

ECONOMICS OF



RENOVATION

Implications of a Set of Case Studies

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1 Executive Summary

In the current context of climate change, energy insecurity and rising energy prices, the EU is at the crossroads for its future energy policy. It is widely accepted that bold action in energy efficiency is key in order to respond to the multiple challenges.

Buildings are clearly perceived as the “low hanging fruit” with greater potential for cost-efficient action in the energy efficiency field. In this context, the necessity of a wide campaign of deep renovation of the existing EU building stock is often mentioned, but so far no EU-wide analysis of its economic implications has been undertaken.

This study by Ecofys intends to provide a notion of the economic feasibility of deep renovations for single and multi-family homes across the EU, taking a case-study analysis as basis.

Main findings of this study:

- **The time for deep renovation across Europe is now:** The study concludes that deep renovation has the potential to be the preferred solution from ecologic and economic point of view, even without subsidies, for the necessary immediate action on the EU building stock;
- **“Shallow” renovations significantly increase the risk to miss the climate targets:** The study points out that, if superficial renovations of buildings are undertaken on least performing buildings, huge absolute savings remain untapped. The achievement of the EU’s long-term energy savings and climate goals will be impossible if the current trend of ‘cream skimming’ renovations is kept;
- **Spending on deep renovations is worth from the first day:** For all studied EU countries, energy related costs per saved kWh for deep renovation turned out to be equal or lower than actual energy costs. We already have favourable market conditions across Europe to make deep renovation a financially more attractive option than inaction (continue paying higher energy consumption); the only exception is UK, where in the past gas prices have been relatively low compared to continental Europe. This low-price period might end soon as the UK imports more and more gas at higher continental Europe’s price level. Thus even in the UK deep renovation is the right choice to be on the safe side.

Methodology:

- Results were taken from case studies under the very ambitious “Low energy building stock” (“Niedrigenergiehaus im Bestand”) deep renovation programme, managed by the German Energy Agency (DENA). these results were extrapolated to other EU countries using EUROSTAT data on price level indices, mortgage rates, inflation rates, energy prices and heating degree days;
- This study has been made under conservative assumptions regarding future energy prices, and excluding any possible subsidy that would make the investment even more advantageous.

2 Background

Buildings play the major role in achieving Europe's very ambitious climate targets. On 19 May 2010 a milestone in European climate policy came into effect: the recast of the Directive on the Energy Performance of Buildings (EPBD).

For new buildings the recast explicitly requires "nearly zero energy" being the standard by 2019 (public buildings) or 2021 respectively (all other buildings).

As to the building stock the recast requires Member States "to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements ... in so far as this is technically, functionally and economically feasible [EP 2010]." Though even the term "nearly zero energy" used for new buildings still needs further definitions on European and National level, obviously the wording for major renovations of existing buildings leaves more uncertainty about the actual level of energy performance that is spoken of. This uncertainty can be reduced by evidence from realized, ambitious major renovations. A "major" renovation is accomplished when "total cost of renovation relating to the building envelope or the technical building systems is higher than 25 % of the building's value or if more than 25 % of the surface of the building envelope undergoes renovation".

The term "economically feasible" cited above refers to another novelty in the recast. The economic feasibility is to be calculated within the context of a "comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements". Such framework does not yet exist but is to be laid down by the Commission until 30 June 2011. Further details on the EPBD recast's relevant paragraphs are provided in the Annex of this paper.

Since 2004 a well documented series of progressive major renovations for residential buildings has aimed at achieving at least new buildings' energy performance under the umbrella of the ambitious initiative "Low Energy Building Stock", managed by the German Energy Agency (DENA). Due to their high ambition these renovations belong to the category of "deep" (major) renovations in contrast to "shallow" renovations only aiming at minor savings.

This paper discusses the economic feasibility of deep renovations for single and multi family homes using the German "Low Energy Building Stock" programme as a case study. In order to put the results into a European perspective, an estimation of the economics of such projects incl. a hint to job creation potential for some selected European countries is included.

3 Methodology

3.1 Calculation of Cost per Saved kWh Final Energy

A “comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements” is not yet available. Instead the economic calculations follow the methodology being described by [Ecofys 2009]. The ultimate aim of that methodology is to transform investments in “beyond the business as usual energy efficiency” into “Euro-ct per saved kWh”. This enables a direct comparison between:

- What does it cost to save one unit of energy? - and
- What does it cost to buy one unit of energy?

[Ecofys 2009] conclude that current calculations for cost-optimal levels of renovation often suffer from several major distortions. Distortions can happen in both directions: either making the energy efficiency investment look better or worse, cf. Figure 1. As far as possible these distortions have been eliminated in this paper.

Distortions that often make investments look	
better	worse
static calculations	application of payback method
exponential energy price increase	high interest rates
	zero residual values
	too short life-times
	questionable alternatives

Figure 1 Distortions

- *Static calculations* do not take into account interest rates. Therefore an interest rate > 0 % has to be accounted for.
- Inferring from historic energy price developments to future price assumptions is often done by applying inconspicuously small annual price increases. Still the result is an *exponential energy price increase*. Especially when applied in calculations for long-term investments like better energy performance of buildings this leads to unrealistically high future energy price levels. It is more serious to assume an average price level for the period under consideration. Figure 2 shows the average 2007-2009 consumer *real* price for natural gas/heating oil, differed by single-family (SF) or multi-family (MF) homes respectively, based on [Eurostat 2010 a]. These “ct per kWh gas” can be compared with the “cost per saved kWh” of the energy efficiency investment in a country.

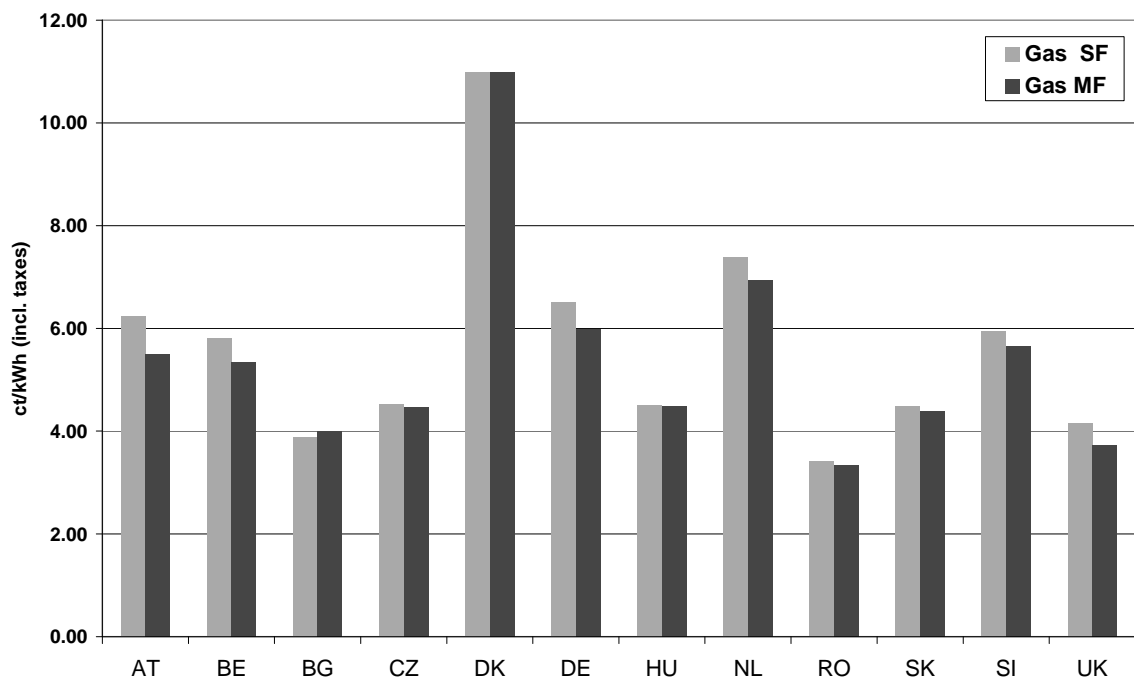


Figure 2 Gas prices for single family and multi family homes in selected European countries

- *Payback calculations* tend to prefer cheaper investments that usually not only have smaller savings but also shorter lifetimes. Especially in the context of buildings with lifetimes of several decades, the payback calculation is an inappropriate tool to prepare decisions. Instead a calculation method is needed that gives an indication about the net benefit of a long-term investment - the calculation of net present values.
- Investments in better energy performance of buildings are usually financed by mortgage loans. Nevertheless often much *higher interest rates* are assumed which lead to an underestimation of benefits from energy efficiency. For the purpose of this study we take long-term interest rates of housing loans to households (>10 a) [Eurostat 2010 b]. To level out fluctuations, the 2005-2009 average is taken. 20 years are taken as calculation period for the annuity of the investment. All calculations in this paper are based on *real* prices (e.g. energy prices, mortgage interest rates) - in contrast to nominal prices which include inflation - meaning that inflation has to be eliminated. Long-term inflation for different European countries was derived from Eurostat HICP Index [Eurostat 2010 c]. Figure 3 illustrates nominal and estimated real mortgage rates for several European countries.

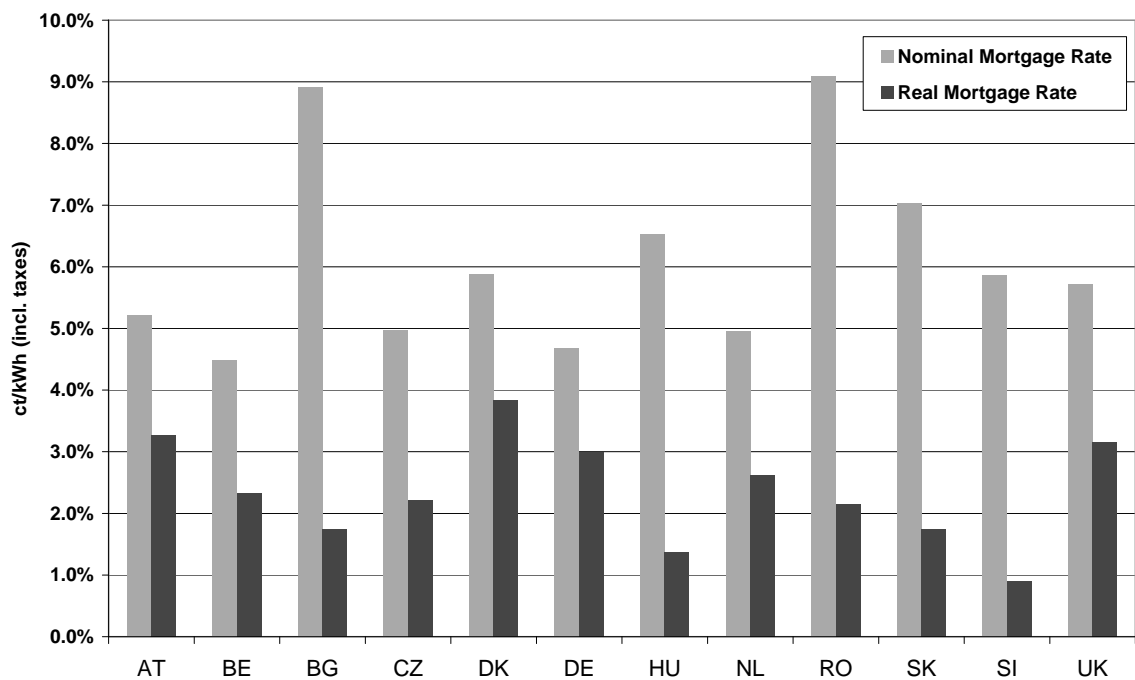


Figure 3 Nominal and Real Mortgage Rates in Selected European Countries

- Usually the *lifetime* of the investment exceeds the calculation period. Therefore only the value of the investment that is used up during the calculation period must be taken into account. Consequently the *residual* is not taken into account. Assuming a calculation period of 20 years Table 1 gives some examples for the residual for different combinations of real interest rate and lifetime.

		Residual values				
		Lifetime (years)				
		20	30	40	50	80
real interest rate	3.00%	0%	24%	36%	42%	51%
	3.50%	0%	23%	33%	39%	47%
	4.00%	0%	21%	31%	37%	43%
	4.50%	0%	20%	29%	34%	40%

Table 1 Relative share of residual values in total investments, calculation period 20 years

- The best time for a major renovation or for improvements of components is when a renovation has to be done anyway. The cost for these “anyway investments” has to be subtracted from the total investment in energy efficiency as otherwise the *questionable alternative* “do nothing” would be the baseline for a comparison.

It is noteworthy that although certainly having a positive monetary value, the following co-benefits of correctly implemented energy efficiency measures are not considered in this paper, which equals the usual practice (cf. [PHI 2008]):

- Higher independency from energy imports
- Mitigation of externalities like global warming (external costs)
- Higher quality energy services resulting in better health like,
 - Better thermal comfort
 - Better indoor air quality.
- Risk reduction
 - Less risk of damaging the building construction
 - Less poverty risk in case of steeply increasing energy prices.

We also do not discuss the “investor-user-dilemma” as this is not about the efficiency of an energy saving investment but mainly on how to fairly distribute its benefits.

3.2 Illustrative Transfer of Results to other European Countries

Empirical evidence for deep renovations in this study was taken from DENA’s “Low Energy Building Stock” series. As no comparable data for other European countries was readily available these results have been transferred to some other countries’ context. The selection of countries depended on the availability of all necessary input data within the Eurostat statistics. The remaining countries underwent another selection by climatic conditions, i.e. countries with heating degree days similar to Germany and negligible cooling demand in residential buildings were selected. Finally some high inflation countries were eliminated to avoid questionable results.

As an input for the calculation of the “cost per saved kWh” and their interpretation, the following data is needed:

- 1 Measures’ lifetime
- 2 Calculation period
- 3 Real energy price
- 4 Real long-term mortgage rate
- 5 Heating degree days for recalculation of energy savings
- 6 Additional cost caused by deep energetic renovation

Having results for one country (Germany), especially 3 to 6 need to be addressed. Items 1 and 2 were assumed to be the same in all selected countries.

Figure 3 already presented an overview of real long term mortgage rates. Figure 4 shows the 30 years average (1980-2009) for heating degree days. The higher the value, the longer and/or colder the heating season. The values show country averages - so there will be also colder regions in every country with more attractive economics for deep renovations.

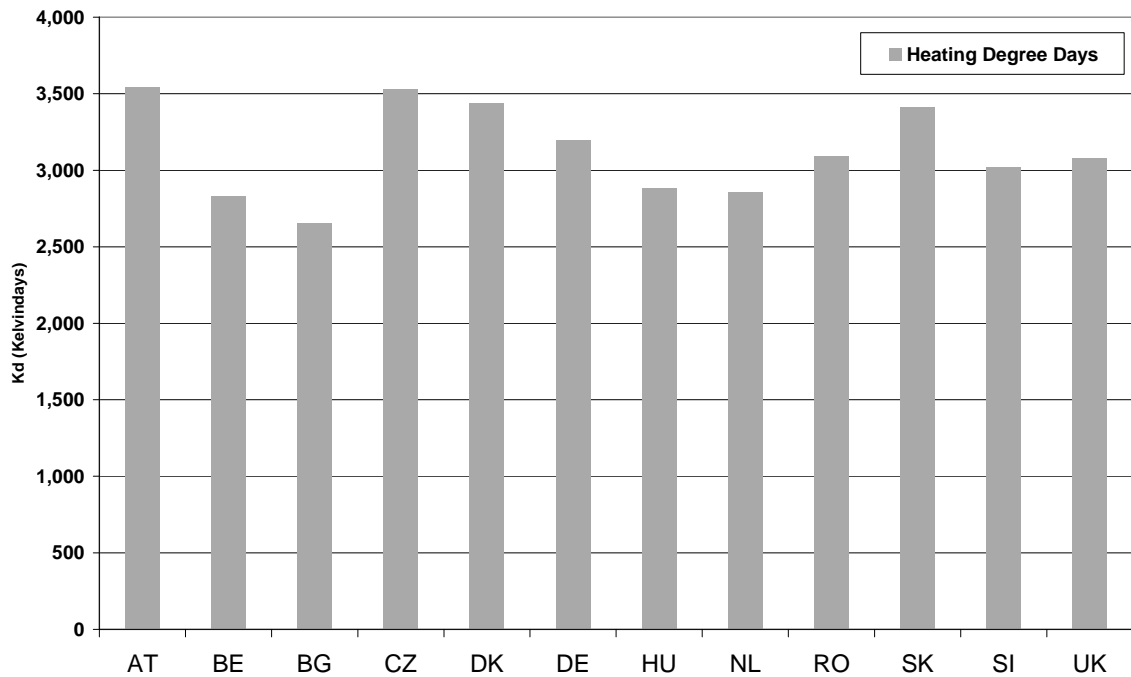


Figure 4 Heating degree days in selected European countries (30-year average)

The most critical transformation relates to item 6 - the additional cost caused by deep renovations that we know from Germany to another country. Price Level Indices (PLI), which are available from Eurostat's Purchasing Power Parities data for different sectors [Eurostat 2008] were applied for this transformation. As Eurostat does not provide a specific index for (deep) renovation of buildings, the PLI for new residential buildings were taken as a proxy, see Figure 5. For a first indication on the economics of deep renovation in Europe, this approach promises sufficient reliability. The EU 27 average has a PLI of 100. Lower values signal lower price level and vice versa.

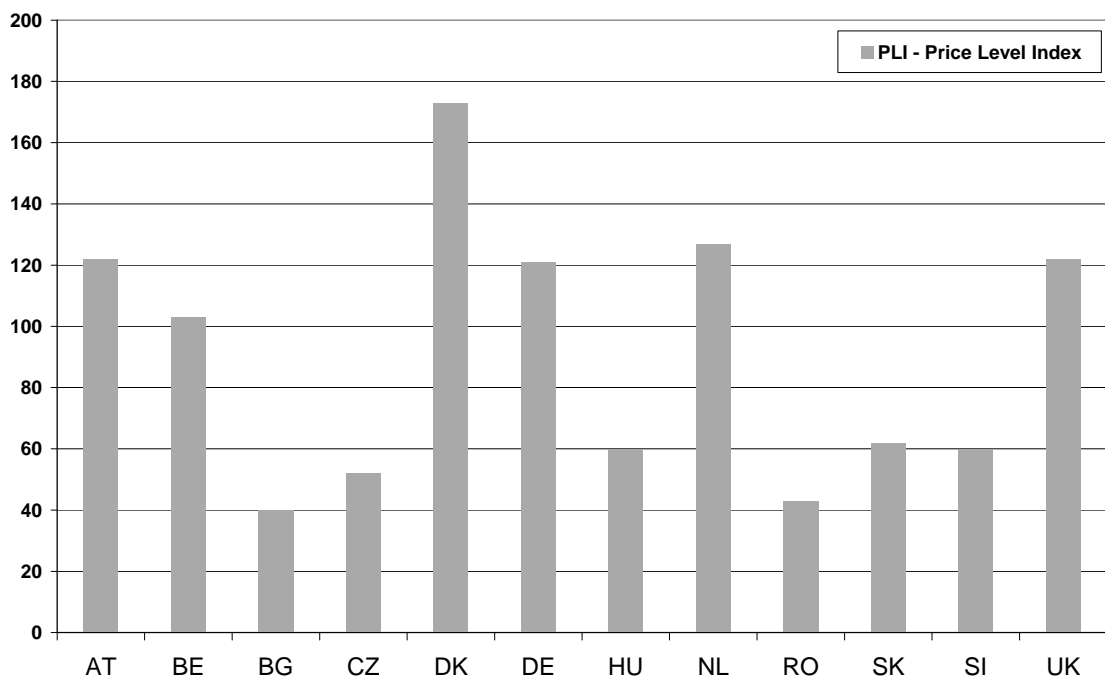


Figure 5 Price Level Indices for new residential buildings 2007

An estimation on job effects can be made by using a simplified method that neglects smaller effects but still offers a good indication of possible employment related impacts of energy efficiency measures: the assumed additional turnover from energy efficiency projects is divided by the average turnover per employee in the construction sector (available from Eurostat) and multiplied by a specific factor, a methodology that we already used in the impact assessment for the EPBD recast.

$$Job_creation = (additional_turnover/turnover_per_employee)*factor$$

This factor depends on the specific labour intensity of the measures carried out. Depending on exact kind of activities, this factor may vary between 0.5 (share of material costs of energy efficiency measures twice as high as the usual mix of material and labour costs as presently observed in the building industry of the EU27) and 1.0 (share of material costs according to usual mix). In the present study the factor was assumed to be 0.7.

4 Selected Buildings from the “Low Energy Building Stock” Initiative

The pilot initiative “Low Energy Building Stock” of the German Energy Agency is designed to produce best practice examples for deep renovations, e.g. by using components usually applied in new very-low-energy buildings or Passive Houses in renovation. In fact the series anticipates subsequent levels for funding by the federal German KfW bank. Up till now there have been several project phases, of which the first three featured residential buildings, the renovation starting between 2004 and 2007. Typical measures comprise:

- Thermoskin, insulation thickness between 10-24 cm
- Insulation of cellar ceiling, 5-20 cm
- New windows, U-values 0.8-1.4 W/m²K
- Roof insulation
- Solar thermal collectors for Domestic Hot Water
- Ventilation system with heat recovery or exhaust air only
- Reduction of heat bridges.

The quality of the building envelope can be shown as average U-value, H_t' . Figure 6 shows the extraordinarily high standard of the building insulation after renovation. Note that “EnEV 2007” indicates the requirements for *new* buildings according to the German Energy Saving Ordinance from 2007. Obviously all renovated buildings are much better, most of them are even better than today’s new build level (EnEV 2009 = EnEV 2007 minus 30%) and some almost reach Passive House level.

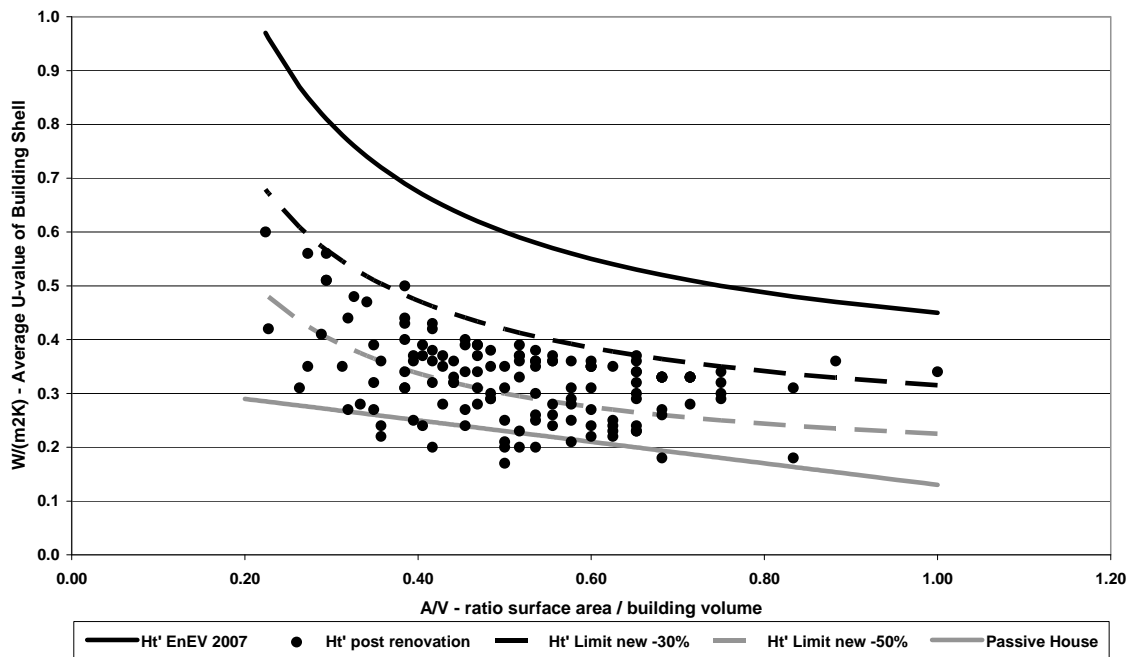


Figure 6 Specific transmission losses of demo buildings (dots) vs. several building standards

For our study we picked several

- Single family homes, vintage 1958-1978
- Multi-family homes, vintage 1958-1969.

They represent the widest-spread residential buildings in Germany. As they are not the worst from energetic point of view, even higher savings may be achieved in older vintages.

Merged to a reference single family home and a reference multi family home the buildings can be characterized as follows before and after renovation:

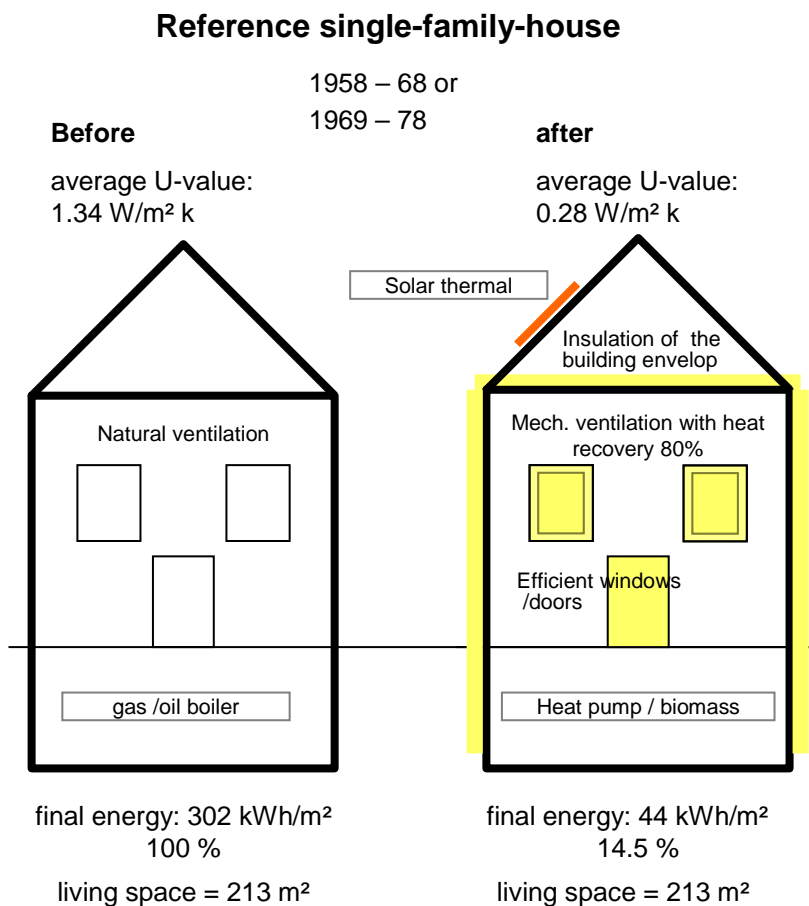


Figure 7 Reference single family home, before and after deep renovation

Single family homes show huge savings of appr. 85% (more than 250 kWh/m²a) in terms of final energy after renovation. The majority of buildings was described as having a heated cellar, this is why the insulation layer in the reference home is interrupted at the bottom.

Reference multi-family-house

1969 – 78

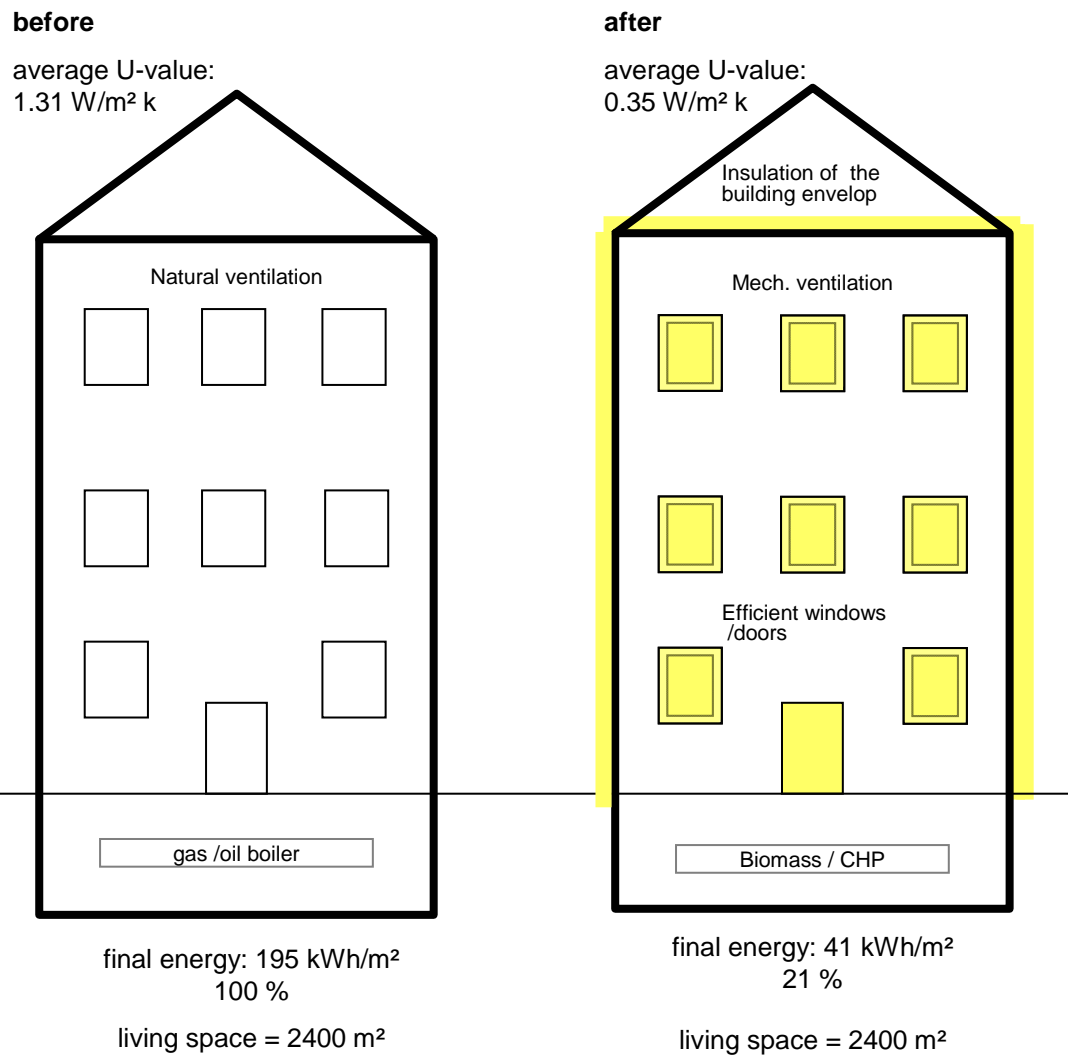


Figure 8 Reference multi-family home, before and after renovation

Multi family homes show huge savings of appr. 80% (more than 150 kWh/m²a) in terms of final energy after renovation. The majority of buildings was described as having a heated cellar, this is why the insulation layer in the reference home is interrupted at the bottom.

Prices for additional deep renovation expenditures were either derived from architects' information or from re-calculating the findings of [IWU 2010].

5 Results

The German projects show the following specific costs for single/multi-family homes:

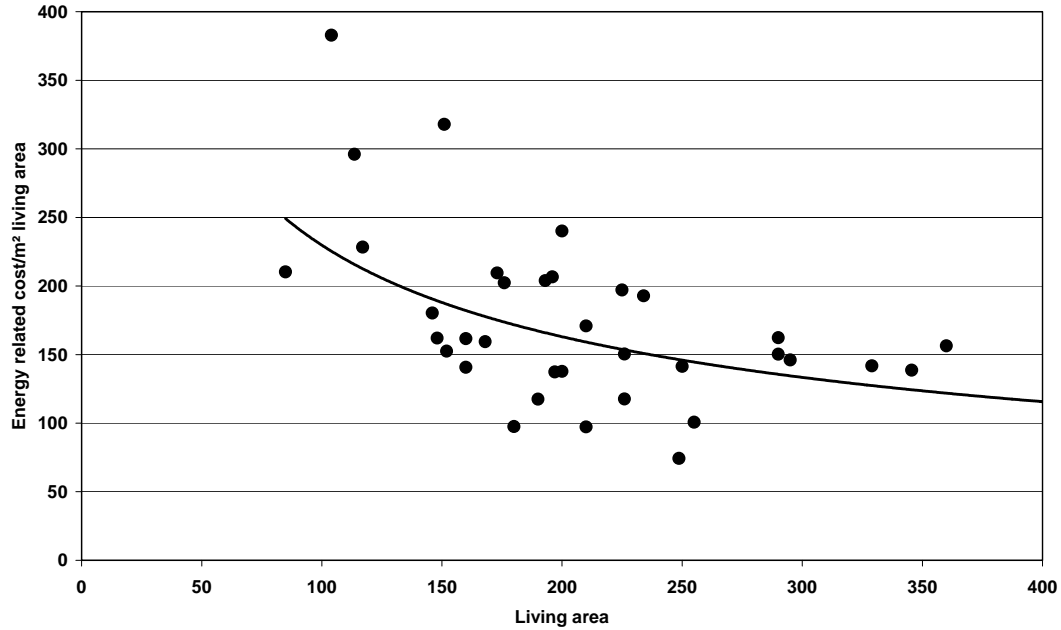


Figure 9 Energy related costs for deep renovation of single family homes (€/m²)

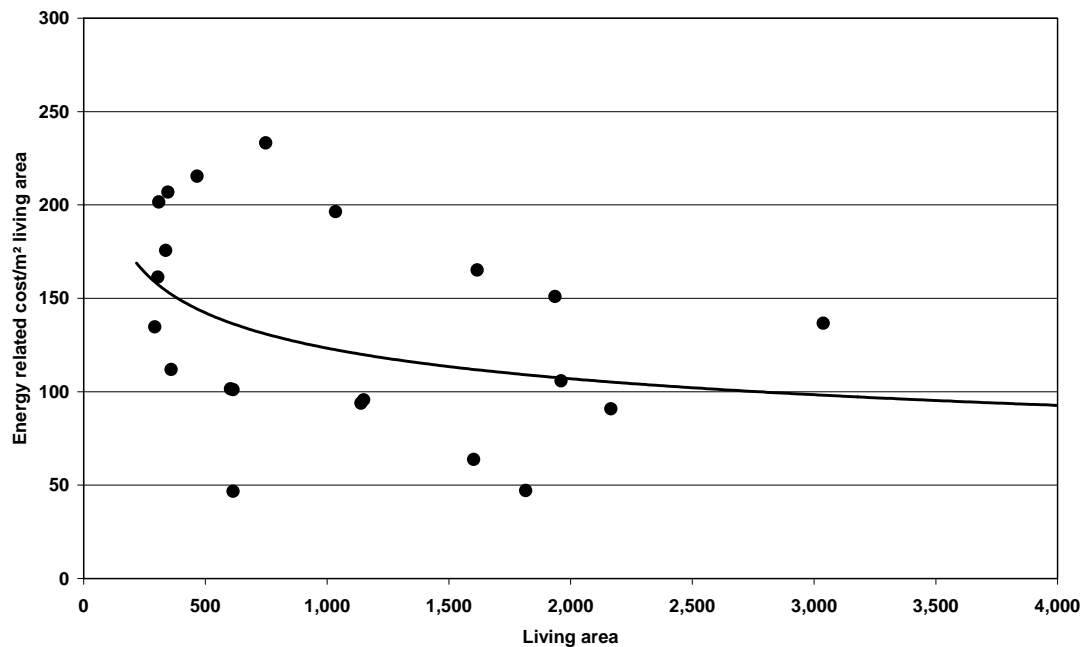


Figure 10 Energy related costs for deep renovation of multi family homes (€/m²)

Figure 10 and Figure 11 show a cost depression with increasing living area and lower specific cost in multi family homes compared to single family homes.

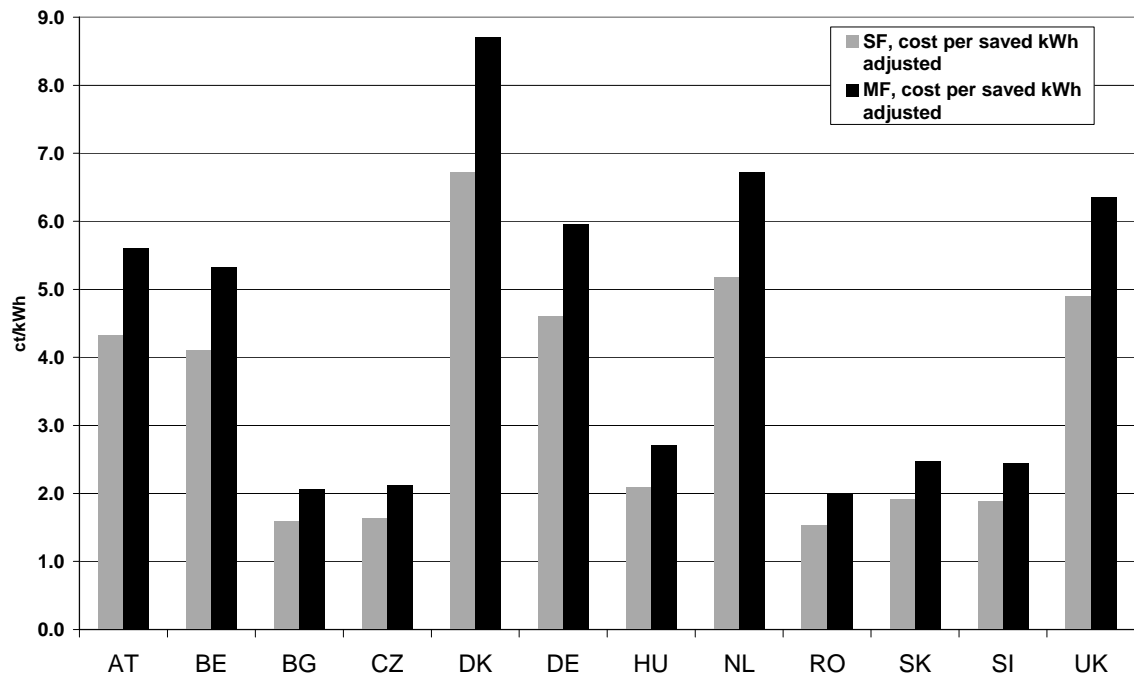


Figure 11 Estimated, adjusted national cost per saved kWh for single- and multi-family homes

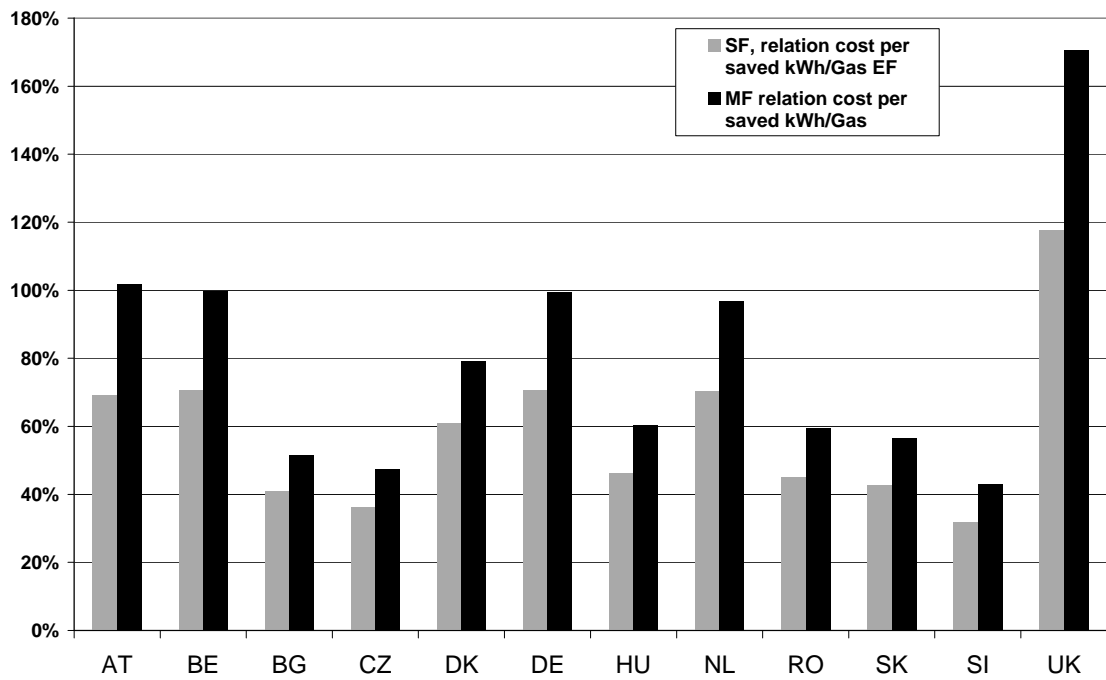


Figure 12 Estimated, adjusted relation between national cost per saved kWh for single- and multi-family homes and the local energy price

These specific costs are transferred to average cost per saved kWh for the whole DENA sample, separately for single- and multi-family homes. In Figure 11 these are the values of Germany (DE).

Applying the transformation steps explained before the German cost per saved kWh are transferred to several selected European countries, see Figure 11. There is quite a big variety in costs per saved kWh that can be expected for deep renovations which are comparable to the German example in other European countries.

As explained before deep renovations are very attractive when the possible cost per saved kWh is lower than the actual real energy price in a country. The relation between those can be shown by dividing the national cost per saved kWh by the national energy price, see Figure 12.

Figure 12 needs some additional explanation to ensure proper interpretation:

- Note, that all values are based on a German sample of deep renovations. The German sample has been hypothetically transferred to a few European countries by means of EUROSTAT data on price levels for energy and construction and climate. Therefore Figure 11 and Figure 12 give an indication on what may be expected when the German deep renovation examples would be implemented in these countries. Obviously evidence from projects in these countries with comparable ambition would be welcome to get real results.
- The graph is based on a conservative assumption on future energy prices. The average national household gas price for 2007-2009 has been taken without assuming further real gas price increases over the calculation period of 20 years. Moreover no subsidies etc. are included, which would lower the price per saved kWh.
- The graph is based on energy related costs per saved kWh (Figure 11) for a sample of very ambitious *deep* renovations, meaning that final energy consumption was cut by more than 80% being in line with long-term climate targets. The energetic quality of the renovated buildings in the German sample is appr. 50% better than what is currently required for new buildings.
- A value of 100% indicates that already at the mentioned conservative assumptions deep renovation is financially equivalent to not investing in energy efficiency and paying for high energy consumption. In other words: the energy savings alone pay for the additional investment. Note that positive side effects of deep renovation like increased real estate value, more comfort, lower vulnerability to energy price increases etc. are for free. A value lower than 100% indicates that the energy savings over-compensate the additional investment. 50% means savings twice as high as the additional investment.
- Thus the overall picture is remarkably positive. Most countries show values of cost per saved energy between appr. 40% and 100% of the local gas price.
- UK is the only exception with values between 120% and 170%, the major reason being the low gas prices presented in Figure 2. All other UK numbers in Figure 3, Figure 4 and Figure 5 show values being very close to the German reference case. Assuming real energy prices for the UK similar to Germany would get the UK numbers in Figure 12 close to German level. In fact, there is reason to assume that the long period of UK gas prices being significantly below the level of continental Western Europe might end soon. Few

years ago the UK became a net importer of energy, i.e. there is an increasing influence of continental European gas prices on the UK market.

- Thus Figure 11 not only shows the price per saved kWh but also the “break-even-gas-price” where the avoided energy cost equal the additional investment in deep renovation. For the UK case this means real gas prices at a still moderate level around 5-6 ct/kWh (as average for the next 20 years) would suffice to make deep renovation “look good” (again: ignoring the value of all positive side effects in order to follow the usual practice).

Finally job effects per m² deep renovation are roughly estimated, see Figure 13.

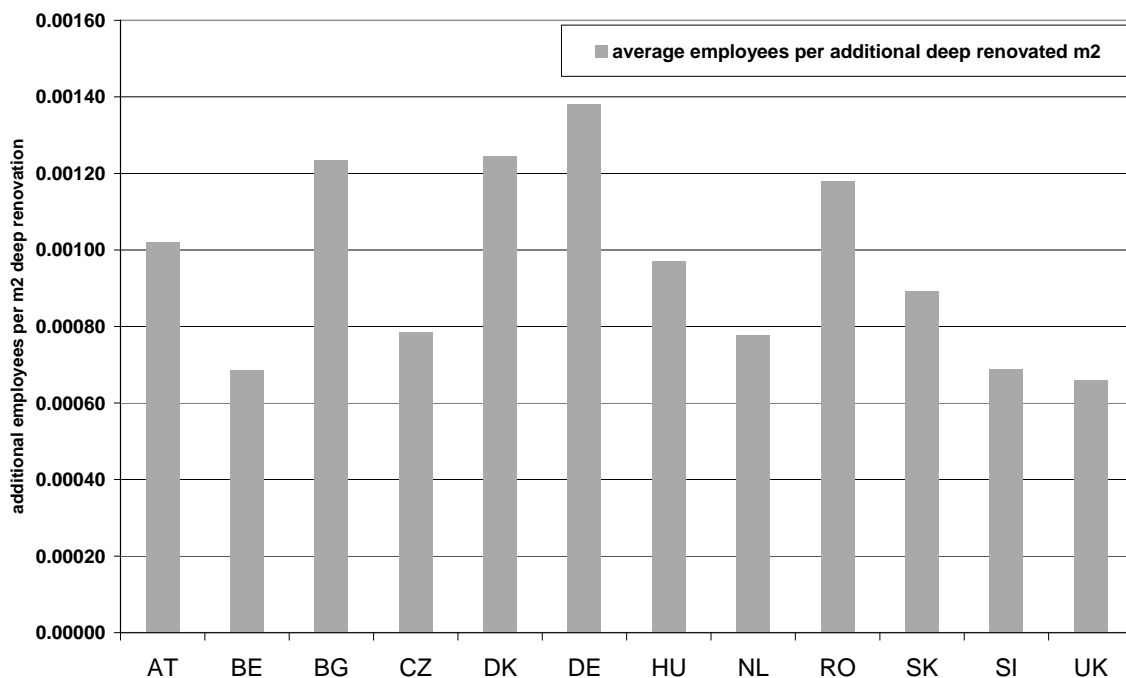


Figure 13 Roughly estimated additional job effects by deep renovation

Taking Germany as an example, with roughly 3.5 billion m² of residential area and provided the renovation rate of 2% recently published for the German climate concept this would mean ca. 100,000 additional employees by deep renovation. More profound job effect analyses would need forecasts on the development of renovation rates throughout Europe.

6 Conclusions

Currently the discussion starts on the “adequate” energetic level for renovation. Based on empirical evidence from the German Energy Agency (DENA) administered program “Low Energy Building Stock” the results presented here indicate that in Europe deep renovation has the potential to be the preferred solution from ecologic and economic point of view even without subsidies. Further evidence should be derived from real deep renovation projects all over Europe.

Due to lack of such evidence, we adjusted prices and savings from the German experience by applying Eurostat Price Level Indices, mortgage rates, inflation rates, energy prices and heating degree days. This means the values presented here should be interpreted as an indication and tendency for what should be expected when such projects would be realized in other European countries.

Note that the often heard argument “let’s use the available annual budget for many cheap, shallow renovations saving 30-50% instead of using it for fewer, more expensive deep renovations saving 70%-90%” may lead to unwanted, irreversible long-term consequences. Dynamic simulations for future building stock scenarios have clearly shown, that “deep renovation at reasonable speed” is a more promising strategy to reach the 2050 climate targets than “shallow renovation at high speed” - shallow meaning that current national requirements for renovation are just met [Ecofys 2010]. It is important to do projections till 2050, as projections till only 2020 may be misleading and suggest an inadequate strategy. As the schematic paths in Figure 14 show, at the interim milestone 2020 a “shallow renovation” strategy might look better than a “deep renovation” strategy, while surprisingly failing to achieve the crucial 2050 target. The usually performed short-term projections contain a severe risk of getting *irreversibly* caught in this “speed trap of shallow renovation”: usually renovations with the best investment/saving ratio are done at the start of a nation’s renovation program. These are the buildings having the highest absolute saving potential. When these buildings are renovated “shallow”, huge absolute savings remain untapped. This loss cannot be compensated any more later on by buildings with lower saving potential, - an important finding that was confirmed by [Ürge-Vorsatz 2010].

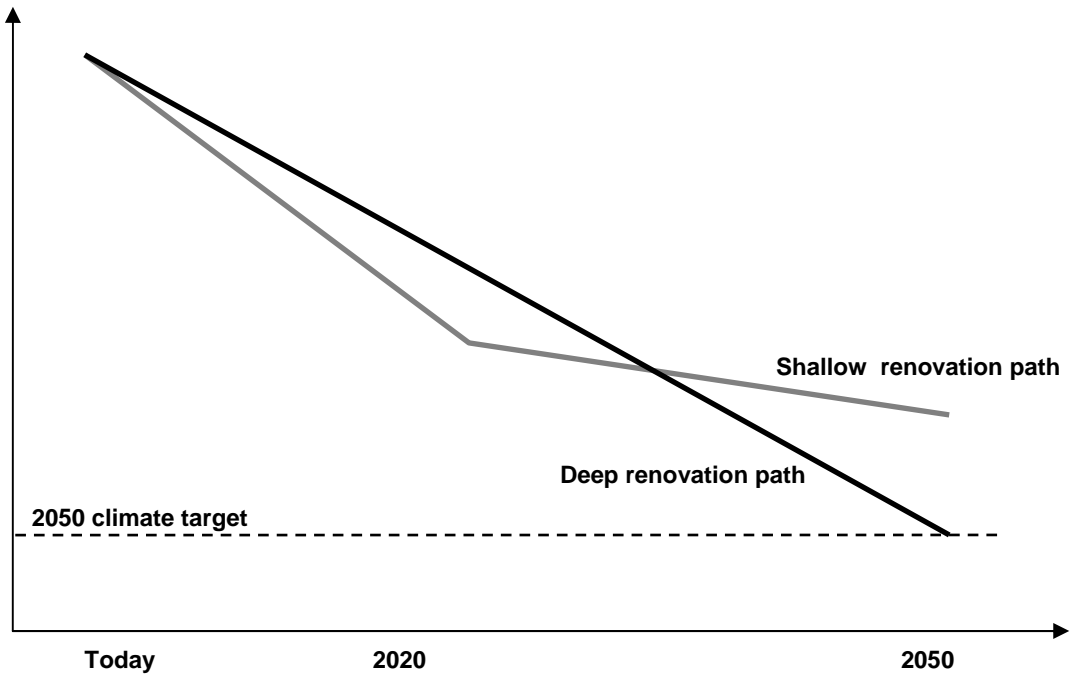


Figure 14 The "speed trap" of shallow renovation

7 Annex - Selected excerpts from the EPBD recast

(Preamble)

(14) “The Commission should lay down a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements.” ...

(15) “Buildings have an impact on long-term energy consumption. Given the long renovation cycle for existing buildings, new, and existing buildings that are subject to major renovation, should therefore meet minimum energy performance requirements adapted to the local climate.”

(16) “Major renovations of existing buildings, regardless of their size, provide an opportunity to take cost-effective measures to enhance energy performance.”

(Article 2) “For the purpose of this Directive, the following definitions shall apply:

...

(10) “‘major renovation’ means the renovation of a building where:”

(a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated;

or

(b) more than 25 % of the surface of the building envelope undergoes renovation;

...”

(14) “‘cost-optimal level’ means the energy performance level which leads to the lowest cost during the estimated economic lifecycle, ...”

(Article 4 - Setting of minimum energy performance requirements)

1. “Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels. ... A Member State shall not be required to set minimum energy performance requirements which are not cost-effective over the estimated economic lifecycle.”

(Article 7 - Existing Buildings)

“Member States shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements ... in so far as this is technically, functionally and economically feasible. Those requirements shall be applied to the renovated building or building unit as a whole.” ...

(Article 10 - Financial Barriers and Market Incentives)

6. Member States shall take account of the cost-optimal levels of energy performance when providing incentives for the construction or major renovation of buildings. ...

(Annex - III Comparative methodology framework to identify cost-optimal levels of energy performance requirements for buildings and building elements)

The comparative methodology framework shall require Member States to:

- define reference buildings that are characterised by and representative of their functionality and geographic location, including indoor and outdoor climate conditions. The reference buildings shall cover residential and non-residential buildings, both new and existing ones,
- define energy efficiency measures to be assessed for the reference buildings. These may be measures for individual buildings as a whole, for individual building elements, or for a combination of building elements,
- assess the final and primary energy need of the reference buildings and the reference buildings with the defined energy efficiency measures applied,
- calculate the costs (i.e. the net present value) of the energy efficiency measures (as referred to in the second indent) during the expected economic lifecycle applied to the reference buildings (as referred to in the first indent) by applying the comparative methodology framework principles.

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NOTES:



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