratio would, however, be almost unchanged.

1) In this report, we only consider energy efficiency renovations that reduce the total energy used for heating and cooling. We do not consider shifts from fossil fuel based energy sources to green ones by, for instance, installing solar panels on the rooftop. In some EU countries, the excess power generated through these sources can be sold to the grid which would have a positive impact on disposable income. Such effects are not included in our analysis. Due to the small share of energy expenses in total income, we do not expect the impact on riskiness of the borrower of such renovations to be substantial (see also slide 24 of this report).

Causal link between LTV ratio and risk weights

The lower increase in the LTV ratio from taking into account the higher collateral value after the energy renovation leads to a **lower increase in the risk weight**.[1]

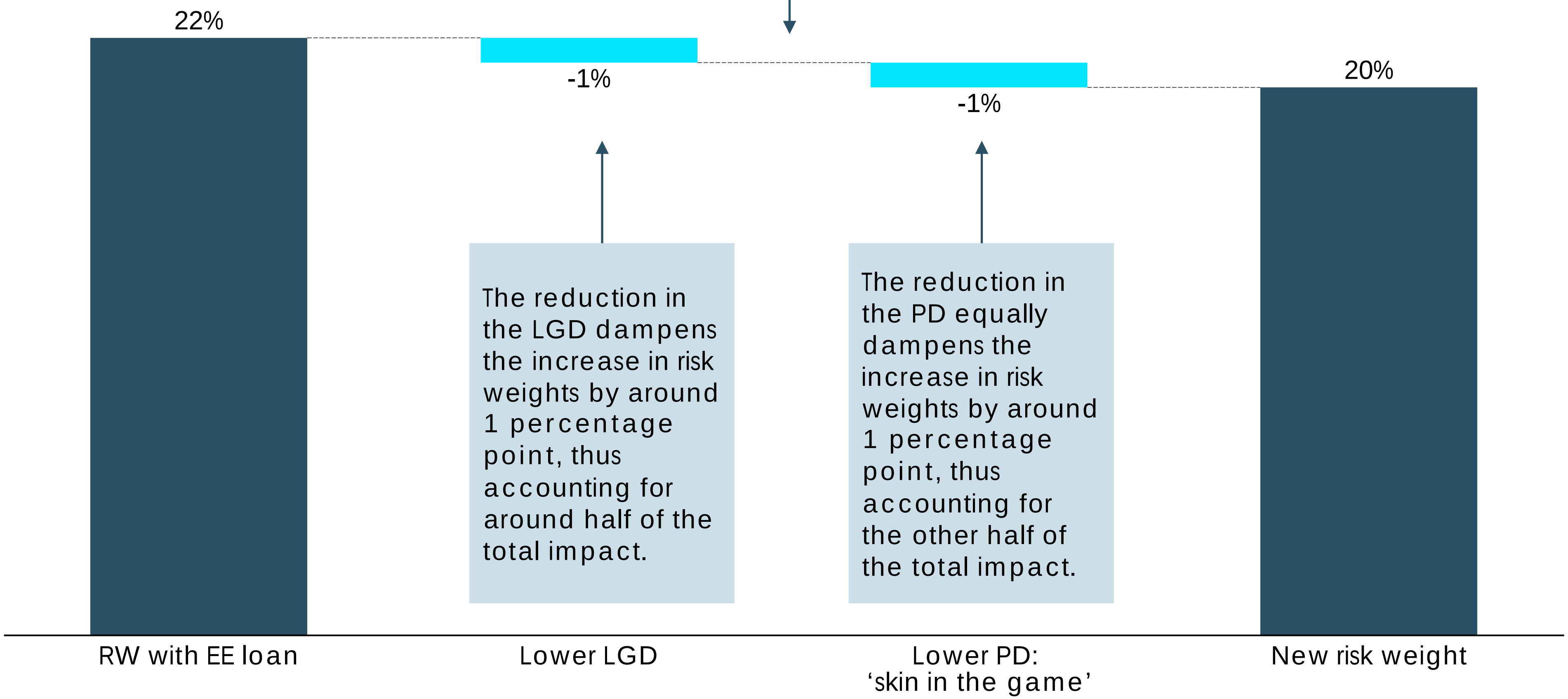


1) It should be noted that our model is tailored to banks using the advanced IRB approach, where both the LGD and the PD are estimated by the banks. For banks using the standardised approach or the foundation IRB approach, results will differ (see also slide 29 of this report).

The LTV impact on both PD and LGD is important

The impact on the LTV ratio affects both the LGD and the PD. On the one hand, a lower LTV ratio reduces the LGD because it means a lower exposure by the bank if the borrower defaults on the loan. This makes it more likely that the bank will be able to recover the entire loan in the event of a default. On the other hand, a lower LTV is also associated with a lower PD because it implies a higher equity stake in the property, which makes a strategic default less likely.[1] This is the so-called ‘skin in the game’ effect, or equity channel.

Impact of lower LTV on LGD, PD and risk weights
Percent; percentage points



1) See, for instance, Campbell & Cocco (2015)

Little impact from energy bill on risk weights

The impact of higher after-energy-bill disposable income seems to be negligible on the regulatory capital requirements.

A more energy efficient building implies lower energy expenses, as less energy is ‘wasted’. Lower energy expenses decrease the loan-to-income (LTI) ratio, if income is measured net of the energy bill.

However, the impact on the LTI ratio will be limited because energy expense is a small fraction of the entire income. Typically, the energy bill for heating and cooling takes up around 2-4% of the household’s gross income. Increasing the energy label of a 100m^2 house from D to B would reduce the energy bill by around 50%. Taking as a starting point an average LTI ratio of around 200%, energy savings associated with the renovation would reduce the LTI ratio by around 2-3 percentage points.[1]

A change in LTI of this magnitude will have limited impact on the PD. Using the results from an ECB study[3], a 1 percentage point decrease in the LTI ratio reduces the PD by 0.001 percentage points. From the median PD for mortgages, the 2 percentage points decrease in the LTI would imply a reduction in the PD from 0.9% to 0.898%.

The impact on risk weights from such a decrease in the PD would be around 0.03 percentage points and borrowing costs therefore would remain practically unchanged by the reduced energy expenses. Even if the entire energy bill was removed, risk weights would decrease by less than 0.1 percentage points.

1) Relative energy costs differ significantly across EU countries and housing situations. The approximate estimations reported here are based on a two-person household where both parties earn the average net salary in the EU. The energy bill is estimated based on the average EU energy mix and the average energy prices and assumes a house of 100m^2 and with energy label D. The average house price is estimated based on data from Deloitte’s European property index and Copenhagen Economics (2015). The LTI ratio is calculated as the average mortgage loan over total net earnings of the household.

2) Gaudêncio et al. (2019), Table 2

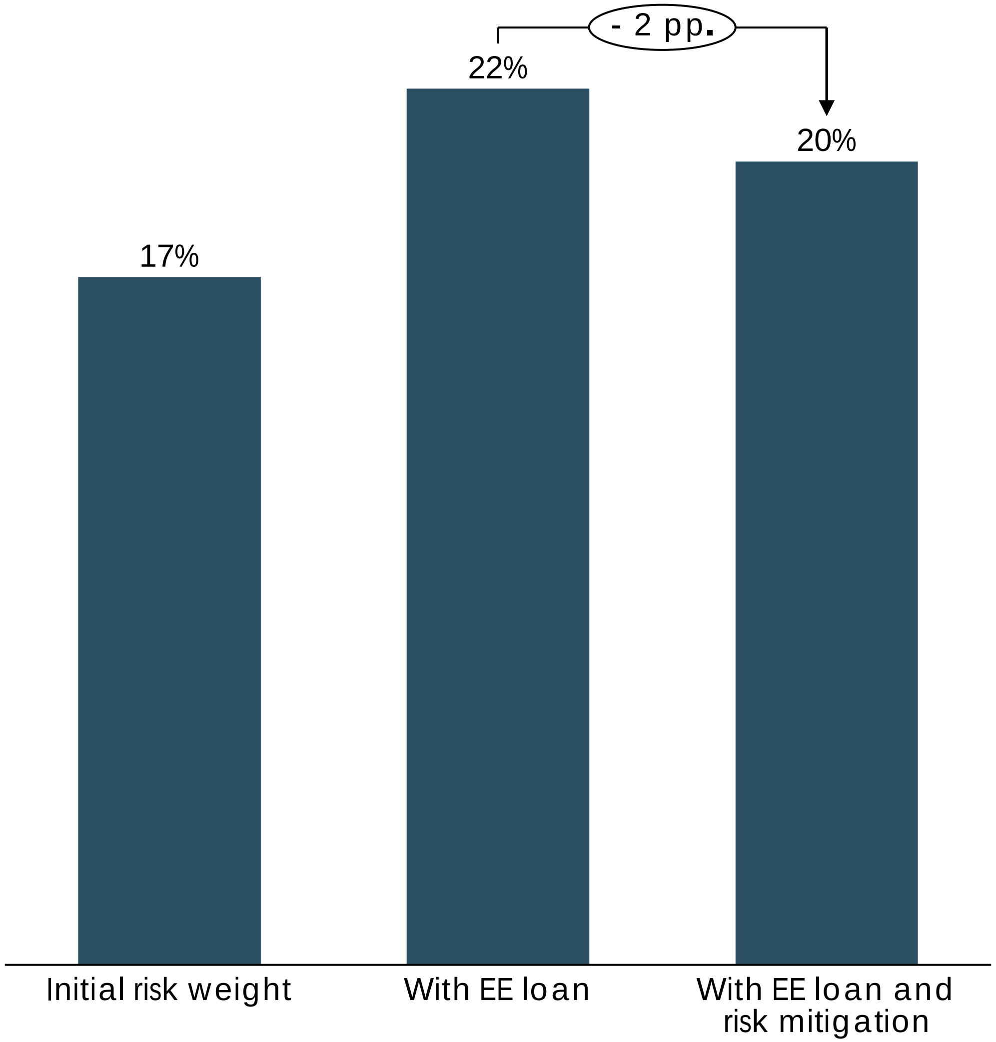
The correct regulatory treatment of EEM based on the current portfolio: Three alternative scenarios

Three alternative scenarios to illustrate the potential impact on risk weights and capital costs

Apart from our main scenario (see figure to the right), we also analyse the impact on risk weights and capital costs in alternative scenarios to account for the fact that our assumptions are very case-specific and uncertain:

- Energy savings, renovation costs and the impact on property prices after energy renovations could change over time and across countries. The inputs in the main scenario are based on average European data as far as possible. If no European data were available, we drew on data from a previous study on the impact of energy efficiency on house prices.[1]
- Moreover, considerable divergence exists across European countries with respect to how mortgages are regulated (e.g. LTV limits differ and renovation loans are treated differently from a regulative perspective).
- Assessing scenarios with changed assumptions allows us to analyse the sensitivity of our results to different assumptions.

Impact on risk weights in the main scenario
Percent



1) See the appendix for details on the methodology and data used. The study we refer to is *Copenhagen Economics (2016) – Do homes with better energy efficiency ratings have higher house prices?*

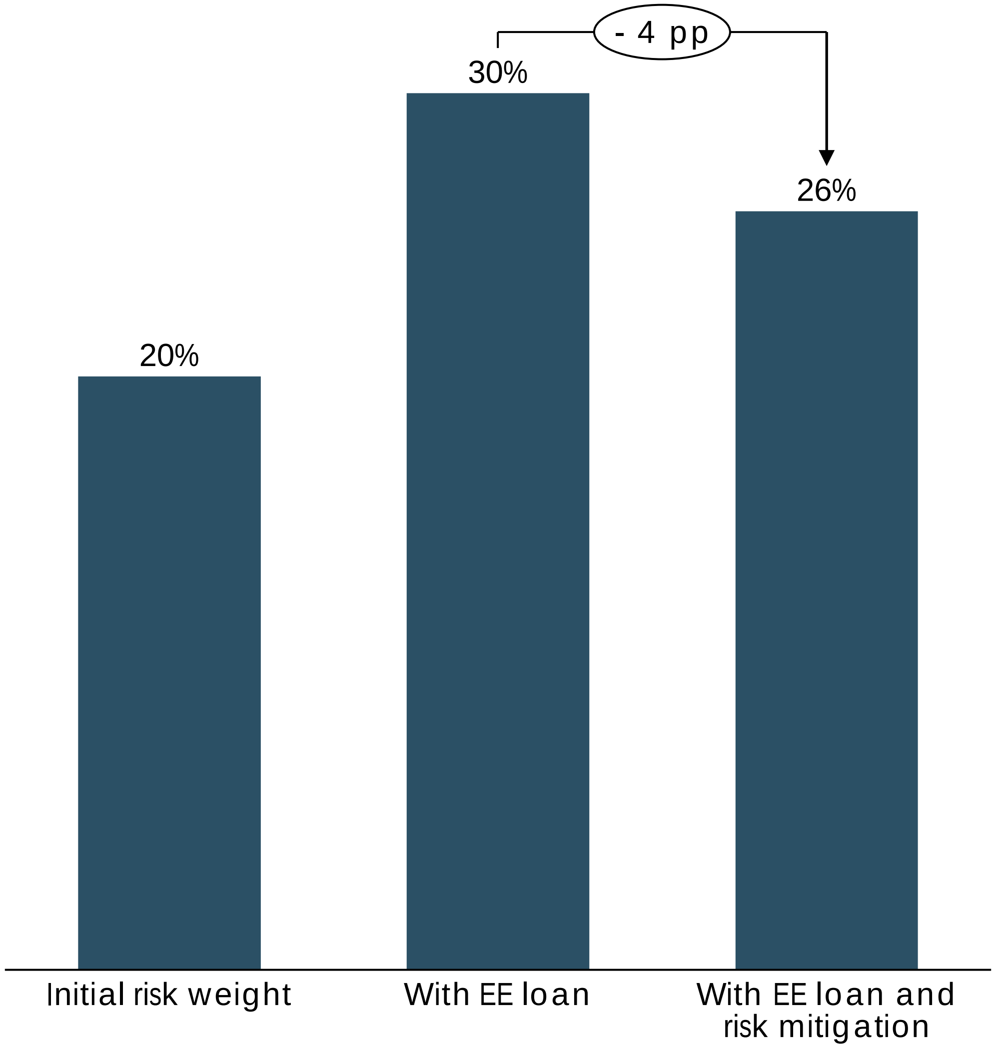
Scenario 1 – Surpassing the LTV limit: Risk mitigating factors become even more important

When the composite loan surpasses the LTV limit, that part of the loan is more expensive

In our main scenario, we assumed that the energy renovation could be financed using the current value of the house as collateral. This is not always the case. It could be that the customer is at the current LTV limit (the collateral has been exhausted). This is typically the case for new homeowners:

- Therefore, <u>without</u> using the value of the renovation as collateral, the entire renovation would have to be financed with an unsecured loan, carrying a risk weight of 75%.
- In contrast, using the value of the renovation as collateral, almost half of the loan to the renovation could be collateralised. This means it can be financed through a mortgage, with a lower risk weight of around 20% in contrast to a consumer loan with a risk weight of 75%.
- Therefore, the risk mitigating factors have a larger impact on risk weights because they reduce the share of the loan that has to be taken out as a consumer loan. Concretely, we estimate the reduction in risk weights to be around 4 percentage points.

Potential impact on borrowing costs
Percent



Scenario 2: Consumers value energy efficiency more than what has previously been observed.

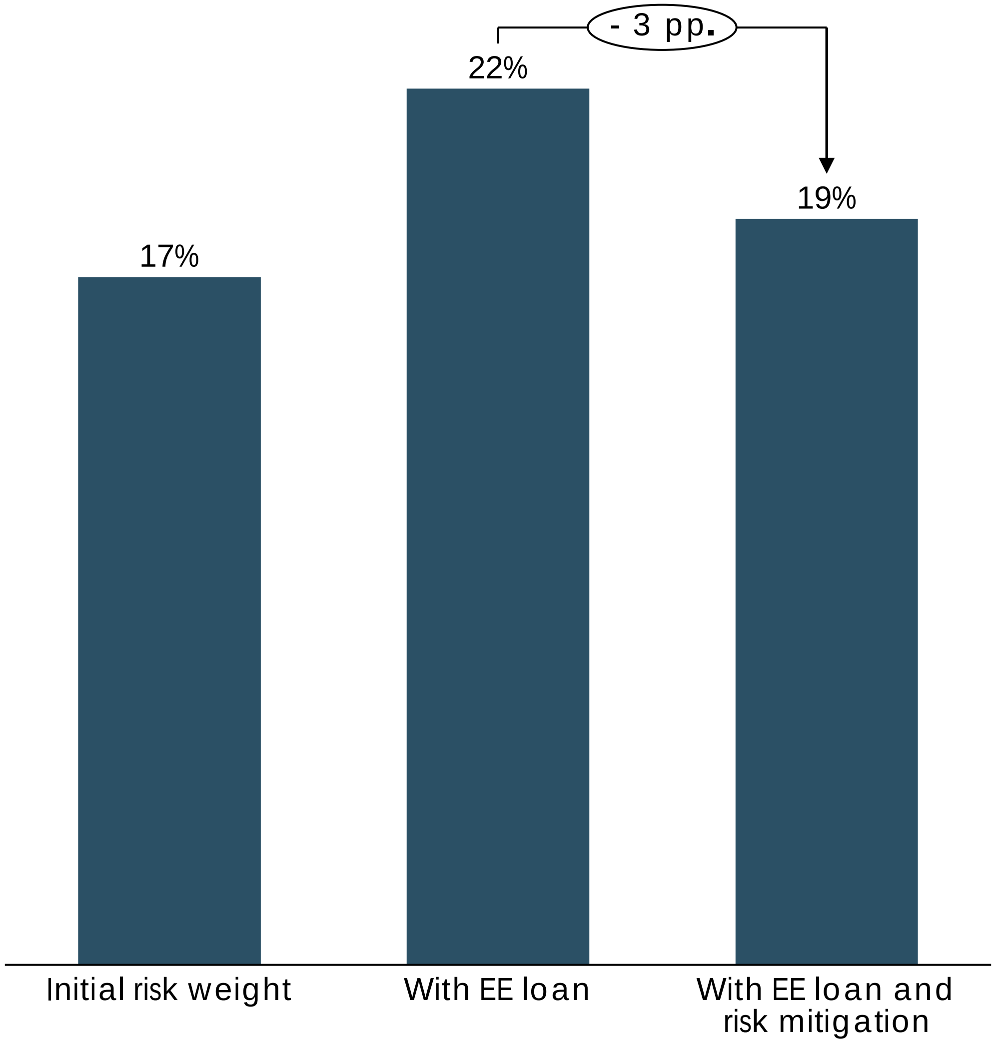
The estimated property price increase might converge to the discounted energy savings

In theory, a rational home buyer should be willing to pay a price mark-up for an energy efficient home that equals the discounted future energy savings (with a maximum price increase that equals the cost of renovation). Using Danish data in a study from 2016, Copenhagen Economics has, however, found increases of only around 60% of the potential future energy savings.[1]

However, it could be that the growing focus on sustainability and energy efficiency in the recent years have increased awareness for energy standards of buildings.

Therefore, in this scenario we assume that the value of the property increases all the way up to the discounted energy savings of the renovation over the investment horizon. This implies a larger decrease in the LTV ratio, if this increase in property value is taken into account. Risk weights decrease accordingly by around 3 percentage points and capital costs are around 5 bps. lower than if the risk mitigating effect stemming from a lower LTV is not taken into account.

Impact on risk weights, second scenario
Percent



1) While the willingness of owners to pay for energy-inefficient houses is reduced by the implicit option to renovate their house instead of buying a more efficient one, the price increase should still be closer to the discounted savings, as found in the analysis of sales prices in Denmark.

Scenario 3: Alternative mitigating effects

Other risk mitigating factors might affect the PD

The PD for a customer might be affected by risk mitigating factors related to energy efficiency other than the LTV and the LTI. Such factors could be the forward-looking attitude of borrowers or the additional possibilities to manage risks for borrowers provided by the bank advising on energy efficiency improvements.

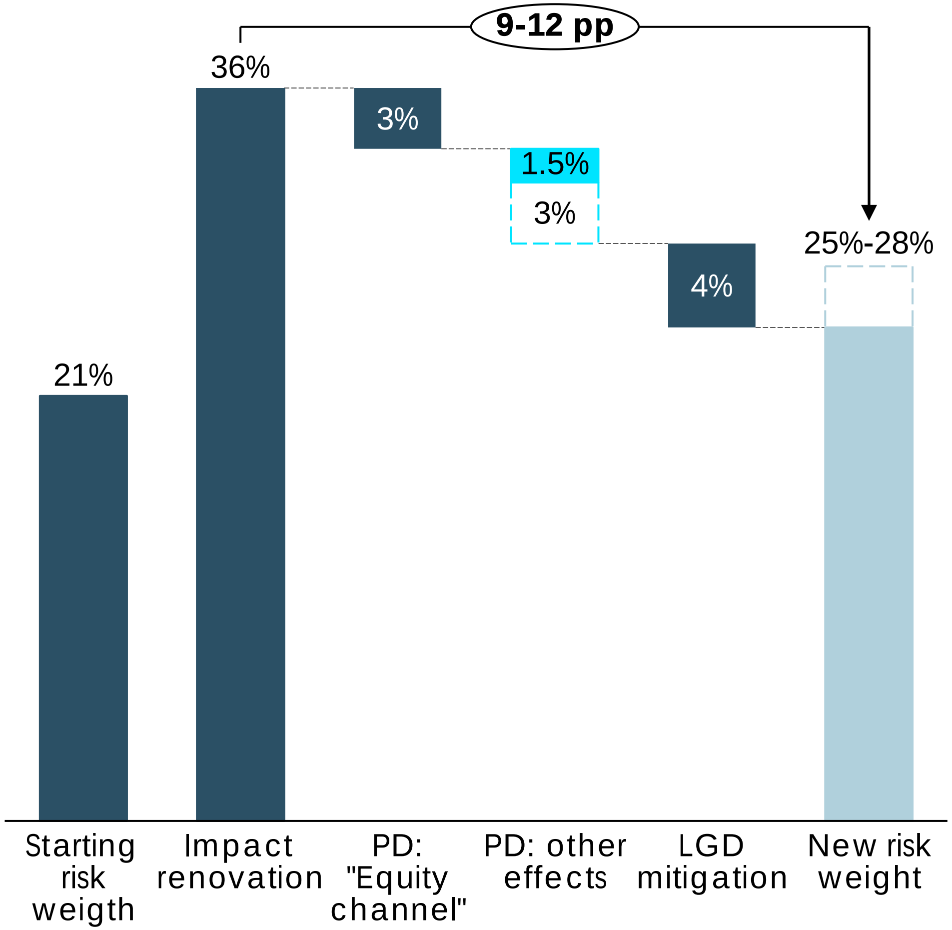
In this scenario, we account for such additional risk mitigation effects by incorporating the estimate of a recent study on the correlation between energy efficiency and the probability of default in our model. The study was prepared as part of the preceding EeDaPP project and finds that an energy efficient building (EPC A) has a PD that is around 0.37 basis points lower than non-energy efficient buildings (EPCs other than A).[1]

Renovating a label F building (note that this is a lower label than the starting point in the other examples) to reach label A, the risk mitigation from the PD impact decreases the increase of the risk weights by close to 5 pp.[2]

The so-called equity channel ('skin in the game') is an important driver of the PD effect.[3] Depending on the degree to which the collateral value is updated after a renovation, this channel accounts for between 40%-70% of the total PD effect. Other PD effects, such as behavioural characteristics described above, could enhance the total risk mitigation by between 20%-40%.

Results from EeDaPP: Impact on risk weights of moving from a label F building to a label A building

Percent



1) See EeDaPP (2020) – Final report on correlation analysis between energy efficiency and risk (D5.7) / 2) For this estimation we use starting values for the EPC and the PD that are aligned with the sample of buildings that was analysed in the study. We start from a median non-efficient home with label F (that is renovated to reach label A) and an average PD in the sample of non-efficient properties of close to 1.5%. / 3) A recent study confirms the importance of the equity channel for the impact on the PD, see An & Pivo (2017).

The impact will be muted for banks not using internal models

Under the standardised approach, the impact from the risk mitigating factors could be less direct

Under the **standardised approach**, the impact from the risk mitigating factors will be impaired. This is because risk weights for mortgage loans under the standardised approach are prescribed by the regulatory framework in a more broad-brush way, based on specific bands for the LTV ratio of the loan (see table below[1]). This makes risk weights less sensitive to changes in the collateral value that drive the impact of energy efficiency investments on risk weights. In many cases, a higher collateral value due to a energy renovation will not move the LTV ratio by the required amount to switch from one band to the next, lower one. In that case, there will be **no impact from the risk mitigating factors** of energy renovations on risk weights. Only if the increase in the collateral value means that the customer changes the LTV band, will capital requirements be reduced (discretionarily). For a solution that takes into account such effects on a customer-by-customer level, standardised risk weights would have to be calibrated in a way that still allows taking into account the risk mitigation factors in a continuous way.

For banks using the **foundation IRB** approach, risk mitigating factors can only be incorporated to the extent to which they affect the PD. This is because under the foundation IRB approach, banks are not allowed to estimate the LGD themselves. This means that the part of risk mitigation that is due to the impact on the LGD **cannot be taken into account**.

Standardised approach: Risk weights for residential real estate exposures by LTV band

LTV band	Below 50%	50%-60%	60%-80%	80%-90%	90%-100%	Above 100%
Risk weight (whole loan approach)	20%	25%	30%	40%	50%	70%

1) The risk weights reported in the table are the risk weights according to the final Basel III framework. See, for instance, BCBS (2017) *High level summary of Basel III reforms* for an overview.

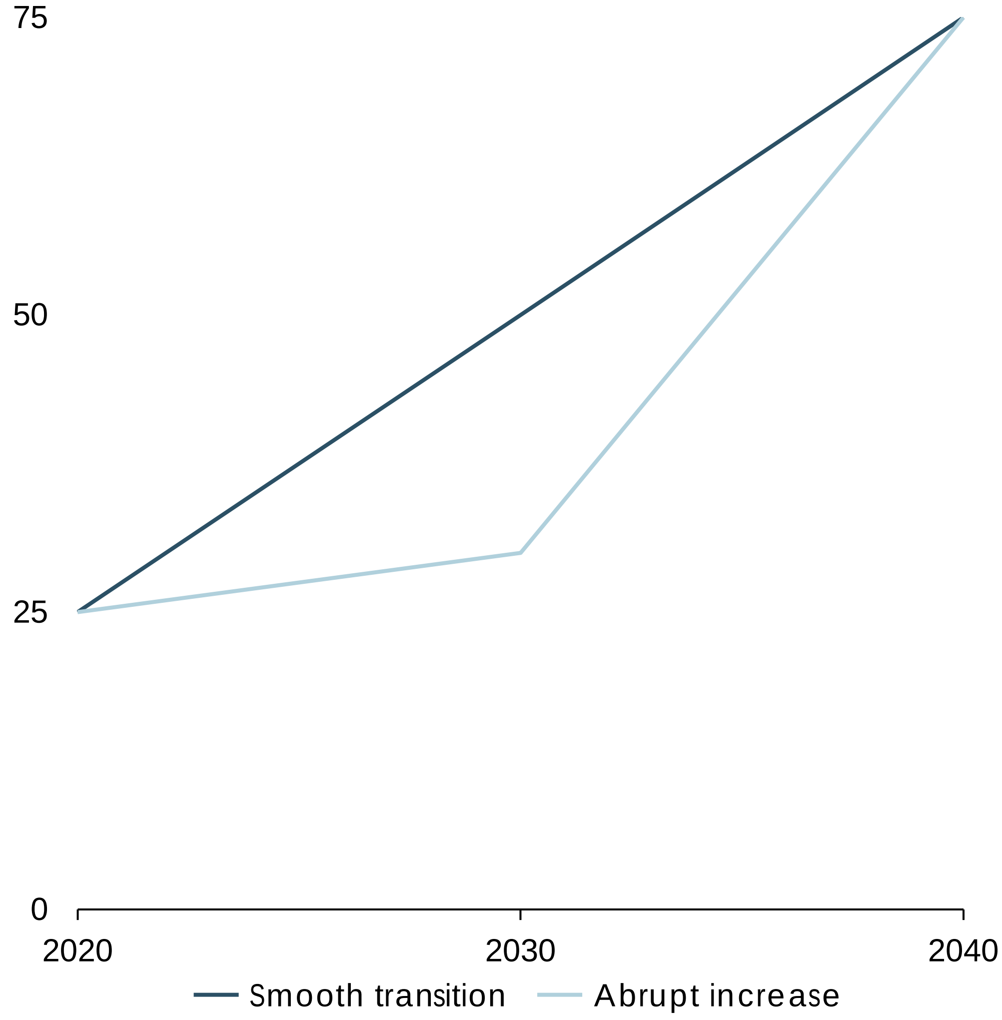
2.3
Forward-looking perspective

In the forward-looking perspective, future transition risks need to be considered

The forward-looking perspective allows to incorporate transition risks

- Transition risks can be expected to affect disposable income and property values in the future. Thus, they have an impact on the risk of a mortgage loan today.
- We capture transition risks by simulating increase in the CO_2 tax.[1] There are two main scenarios that could be analysed: a scenario with an abrupt increase in the CO_2 tax and a scenario with a smooth transition to a higher energy price.[1] We focus on a smooth transition path, following a scenario by NGFS.
- A higher CO_2 tax constitutes a risk for owners of buildings heated with fossil fuels such as natural gas or oil. The idea is that an energy efficient building will be less sensitive to such risks, e.g. buildings that are not heated with fossil fuels would not be affected by a CO_2 tax.
- A higher CO_2 tax would all things equal decrease the value of the building because it increases energy prices. But the increase is larger for owners of less efficient buildings.
- Therefore, energy efficient properties are expected to decrease less in value relative to less efficient houses when the CO_2 tax increases. The associated increase in LGD makes them more risky.
- These lower effects for PD and LGD for EEM buildings means that an increased CO_2 tax results in a **lower increase in risk weights** than for less efficient houses.

Effective CO_2 tax scenario – two scenarios
EUR/tCO_2e



1) Note that other factors could additionally increase the cost of emitting CO_2, such as restricted fossil fuel reserves at low exploitation costs. Our CO_2 price scenario does not consider such potential developments but is calibrated to a CO_2 price increase so as to comply with the Paris climate goals. It is therefore considered an appropriate scenario and illustrative of the impact of higher costs of CO_2 emissions.

How a CO_2 tax could affect risk weights

An increased CO_2 tax **increases the price of energy coming from fossil fuels**.

The increase in the price of energy **increases the price of heating** for buildings heated with fossil fuels.

This increases the heating bill and **reduces the value** of less efficient buildings relative to more efficient ones.

The reduction in value **decreases the collateral**, which leads to a **higher LGD and higher PD**.

The increases in LGD and PD **increases risk weights**.

Buildings are affected differently by increased CO_2 taxes depending on the energy efficiency, type of heating and geography

- Energy efficient buildings are less exposed to CO_2 taxes than less efficient buildings as they have lower energy consumption for heating and therefore of CO_2.
- Buildings that are heated with heat pumps or solar panels are less (or not) exposed to CO_2 taxes.
- Buildings that have low consumption of heat, because they are in warmer climate, are less exposed to CO_2 taxes.

We expect the risks to mainly **materialise in connection with other shocks/crises** (when collateral values become more important), while the impact running through monthly disposable income is most likely negligible (see also Slide 23).[1]

1) Disposable income could further be affected by costs of CO_2 emission that are not related to housing, such as transportation. This could potentially increase the riskiness of the borrower, since this would further decrease the disposable income. Since such effects are not related to the energy efficiency of the building, they are not included in this study.

Transition risks can be analysed in a scenario analysis

What happens to collateral values if CO_2 taxes increases to the level compliant with the Paris agreement or the effective tax in other countries?

Transition risks are very **case-specific** and depend, among other things, on the country in which the property is located, the heating source and the energy efficiency of the building.[1] The question of how a CO_2 tax affects the riskiness of a mortgage loan therefore depends on the specific mortgage. We analyse the impact of an increasing CO_2 tax in a case-specific manner **for the average European household**.

We conduct the scenario analysis in 3 steps:

1. **Estimate the impact on energy costs from an increase in CO_2 taxes**
2. **Estimate the impact on collateral prices**
3. **Estimate the impact on risk weights**

1) See, for instance, BCBS (2021) *Climate-related risk drivers and their transmission channels* for a details on how transition risks can be treated

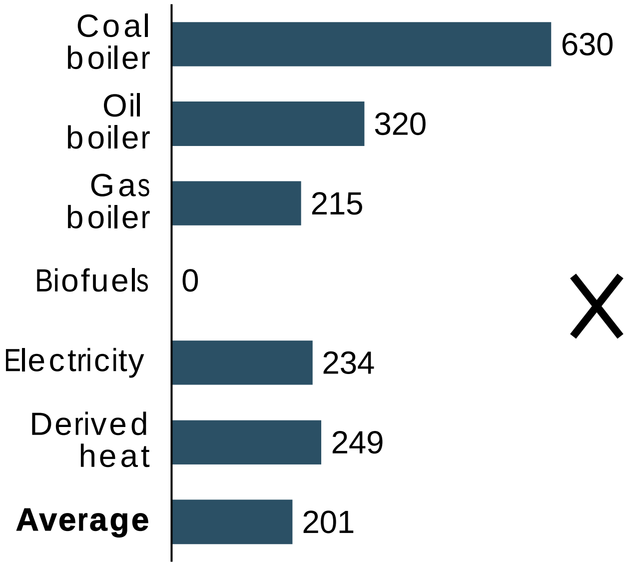
Step 1: An increased carbon tax increases the costs of heating

We examine a case where the cost of heating and cooling increases per kWh when CO_2 taxes increases

- The increased CO_2 price is based on a scenario from the Network for Greening the Financial System[1] that is necessary to reach the climate goals in the Paris Agreement
- This leads to a heating price increase of 2 cents per kWh for an average label D house using the average EU energy mix and average emission factors for different energy sources

Direct carbon emission intensities from different energy sources

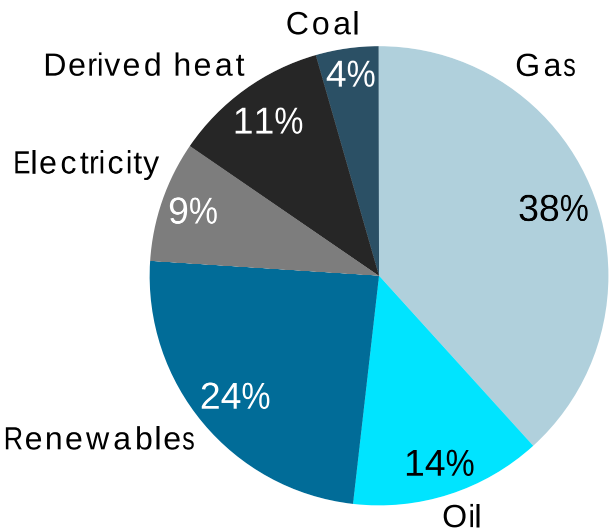
gCO_2/kWh



X

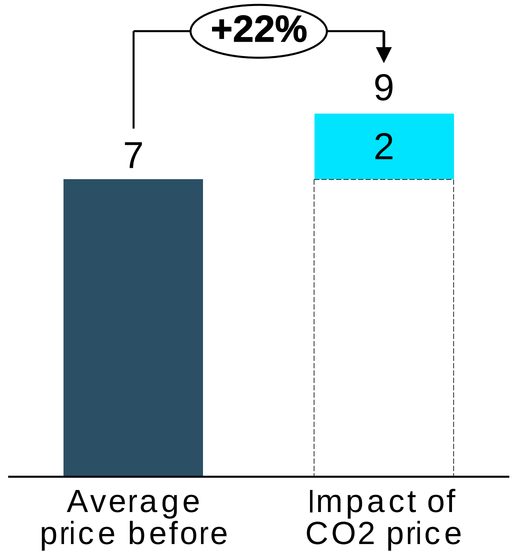
EU energy mix for heat consumption

% of total heat consumption



Impact on cost of heating, average label D house

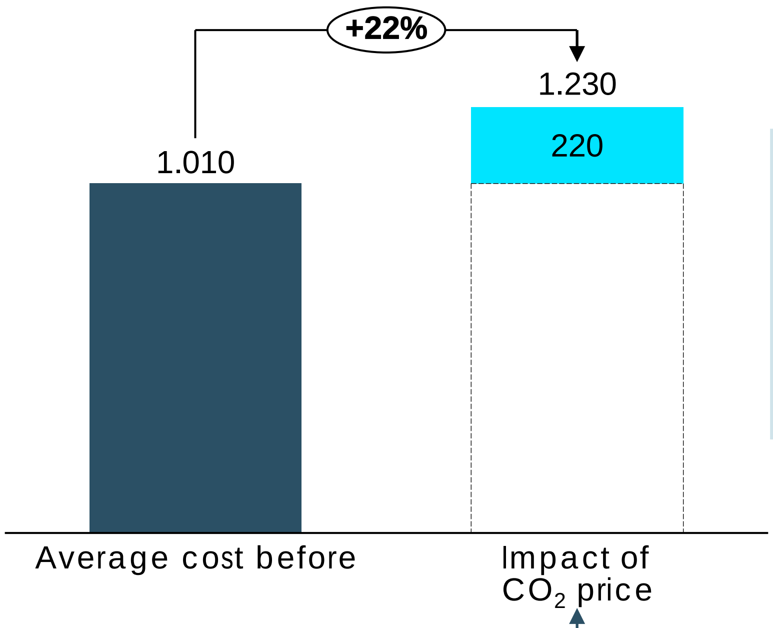
Cent/kWh



1) See NGFS (2020), p. 18.
Note: The impact per kWh does not depend on the energy mix. However, the energy label is important for the total impact on the heating costs.
Sources: Emission intensities: IPCC. the World Nuclear Association, and https://www.benuk.net/Carbon-Emissions-Calculator.html. Energy mix: Eurostat

Step 2: Higher energy prices increase the energy bill and reduce the collateral value

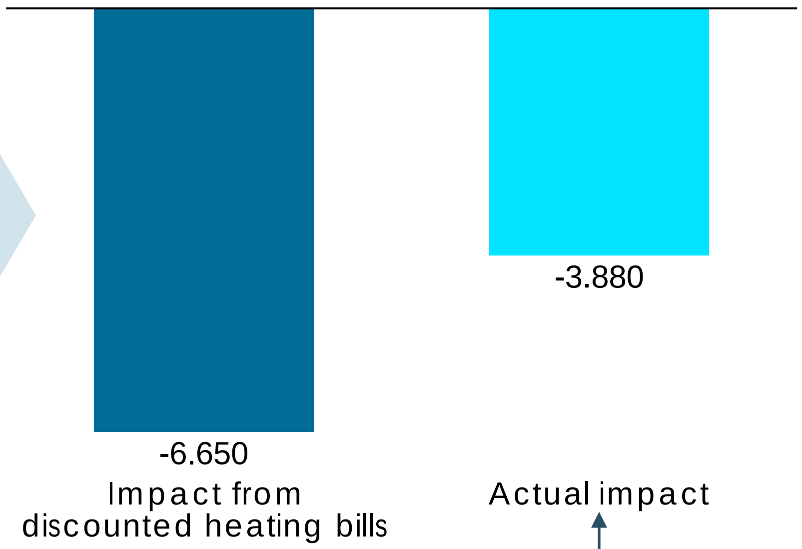
Impact on annual heating bill
EUR, for average label D house in Europe



In this scenario, the heating bill increases **EUR 220** per year for an average house with label D, an increase of **22%**

The increase in heating costs over the investment horizon reduces the **value of the house**

Decrease in house value and collateral
EUR, for average label D house in Europe



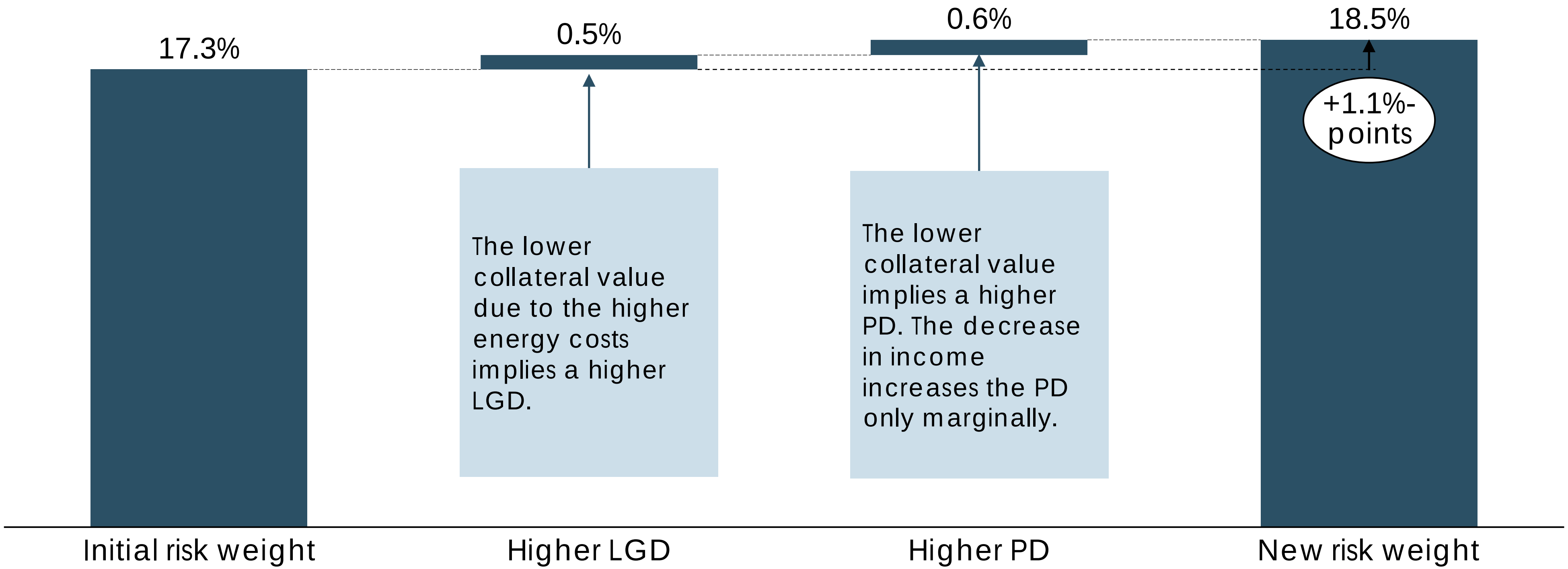
In practice, home buyers seem to **only partly** price in energy-related costs when purchasing a house.[1]

1) See, for instance, Copenhagen Economics (2016) – Do homes with better energy efficiency ratings have higher house prices? In that study, we find that house prices in Denmark reflected only around 60% of differences in energy costs across houses. We apply this 'irrationality factor' in this report to estimate the impact of changes in the energy bill on the property value.

Step 3: The calculated risk weights show that transition risks seem manageable for the average European household

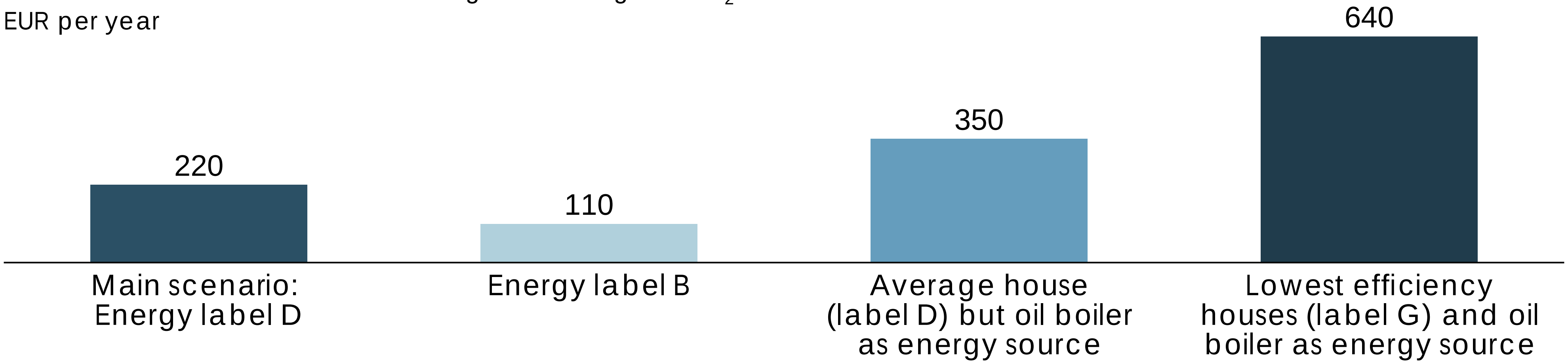
The CO_2 tax affects both the LGD and the PD. The higher heating costs lower the collateral value in the house and increase the LGD because the bank has a higher exposure if the borrower defaults on the loan. This makes it less likely that the bank can recover the entire loan in the event of a default. Furthermore, the lower collateral value also results in a higher PD because it implies a lower equity stake in the property, which makes a strategic default more likely.

Impact on risk weights in our CO_2 tax scenario
Percent, percentage points

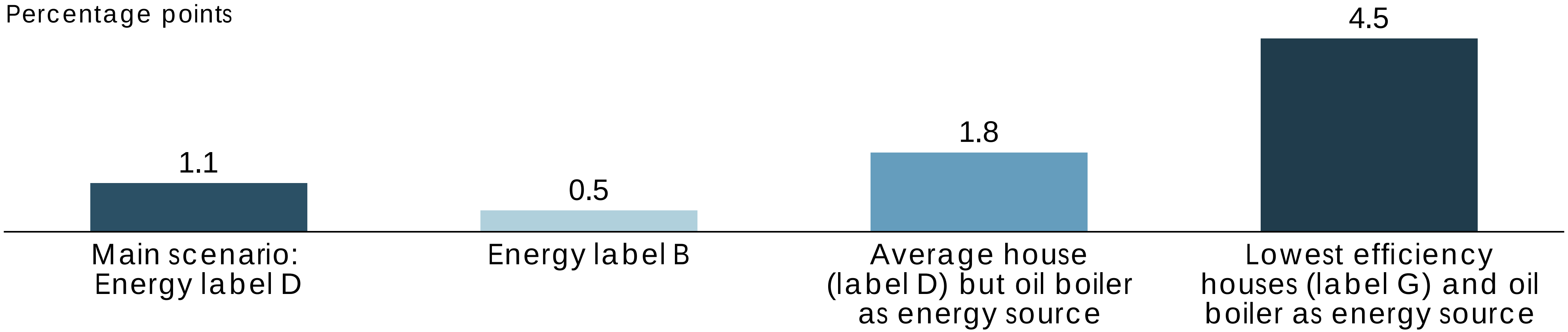


Results from alternative scenarios show heterogenous impact on costs and risks across energy label and energy source

Increase in annual cost of heating from a higher CO_2 tax
EUR per year



Increase in risk weights from a higher CO_2 tax
Percentage points



Note: All cases are based on an average European house.

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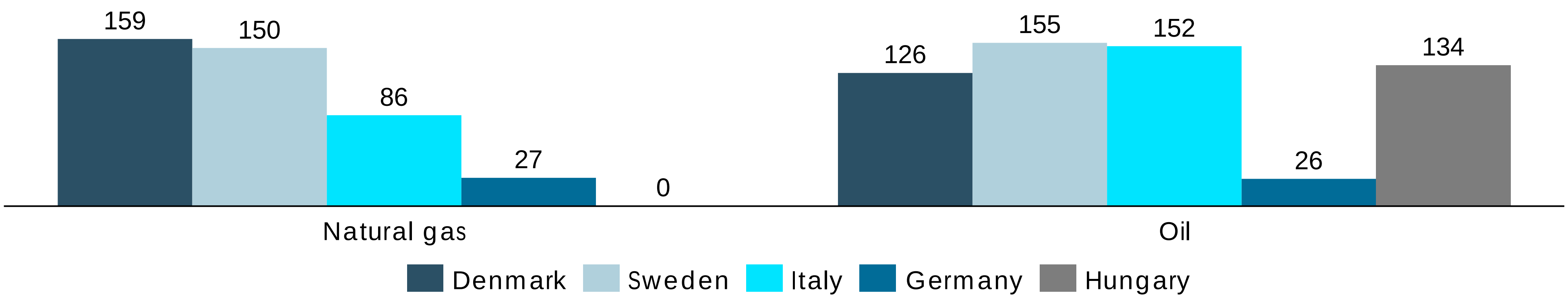
The transition risk varies between EU countries as the effective CO_2 tax for heating varies significantly

For each building, financial institutions should consider the transition risks based on three factors for the cost of heating:

1. **The energy consumption**: The heat consumption is dependent on the need for heating (heating degree days, i.e. geography), the building size and the energy class.
2. **Energy source**: The costs of using oil or electricity for heating vary, and the effectiveness of the heat source also matters. For example, an electric heat pump is a much more efficient heating source than an electric radiator[1].
3. **Energy taxes**: Different energy sources are taxed differently in different countries. For some countries, the energy tax is already high, and for other countries there is a greater potential for increased energy taxes in the future.

Looking across EU countries, there are significant differences in the effective taxation of CO_2 from heating. For natural gas, the effective tax rate is EUR 150-160 per ton emitted CO_2 in Denmark and Sweden, while there is no tax on natural gas for heating in Hungary. If the tax rate in Hungary were to catch up with Denmark or Sweden, this leads to an additional cost of EUR 470 for an average Hungarian household using natural gas for heating in Hungary.[2]

Effective CO_2 tax for household heating with natural gas and oil in selected EU countries
EUR per ton CO_2



*Note: There may be national taxation rules applied in different member states that are not caught in the EC revision. The Danish number has been revised according to Danish rules for heating with electricity. *The EU average CO_2 per kWh electricity has been applied. There are varying emissions from power consumption in different countries. A Euro 30 ETS price is assumed for the electricity production.*

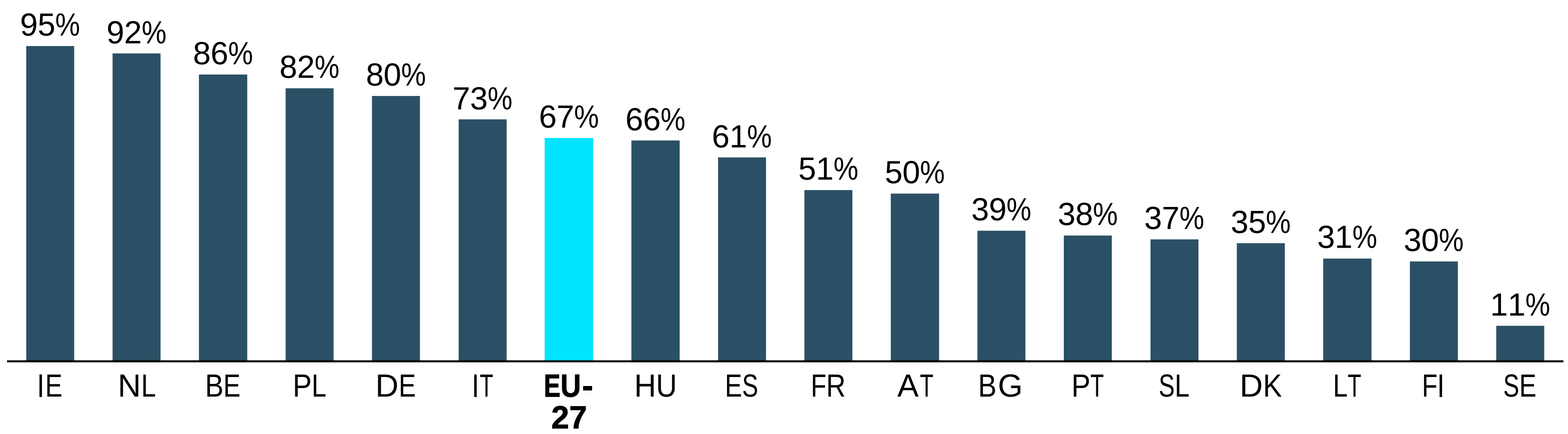
Source: European Commission (2020) Exercise duty tables: Part II Energy Products and Electricity

1) See for example https://aspirationenergy.com/heat-pump-vs-electrical-heater/ / 2) An average Hungarian house consumes 1.28 TOE for heating with natural gas as the standard heat source. Converting this into emissions gives 3 tons CO_2. With a carbon tax increase of EUR 155 per ton, this is approximately EUR 470 per house.

Some EU countries are very reliant on fossil fuel for heating, while other countries are not

Share of fossil fuel heating across EU (selected countries)

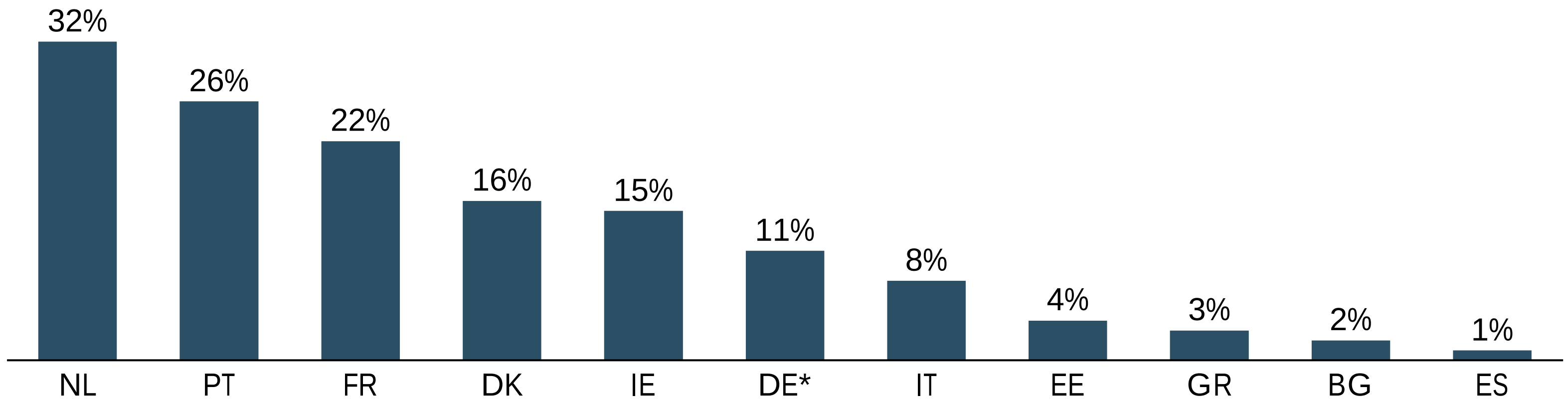
EU countries have vastly different energy mixes in their heating consumption. Ireland and the Netherlands are very dependent on fossil fuels, whereas Sweden has almost no fossil fuel in heating



Note: The shares take into account the fossil fuel based energy consumed when heating with electricity or derived heat.
Source: Eurostat, disaggregated final energy consumption by source

Share of energy efficient buildings (label A or B)

However, the Netherlands also have a high share of energy efficient buildings with lower heat consumption. Spain has a low share of energy efficient buildings, but also has less need for heating as there are fewer heat degree days[1]

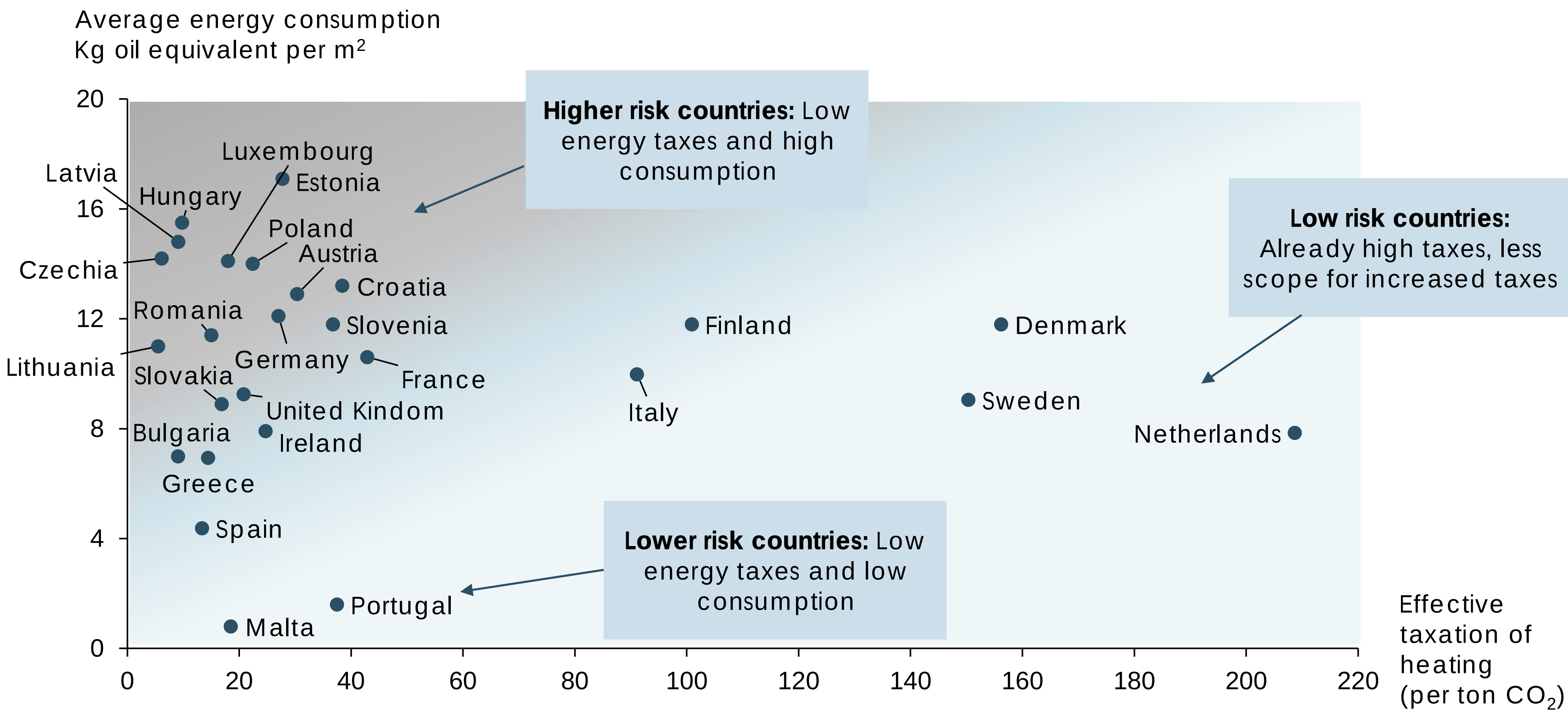


Note: Data was only available for a subset of European countries. Data for Germany are from 2014
Source: BPIE (2020); DENA (2016)

1) This is evident at least in some regions in Spain, see https://www.eea.europa.eu/data-and-maps/indicators/heating-degree-days-2/assessment

Many EU countries have relatively low effective CO_2 taxes for heating, putting buildings at risk of higher costs

Correlation between energy consumption and implicit energy taxes for heating in European countries



Note: Effective taxation of heating by oil, natural gas and electricity covers 41% of the energy used for heating in Europe and are weighted with each country's energy mix of these three sources. Heat energy from e.g. coal, biomass and nuclear is not included. There may be national taxation rules applied in different member states that are not covered in the EC revision.
Source: European Commission (2020) Exercise duty tables: Part II Energy Products and Electricity and X-tendo (2020): Energy performance certificates assessing their status and potential, p. 13

3
Mapping of current treatment of Energy Efficient Mortgages: Are risk mitigating factors included?

Purpose of the chapter: Are risk mitigating factors included in regulatory capital treatment of EEM?

In the previous chapter, we identified two key components of ensuring a fair regulatory treatment of Energy Efficient Mortgages; 1) collateral valuation practices for remortgaging and 2) forward-looking risk analyses.

In this chapter, we analyse whether these two risk mitigating factors indeed are included in the regulatory capital assessment of European institutions. The gap between how the asset should be treated (identified in chapter 2) and how they actually are treated (identified in this chapter), will guide us in providing recommendations to regulatory, supervisory and internal model treatment of EEM.

The extent to which housing value is used as a collateral differs across countries, banks and customers

Collateral valuations differ across European financial institutions

Overall, our research suggests that the extent to which the right collateral are included varies greatly between countries, banks, customers and type of loans.

Collateral valuations are practiced in very different manner across European financial institutions, and this affects capital requirements of the asset on a institutional level.

A fair treatment of energy renovations requires that mortgages can be used for financing

The extent to which a loan is collateralised can greatly alter the inherent risk of the loan, which in turn impact the capital charges and therefore the lending costs that the customer is facing. The best example of this is mortgages. Mortgages use the value of the house as a rather solid collateral – therefore mortgages in EU currently have interest of around 1%-2%, in oppose to unsecured consumer loan, with interest closer to 5%-6%.

Thus, to ensure a fair treatment of lending to energy efficient renovations, it is crucial that the collateral sufficiency is included in the lending.

1) Market value can be either updated using housing price indexes or revaluation by an internal/external valuator. The prior is often used due to lower costs. 2) In Germany, the property valuation is based on the so-called *Mortgage Lending Value* (MLV) that excludes speculative elements.

Four different types of mortgage lending practices that influence how lending to energy renovations can be collateralised

Fundamentally, we have identified four different types of mortgage lending practices that influence how lending to energy renovations can be collateralised. Here, ranging from the most efficient to the least efficient use of collateral:

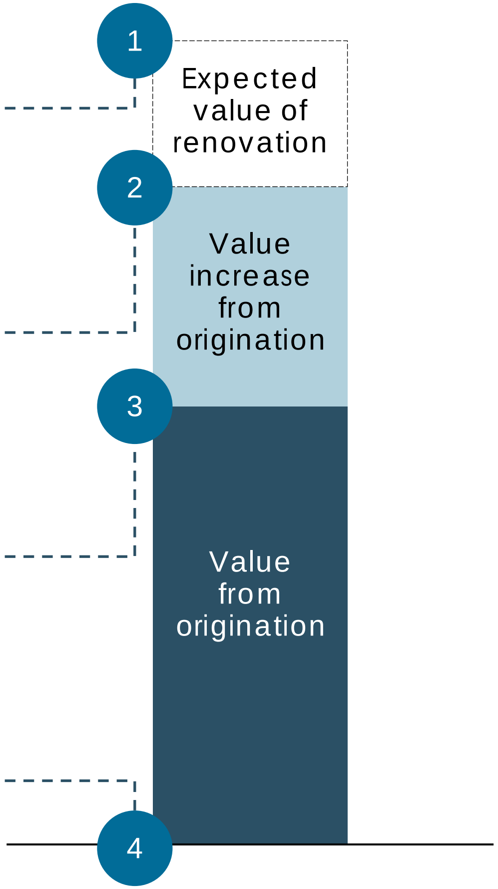
1. Mortgage type: Remortgaging based on expected future value including value of renovation
Consequence: Enables a fair treatment of energy renovations where risk mitigating factors are included, corresponding to the main case in chapter 2

2. Mortgage type: Remortgaging based on present value not including value of renovation
Consequence: Current value of the building can be used as collateral. This includes any house price increase since origination

3. Mortgage type: Remortgaging based on value of origination
Consequence: The value of the house at origination can be used as collateral, but only based on previous repayments of the loan

4. Mortgage type: Remortgaging not possible
Consequence: The borrower cannot use the value of the house as collateral to finance energy renovations; finance to the renovation has to be an unsecured consumer loan or private savings

Illustration: Valuation of collateral in different mortgage models



In the following, we will go through each of the four types

Using the expected future value for remortgaging: Appropriate treatment of energy efficient mortgages but rarely the case

Loan characteristic	
Description of loan	The value of the property is updated both with respect to underlying changes in house prices and the impact on the property value of the energy renovation. The expected future value of the property is the basis for remortgaging.
Consequence of loan type	Homeowners can use the potential increase in the property value, after the renovations is finished, as collateral, even before the renovation takes place. We estimate that this will allow new homeowners to finance around half of their renovation costs with a mortgage loan. This model is aligned with the fair treatment of EEM as outlined in Chapter 2.
Gap to best-practice	No gap. Risk mitigating factors are correctly included.

When is it used?	
Which countries?	Credit institutions rarely use the expected future value of mortgages as the collateral value. In Scandinavia and Spain, we have identified some mortgage banks that offer mortgage products based on the expected future value, but this is often not the practice.
Which situations?	This typically applies to large renovations. The savings from lower capital charges have to exceed the costs from the valuation for this to be profitable.

Using the present value of the property: Ignores the risk mitigating factors of energy efficiency

Loan characteristic	
Description of loan	The value of the property is updated only with respect to underlying changes in house prices but does not take into account the impact on the property value of the energy renovation. The pre-renovation value of the property is the basis for remortgaging.
Consequence of loan type	A renovation can be mortgage-financed only if the lending need stays within the current LTV limit. For example, if the LTV limit was maxed out at origination, it requires the repayments and potential increase in collateral since origination surpass the cost of the renovation. New homeowners have to use consumer loans or private savings to finance the renovation.
Gap to best-practice	Will depend on development in house prices and the size of repayments. If there is sufficient collateral within the LTV limit, the gap will be as in the main case in chapter 2, i.e. 4 basis-point. For new homeowners without additional funds, the gap to best-practice will be the difference between a typical mortgage rate and a consumer loan, e.g. 4-5 percentage points.

When is it used?	
Which countries?	Most European credit institutions allow for using the present value of the collateral. This is for instance the case in Sweden and the Netherlands.[1] There are country- and bank-specific variations in the calculation of the present value. Automated valuation models, indices and internal/external valuators are the most frequently used.
Which situations?	This approach seems to be the most common among European credit institutions.

1) ECBC Factbook (2019)

Remortgaging only based on value at origination: Mortgage loan for energy renovations unlikely

Loan characteristic	
Description of loan	The value of the property is not updated at all. The value of the property at the origination of the loan is the basis for remortgaging.
Consequence of loan type	Homeowners can only withdraw home equity equal to the amount they have already repaid as the collateral value is capped at the origination. Any house price increases from the time of origination is not taken into account. For new homeowners or homeowners who have not repaid sufficiently, it is not an option to finance renovations through their mortgages.
Gap to best-practice	With this type of loan only previous repayments can be used as collateralised lending, increasing the risk that lending to energy renovation will be based on unsecured consumer loan.

When is it used?	
Which countries?	We find this to be specifically pronounced in some countries, but there are variations between credit institutions. In Germany, the collateral value for *Pfandbriefe* is calculated using the *Mortgage Lending Value* which attempts to correct for speculative elements in the market price.
Which situations?	This approach is relevant in jurisdictions with a conservative valuation of property values and where updating the property value is associated with high costs for the credit institution and/or the borrower.

Remortgaging not possible: Not possible to obtain a mortgage loan for energy renovations

Loan characteristic	
Description of loan	The lending conditions are set from the beginning with fixed amortisation throughout the duration of the loan.
Consequence of loan type	Collateralised lending to energy renovation is not possible. Possible source of finance are unsecured consumer loans and private savings.
Gap to best-practice	The gap to best-practice would be the difference in interest rate between a mortgage loan and a consumer loan – typically around 3-4 percentage points. This is equivalent to around EUR 1,800 a year for a EUR 50,000 renovation.

When is it used?	
Which countries?	We find this to happen in some countries, but it varies between credit institutions. No member states do *not* allow for refinancing of mortgages.
Which situations?	Our research shows that mortgage products are not always profitable for the credit institutions. In cases where it is too expensive to remortgage, banks do abstain from offering the possibility of refinancing the loan.

Restrictions on remortgaging have cause in financial stability concerns

In some countries, remortgaging based on current value is prohibited due to financial stability concerns

Frequent revaluations of property prices can have undesirable effects on financial stability for institutions. An increase in reported property prices cause risk weights of mortgages to decline. This implies *lower* capital requirements in times when housing prices are increasing. This gives banks an increased leverage, further stimulating credit growth in an already expanding economy.

Revaluations could therefore be *procyclical,* enhancing business cycle fluctuations.

The Final Basel III framework allows for revaluations in case of large renovations

The work around the Final Basel III framework has incorporated these concerns, but in the same time made sure renovations can be used as collateral.

The Basel Committee generally advocate for the use of property value at origination. However, according to the new Basel package, the value of the property feeding into the regulatory LTV can be updated when a modification *unequivocally* increases the value of the property.[1]

This allows for renovations to be used as collateral without evoking financial stability concerns over procyclical capital requirements. However, it leaves the challenge for European banks in practice to assess the value of a renovation isolated from the general market trends in housing prices.

1) See BCBS (2017), p. 20

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There is little room for assessing forward-looking climate risk in the current capital regulatory framework

Current situation: Only some credit institutions incorporate forward-looking analyses in their risk management

We find that the integration of climate risks into banks' risk models is still **at an early stage**. While some banks are increasingly emphasising forward-looking models for assessing climate risks, they also indicate that minor attention has been given to incorporating them into the risk management systems. Current forward-looking analyses mainly take the investor point of view and much of the work that has been undertaken so far has been associated with initiatives such as the UN Environment Finance Initiative or the Task Force on Climate-related Financial disclosure (TCFD)[1].

Our research points to uncertainty as the main reason why many banks are still cautious about implementing forward-looking models into their risk management. The nature of future climate risks are highly unpredictable and any forward-looking model is therefore much dependent on the underlying assumptions. Until a **unified framework** is adopted this can be a factor keeping credit institutions from taking further steps in that direction.

Barrier: A feasible bottom-up approach is still to be developed

Our research indicates that there are still gaps to be filled before a workable forward-looking methodology is ready to assess the climate risk of individual real estate exposures. For a scenario-based framework to be relevant for the risk management, a **bottom-up approach** is necessary to capture the individual characteristics of the property.

At this point, forward-looking analyses are most commonly used to assess the climate risk **on a portfolio level**. One reason is that data granularity is not yet sufficient.[2] Therefore, most credit institutions employ a top-down approach to assess transition risks regarding real estate.[3]

1) NGFS (2020) p. 15 / 2) NGFS (2020) p. 10 / 3) UNEP FI (2019)

Most banks evaluate probability of default using disposable income before energy bills

Current situation: Banks use disposable income before energy bills in credit risk models

Our research indicates that the energy bill has **very little impact** on the credit risk of the customer and thus on mortgage rates.[1] In line with that, European credit institutions rarely take the energy bill of the customer into account in the risk management systems. This means that savings from energy efficiency improvements are not reflected in the credit risk models of individual exposures and can therefore not lead to lower capital charges. The case for including the energy bill in the credit risk assessment therefore does not seem to be very strong.

Moreover, the most commonly used disclosure template for the collection of mortgage data, the RMBS template from the ECB, only requires reporting of primary income measured as the gross annual income.[3] In 2017, ESMA was mandated to develop a new reporting template, a work that is yet to be finished. Though EPC ratings are to be included, the income type will likely not change.

Barrier: In many countries data is not available

A key challenge is that **data on the energy usage** for homeowners is unavailable. There is a need to establish a standardised methodology to either estimate potential savings[4] or to access actual utility bills.

The extent to which these issues are at play varies across member states, and in some countries, such as the Nordics, data are more easily accessible. In any case, the fact that the energy bill seems to play a minor role in the customers' credit risk taken together with the limited data availability suggests that the inclusion of the energy bill in credit risk models is **less relevant**.

1) See, for instance, Gaudêncio et al. (2019) for an estimate of the impact of the loan-to-income ratio on the risk of borrower default. / 2) Based on interviews conducted with financial institutions / 3) https://www.ecb.europa.eu/paym/coll/loanlevel/transmission/html/index.en.html / 4) UK Green Building Council (2015) investigates methods to estimate utility costs from EPC ratings

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APPENDIX 1

Market research and methodology

There are common models for financing real estate purchases in Europe

Table overview of typical real estate financing models in Europe

	Primary funding	Collateral	Asset owner	Typical loan type
Balance sheet model	Deposits, covered and uncovered bonds Funding mix is country-dependent[1]	Real estate	Originator Banks issue mortgage-backed loans	Fixed rate, 20-25 years maturity, early repayment for a fee
Special issuer model	Covered bonds	Real estate	Originator Specialised entities issue mortgage loans that are fully secured by covered bonds	Variable interest, 30 year maturity, early repayment, annuity and interest only amortisations
Securitisation model	RMBS	Real estate	Special-purpose vehicle Assets are removed from credit institutions' balance sheets	Variable interest rate, 25-30 years maturity, early repayment, annuity and interest only amortisations

1) ECB (2009), p. 39 / 2) Comprehensive programs are established around Europe, e.g. in Germany (KfW) and Italy (POR and PON), which offers financing for energy renovations at very favourable terms. See Appendix X, for descriptions of public support schemes.

Regulatory capital model: The impact of risk mitigating factors on risk weights and interest rates (1)

In order to estimate the impact of the two identified risk mitigating factors (collateral value and disposable income), we set up a **regulatory capital model** for a generic European bank. The primary inputs to this model are the changes in the probability of default (PD) and loss given default (LGD). The median LGD and PD for the largest European banks[1] serve as a starting point for the model and result in an average risk weight for mortgages in Europe of around 17%.

Energy efficiency investments have a positive impact on the value of the property (affecting the LTV ratio) and the disposable income of the borrower (affecting the LTI ratio). The resulting changes in the PD and LGD directly affect risk weights which, in turn, affect the banks' cost of capital and thereby borrowing costs for bank customers. The impact on borrowing costs compared to a situation where risk mitigating factors are not taken into account, provides an estimate of the importance of appropriately including energy efficiency aspects in the capital requirements framework.

The impact on the LTV ratio

The LTV ratio is one of the most important determinants of the LGD[2] and has also been found to affect the PD.[3] It is therefore a very relevant metric in the assessment of credit risks.
Definitions of the LTV, however, differ depending on whether the loan and house values are updated or not.[4] If the impact on the collateral (the 'value') of energy renovations is updated correctly, this will reduce the LTV ratio and thereby decrease the risk inherent in the loan relative to a situation where the impact on the collateral is not taken into account.

We base our estimate of the impact that an 'average' energy renovation has on the property value, on a set of previous studies in different European countries.[5]

The impact on the LTI ratio

Changes in the LTI ratio directly affect the PD: a lower indebtedness (i.e. a lower LTI ratio) implies that the borrower is less likely to default. If the energy savings due to a more energy efficient home are included appropriately, this will reduce the PD and thus the risk inherent in the loan.

The initial LTI ratio is based on the average mortgage loan for a certain energy label and the income of an average family in the respective country taken from Eurostat's annual net earnings database.

The impact of changes in the LTV and LTI ratios on PD and LGD

When appropriately accounting for the risk mitigating factors of energy efficiency, both the LTV ratio and the LTI ratio can be expected to decrease. A lower LTV ratio is both associated with a lower LGD and a lower PD; a decrease in the LTI ratio implies a decrease in the PD. Both effects make a loan less risky and should therefore entail lower risk weights.

In our regulatory capital model, we use estimates from previous studies on the strength of the correlation between LTV and LTI ratios and LGDs and PDs. In particular, we use the estimates of the impact on the PD from Gaudêncio et al. (2019): They use a Probit model with a large set of control variables and account for country heterogeneities to obtain euro area aggregate estimates of the impact on the PD. Their authors find that, evaluated at the mean of all variables, a percentage point increase in the LTV ratio and LTI ratio increases the probability of default by 0.02 and 0.001 percentage points, respectively.

The estimated impact of changes in the LTV on the LGD is taken from Siemensen & Vilsmeier (2017). Within a stress test framework, the authors translate changes in the LTV ratio to corresponding LGDs, based on two previous studies for the US and Finnish mortgage market. Their results suggest that the LGD increases by around 0.3 percentage points for every 1 percentage point increase in the LTV ratio.

1) See, for instance, EBA (2019)Annex – Chart Pack 2) See, for instance, Siemensen & Vilsmeier (2017), p. 11 / 3) See, for instance, Gaudêncio et al. (2019). One theoretical explanation for this relation is that borrowers with a lower LTV ratio have more equity invested in the loan, which reduces their incentive to default on the loan. / 4) For an overview, see Thebault (2018) / 5) See p. 61 for an overview of the studies.

Regulatory capital model: The impact of risk mitigating factors on risk weights and interest rates (2)

The impact of changes in PD and LGD on risk weights and the cost of capital

Our regulatory capital model then translates changes in PD and LGD into associated changes in risk weights. The basic underlying formula for this estimation is defined in the current European Capital Requirement Regulation (CRR) (No. 575/2013, Article 154). Banks applying the internal approach to credit risk can use their own models to estimate PD and (downturn) LGD but have to apply the formula given in the CRR to obtain the risk weight for a loan. The calculation of risk weights is based on a theoretical framework developed by Vasicek (2002) and should make sure that banks can cover *unexpected* losses, also in the case of most negative tail events.[1]

When the PD and LGD decrease due to the risk mitigating factors inherent in investments in energy efficiency, the regulatory capital model allows us to calculate the impact changes in PD and LGD have on risk weights (risk weights will decrease if the PD and LGD decrease). Lower risk weights imply lower capital costs for banks because this allows banks to hold a smaller capital buffer for a specific loan. Since capital is a more expensive way of funding for a bank than debt, this will make the loan less costly for the bank. When banks pass on these costs savings to consumers, borrowing costs will decrease as a result of the lower capital costs.

We estimate the impact on borrowing costs by calculating a weighted average of the cost of the loan and assuming a full pass-on to consumers. This calculation is based on the following assumptions:

- Cost of capital (before tax): 13%
- Debt funding rate: 1.4%
- Average EU CET1 ratio: 14%

The assumption on a cost of capital of 13% (before tax) is based on a report by ZEB (2018), finding an average (after tax) cost of capital of around 10% and an average corporate income tax in the EU of 22.5%. The debt funding rate is calculated on a country level by dividing bank interest expenditure by total financial liabilities of the largest banks within a country. For all the largest banks located within the EU-27, this amounts to a debt funding rate of around 1.35%. The CET1 ratio is calculated on a country level as the share of CET1 capital over total risk weighted assets of the largest banks within a country. In the entire EU-27, the average CET1 ratio of the largest banks is around 14%.

1) See, for instance, BCBS (2005).

The impact of energy efficiency on energy costs and house prices

Energy performance certificates and energy consumption

The energy performance certificate (EPC) introduced through the European Energy Performance Building Directive (EPBD) measure the energy efficiency of dwellings and allows potential buyers to compare the energy performance of different buildings. However, EPCs are not directly comparable across countries. While all EU member states have introduced EPCs, the EPBD leaves some leeway for member states on how to use EPCs and practical implementation therefore differs across European countries.[1]

To make the EPCs more comparable across countries, we combine the information from three different sources:

- Information on the **median EPC** in European countries from BPIE (2020)[2]
- The **average heating consumption** per square metre from the Odysee-Mure database
- The relative difference in energy consumption between energy ratings (A to G) from Copenhagen Economics (2016), which is based on the Danish definition of EPCs[3]

This provides us with an estimated **average energy consumption** for heating within each EPC and for each of the EU-27 member states.

Energy prices

The average energy consumption for different EPCs together with data on energy prices for different fuel sources allow us to estimate the yearly energy costs for houses with different EPCs and different energy sources used for heating and cooling. We have obtained prices of different energy sources used for heating/cooling from the following databases:

- **Natural gas**: Eurostat, gas prices for household consumers (2018), including taxes and levies (medium household, band D2)
- **Coal**: Heat Roadmap Europe (2017), latest available data series from 2015.
- **Oil**: European Commission (2019), assuming an average oil boiler efficiency of 85%[5]; 2018 prices.
- **Renewable energy**: Average price for primary solid biofuels and heat pumps based on the share of the respective energy source in total renewable energy consumption from Eurostat (disaggregated final energy consumption in households). Solid biofuels prices are from Heat Roadmap Europe (2017) for the year 2015, and heat pump energy prices are based on average electricity prices assuming an effective efficiency of heat pumps of 300% (3kW thermal energy per kW electricity).
- **District heating**: Energiforsk (2016); latest available data series is from 2013. In countries where district heating prices are missing, we use the average price for all countries in the sample.
- **Electricity:** Eurostat, electricity prices for household consumers (2018), including taxes and levies (most representative band; if not reported, band DC is assumed)

Average energy prices per country are calculated as a weighted average based on the energy mix of each country from Eurostat's disaggregated final energy consumption database.

The impact on house prices

Energy efficiency improvements lead to a reduction in monthly energy expenses. An improvement in a dwelling's energy efficiency should therefore also increase its value because future savings of energy costs would be priced in by a rational home buyer. We calculate the theoretical house price increase as the sum of the discounted yearly energy savings from the increased energy efficiency over an investment horizon of 30 years and with a discount rate of 2.6%.[6]

The results of a previous econometric study on the impact of energy efficiency on home values suggest that property prices only increase by around 60% of the theoretical energy savings due to the higher energy efficiency.[7] This means that energy efficiency does not seem to be fully priced in when it comes to house sales prices. We use this 'irrationality factor' of 60% to estimate the impact on house prices from the theoretical price increase based on discounted energy savings. The closer the irrationality factor is to 100% (full pricing in of energy efficiency), the larger the impact of higher energy efficiency will be on collateral values, risk weights and the cost of capital for the mortgage loan.

Several studies have found evidence for a price increase in the dwelling after increasing its energy label, but the estimates differ across countries and studies. We use an average of the estimated impacts in different studies as the impact of energy efficiency on house prices (see p. 61 for an overview of the studies and the impacts they have found).

1) See, for instance, BPIE (2014) and Brocklehurst (2017) / 2) For countries where the information on the median EPC was missing, we assumed that label D was the median EPC / 3) This assumes that the relative energy savings form one label to a higher one is the same in all EU countries. That allows us to estimate the energy consumption within different EPCs, starting from the average energy consumption in each country. / 4) See, for instance, European Commission (2017), Table 7 / 5) See, for instance, DG Energy (2016), p. 11 / 6) This is based on Copenhagen Economics (2016) where a real discount rate of 2.6% is assumed. / 7) See Copenhagen Economics (2016)

Forward-looking perspective

The transition to a low-carbon economy can be analysed as a scenario of an increasing price for emitting CO2. A tax on CO2 emissions will make energy efficient properties more attractive, thereby decreasing the riskiness of energy efficient buildings relative to inefficient ones.

Transition scenarios

We have incorporated two transition scenarios from the *Network for Greening the Financial system (NGFS)* in our model.[1] Both scenarios represent a path of CO2 price increases and are calibrated to keep global warming well below 2 °C. In the *orderly scenario*, the CO2 tax is introduced immediately and is assumed to increase by USD 10 per tonne of CO2 emitted. This is the main scenario we analyse in our report and correspond to a smooth transition path. In the *disorderly scenario*, the CO2 price will only be introduced after 2030 but will then have to increase by USD 35 per tonne CO2 to make up for the lost years in the beginning. In our analysis, we focus on the *orderly scenario*, which, in general, will have a smaller impact on risk weights than the disorderly scenario since the resulting CO2 price is smaller.

Emission intensities

Transition risks that banks face are portfolio-dependent because different energy sources have different CO2 emission intensities and because buildings have different levels of energy efficiency. To estimate the impact of a CO2 price on energy prices, we assume the following (direct) emission intensities for electricity generation[2]:

- Coal: 760 gCO2eq/kWh
- Oil products: 580 gCO2eq/kWh
- Natural gas: 370 gCO2eq/kWh

Emission intensities for heat generation are assumed to be the following[3]:

- Coal boiler (assumed efficiency of 50%): 630 gCO2/kWh
- Oil boiler (assumed efficiency of 85%): 320 gCO2/kWh
- Gas boiler (assumed efficiency of 85%): 215 gCO2/kWh

Together with data on energy efficiency and heating source, we then calculate the impact of the CO2 price on the energy costs for a specific homeowner or on average for a selected country (based on the average country energy mix for heating). For this, we use the discounted (over the 30 year horizon assumed before) value of the implemented CO2 price in the respective scenario.

1) The NGFS, established in December 2017, is a group of more than 80 central banks and financial supervisors that has the goal to strengthen the global response required to meet the goals of the Paris agreement. See NGFS (2020) for a detailed description of the transition scenarios. / 2) Based on data from IPCC ('Emissions of selected electricity supply technologies') and the World Nuclear Association. / 3) Based on data from the UK's Ground Source Heat Pump Association and Parliamentary Office of Science and Technology(2016).

Sensitivity of the model results

Our results are case-specific and based on assumptions about the starting average house price, the discount rate and the 'irrationality factor' which all affect the results. We discuss the sensitivity of the results with respect to these three factors in the following.

Average house prices

The starting average price of a home that is subsequently renovated affects the results because the higher the cost of the renovation relative to the house price, the larger the impact of the renovation on the LTV ratio. Consequently, the impact of taking into account the house price increase due to the energy renovation will also be larger for a less pricy house, since renovation costs can be expected to be similar for houses of the same size but with different house prices. While the location of a house, for instance, affects the house price, it should not affect renovation costs significantly. In our cases, we depart from the average price for a 100m² house from a previous study by Copenhagen Economics based on Danish data.[1] We use Deloitte's property index[2] from the same year to estimate average house prices in all European countries. This results in an average price for a 100m² house with energy label D of around EUR 130,000.

Discount rate

The discount rate affects our results through different channels. In the analysis of the current perspective (not taking into account the forward-looking scenario), the discount rate affects the maximum renovation costs which are capped at the theoretical energy savings over the investment horizon. This ensures that we only include renovations which are just profitable for the homeowner. The theoretical energy savings are based on future discounted savings in energy costs due to the higher energy efficiency after the renovation. In general, the higher the discount rate, the smaller the discounted future energy savings and the smaller the discount rate, the higher the savings. In our analysis, we assume a real discount rate of 2.7% and an investment horizon of 30 years.[3] This results in renovation costs from renovating a 100m² house from label D to B of around EUR 11,000.

Irrationality factor

Based on the previous study by Copenhagen Economics, the impact of energy renovations (and thus a lower future energy bill) is not fully factored into sales prices. The study finds that house prices increase by only around 60% of the discounted future energy savings due to a higher energy efficiency after the renovation. We apply this 'irrationality factor' when translating energy savings into house prices. The closer the impact on house prices to the actual savings, the higher the impact of an energy renovation on house prices and risk weights. Another analysis based on data from the Netherlands[4] has found that around 80% of energy savings are reflected in house prices, i.e. a lower irrationality factor than applied in this study. The impact of correctly accounting for risk mitigating factors in the capital requirements framework would thus be somewhat larger than in our main scenario. To illustrate the sensitivity of the results to the irrationality factor, we have included an alternative scenario (*scenario 2* on slide 25) that assumes that the entire future energy savings are priced into property prices.

1) See Copenhagen Economics (2016) – Do homes with better energy efficiency ratings have higher house prices? / 2) See Deloitte (2017) – Property Index: Overview of European Residential Markets / 3) These are the same assumptions as in Copenhagen Economics (2016) / 4) Presented during the third EEMI Bauhaus event in February 2021.

Literature review: Impact of energy efficiency on house prices

Energy efficiency improvements lead to a reduction in monthly energy expenses and should therefore also increase the value of a dwelling after upgrading its energy label. Several studies have found evidence for a price increase in the dwelling after increasing its energy label, but the estimates differ across countries and studies.

The studies listed in the table below are those that are used to calculate the average impact on house prices used in this report. The impact is reported as the percentage change in the property price relative to energy label D. Many other studies[1] exist that estimate the impact of energy efficiency on house prices but are less comparable to the studies used in this report. Some studies, for instance, report results not by separate energy label and are therefore not included in the average impact used in this report.

The studies use so-called hedonic pricing models to estimate the impact of a higher energy label on the house price. In such models, house prices are decomposed into different building characteristics which are priced separately. The estimated impact of a higher energy label on the house price is therefore supposed to reflect the willingness to pay for a higher energy efficiency if all other characteristics of the house remain unchanged. Most of the studies apply so-called fixed-effects models for the estimation to control for unobserved factors that are related to both energy efficiency and house prices.

Impact of energy efficiency on house prices estimated in different studies
% impact on house prices, relative to label D

Energy label	Copenhagen Economics (2016)	Brounen & Kok (2011)	Hyland et al. (2013)	Fuerst et al. (2015)	Jensen et al. (2016)
A	10.2%	10.20%	9.30%	5%	6.20%
B	6.6%	5.60%	5.20%	5%	6.20%
C	3.5%	2.20%	1.70%	1.80%	5.10%
D	0.0%	0%	0%	0%	0%
E	-3.5%	-0.50%	-0.40%	-0.70%	-5.40%
F	-7.5%	-2.50%	-10.60%	-0.90%	-12.90%
G	-12.0%	-5.10%	-10.60%	-6.80%	-24.30%

1) For an overview of studies analysing the impact of energy efficiency on property values, see, for instance, Table 2 in EeDaPP (2020) *Final report on correlation analysis between energy efficiency and risk*

APPENDIX 2
LITERATURE REVIEW ON CURRENT STATE-OF-THE-ART OF SUSTAINABLE FINANCE

The taxonomy is essential to incorporate climate risks in capital regulation

Issue

It is challenging to single out green assets if you do not know what to look for. To conduct a targeted risk assessment requires that risk managers know which factors that captures climate risk

- Until recently, there has been only few attempts to classify assets based on their environmental impact.
- To distinguish assets fairly in the risk management system, financial institutions have lacked a proper guideline to which factor would be essential to capture climate risks.
- Some banks have applied internally developed classifications, while others have complied with international classifications like the EU-wide taxonomy for sustainable activities.[2]
- However, this implies that similar assets are categorised inconsistently across the financial sector.[3]
- To create a level playing field among banks, assets type should be treated similarly and according to a standard set of rules.

Solution

A common taxonomy for sustainable finance

- A clear, green taxonomy for the European financial sector is essential. Not only to identify which assets are green – but even more importantly to identify the factors that allow financial institutions to evaluate their assets based on their climate risks.
- By setting minimum classification standards of assets' environmental impact, a taxonomy enables an estimation of current and future exposures to climate-related risks.[1] It also improves the potential of assessing the risk differential between green, non-green and brown assets.
- There is a lack of historical data on greenhouse emissions associated with different asset types as well as their riskiness. As risk valuation tools use statistical models to assess e.g. default probabilities, linking asset types to their environmental impact is key.

1) I4CE (2020), p. 18 / 2) https://ec.europa.eu/info/publications/sustainable-finance-teg-taxonomy_en / 3) NGFS(2020), p.4

Initiatives are taken to solve challenges related to data

Issue

No centralised databases to access climate data that will capture the risk mitigating factors of energy efficiency

Data is key to getting a more thorough understanding of climate-related risks. There are currently four main data barriers that prohibit banks from incorporating climate risks seamlessly.

1 Accessibility	Lack of publicly available and accessible data on energy performance
2 Quality	Lack of data quality and limited history of data collection
3 Data tagging / comparability	No tagging to ensure comparability across financial and building performance data
4 Data monitoring	Lack of ongoing data monitoring and analysis of energy performance data

Solution

Data collection initiatives, such as the EeDaPP Initiative, addresses the need for better and more harmonised climate data in the financial sector

The EeDaPP Initiative has been launched with the objective of addressing these challenges. The key contribution of the initiative is to construct a loan-level database that facilitates a proper risk assessment of EEM. To construct this database, it requires that banks intend to gather and report energy-related data to an accompanying portal.

Other initiatives include simulations of energy use before and after renovations that are tested by some financial institutions already today. An example is CRIF Real Estate's *Building Energy Efficiency Simulator* which provides bank customers with an impact of suggested energy renovations on the EPC and the energy use.

Moreover, companies and universities work on developing algorithms that allow for automated retrofitting advice as well as remote verification of energy savings. All such data will be crucial information for banks in order to be able to include risk mitigating factors from energy efficient mortgages in their risk models.

Correlation analyses gives first impression on EEMs impact on risk weights

With recent advancement in developing frameworks for distinguishing green assets, climate data is increasingly accessible for financial institutions. This improves their ability to test the two channels through which EEM can imply lower capital charges; the relation between energy performance and default risk, and the relation between energy performance and property valuation (the collateral).

There are indications that energy performance is associated with both a lower LGD and PD

There are two main channels through which energy efficient mortgages (EEM) can entail risk mitigating factors that should be taken into account.

First, studies indicate that properties with high energy performance certificate (EPC) scores are associated with higher property values[1]. Higher property values lower the loss given default (LGD) for banks, since they are more likely to recover their losses in case of default.

Second, borrowers in energy efficient properties tend to be less exposed to default risk compared to borrowers in less efficient properties.[2]

Filling the knowledge gaps is key to document a risk differential

The higher property price of energy efficient buildings is the result of (priced in) lower energy costs in the future. However, the degree to which home buyers price in future energy savings is uncertain and subject to change over time.

The negative correlation between property energy efficiency and the probability of default (PD) has been documented in different recent studies. But the causal factors behind this correlation are hard to determine.

A detailed analysis within the EeDaPP project on Italian residential mortgage data finds, for instance, that the PD could be around 37 basis points lower for energy efficient buildings (label A).[3]

1) See slides 20 and 61, and EeDaPP (2020), D5.7, Table 2 for an overview of selected studies. / 2) See for instance EeDaPP (2020), D5.7 and Guin & Korhonen (2020) / 3) See also slide 28 for more details on that analysis.

A forward-looking perspective on climate risk captures future uncertainty

Issue

Current risk frameworks do not capture forward-looking risks

Climate risks are fundamentally different to other types of risk. They tend to be long-termed, non-linear and non-cyclical[1], while investment horizons for financial institutions are often short-termed. This leads to a use of short-term risk metrics in the risk management that potentially miss the distinctive nature of climate risks.

> As sustainability is intrinsically linked to longer term developments, relevant metrics should be forward-looking and take account of long-term horizons. This places an additional layer of difficulty and uncertainty on information relevant to sustainability. (HLEG, 2017, p. 20)

Solution

Current progress in climate risk scenarios

Much work has been put into the development of climate scenarios, especially from an investor perspective.[2] While many of the scenarios share the same input data, components and methods for financial practices, the methodology for assessing climate risks differ significantly.[3] In an attempt to harmonise approaches to climate risk scenario analysis, the NGFS has recently published a set of publicly available high-level climate scenarios, mainly aimed at the financial sector.[4] The three main scenarios are based on different assumptions on the future trajectory of emission prices (orderly transition, disorderly transition, do nothing scenario). Moreover, the Bank of England is currently working on a climate risk scenario analysis specifically aimed at banks and insurance companies.[5] We can use this new research on scenario analysis and apply it on EEM to assess the impact on capital requirements.

1) HLEG (2018) / 2) UNEP FI (2019) / UNEP FI (2019) p. 11 / 4) NGFS (2020a) / 5) Bank of England (2019)