Meeting Energy Concept Targets for Residential Retrofits in Germany

Economic Viability, Financial Support, and Energy Savings

CPI Brief

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Climate Policy Initiative

May 2011

Descriptors

Sector: Buildings
Region: Germany
Keywords: thermal retrofit, incremental costs, financial support
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Executive Summary

In the 2010 Energy Concept, the German government committed to reducing the primary energy requirement of buildings by 80% by 2050 and to increase the thermal retrofit rate from 0.8% to 2% per year. The 2% target is less than the 3%[1] rate at which outer walls are currently being renovated each year, so it is achievable even if the government only targets buildings that are already planning a renovation.

If a 2% retrofit rate were achieved, most German buildings would have thermal retrofits by 2050. However, in order to achieve the 80% reduction of the primary energy requirement in the building sector, each thermal retrofit has to be 'deep'; that is, it must reduce the energy requirement by around 80%. This paper addresses three questions this raises:

1. What are the costs of deep thermal retrofit for the owner of the building? Is it economically viable?
2. What scale of financial support will be required if the thermal retrofit rate increases to 2% per year?
3. How much energy could be saved?

1. What are the costs of deep thermal retrofit for the owner of the building? Is it economically viable?

A review of German studies shows that the energy related incremental costs of retrofitting multi-family houses (MFH) to the energy standard for new buildings range from 80 to 185 EUR/m^2, whereas the incremental costs to reduce energy demand to 55% of the energy standard for new buildings ranges from 105 to 230 EUR/m^2. Our analysis shows that **if the building owner can capture the full benefit of energy savings, then saved energy costs will exceed the cost of thermal retrofit for 5 out of 7 cost estimates** (see Section 1).

The German public bank KfW provides a combination of low-interest loans and grants to support thermal retrofits. According to our estimates, KfW subsidizes--on average--a third of the energy related incremental costs to reach the standard for new buildings and 50% of incremental costs to reduce energy demand to 55% of this standard. **With this public support, deep thermal retrofit is economically viable for the owner of the building over the full range of cost estimates, assuming that she investor can capture the full benefits of energy savings** (Section 1).

2. What scale of financial support will be required if the thermal retrofit rate increases to 2%?

Despite the current support level, only a third of retrofits include a thermal retrofit. A variety of barriers explain why households do not pursue thermal retrofits, including lack of information and familiarity, landlord-tenant split, and short-termism. Tailored policies and programs can directly target some of these barriers while financial incentives create motivation and interest to overcome inertia and remaining obstacles. Though the set of these policies are not the focus here (although CPI is currently doing work on information policies), the careful development and refinement of these policies is currently being discussed and will be important for achieving the 2% thermal retrofit rate.

The existing one-third of households that include a thermal retrofit in their renovation activities yet also show that the barriers are not inhibitive. Further improvement of policies and programs, growing

[1] Yearly retrofit rates of outer walls without insulation for buildings built before 1978: 0.36% for renewal of plaster/façade cladding, 1.69% for painting of façade. Retrofit rate of outer walls with insulation: 0.83% (IWU/BEI, 2010).

experience of the building sector, and increasing familiarity of society with thermal retrofit can result in a further increase of the thermal retrofit rate.

Assuming that the 2% thermal retrofit rate can be achieved without increasing individual support levels beyond those of current KfW programs, the public support needed for retrofit to the current standard for new buildings would need to increase to 2-4 billion EUR per year. For the retrofits that would decrease energy demand to 55% of this standard, public support would need to increase to 4-8 billion EUR per year. (Section 2)

We did not assess whether the level of support provided to each household would have to increase in order to achieve the 2% retrofit rate. While the support level might have to be higher in the initial years to achieve this objective, with further improvements to building materials, the costs of materials, the skills of builders, and the trust of homeowners in thermal retrofit, the level of support could then be reduced. We also did not explore the relative merits of different instruments for providing support (loan, grant, tax benefits).

3. How much energy would be saved?

About 70% of residential dwelling units in Germany were constructed prior to the introduction of the first energy ordinance in 1977, and these dwellings are the primary target for retrofit and thermal retrofit. **If a deep retrofit on average reduces energy demand to 70% of the standard for new buildings and is gradually tightened to 55% of this standard by 2015, then a total amount of 110 TWh and 7.5 billion in Euro energy bills could be saved per year by 2020.** (Section 3)

Section 1. Calculations for costs of and savings from deep thermal retrofits

Costs of deep thermal retrofits

In calculating the cost of thermal retrofit, it is essential to consider the different components of the full cost of a refurbishment (dena/IWU, 2010):

1. "Maintenance cost," e.g. replacement of windows, plastering, and painting of walls.
2. Energy related incremental cost, e.g. incremental cost of triple glazing when replacing a window (dena/IWU, 2010).
3. Costs for building extensions and modernization, e.g. modernization of kitchen.
4. The sum of maintenance costs and energy related incremental costs is called the "full cost".

To identify the incremental costs of thermal retrofits, we review studies on retrofitting costs for German buildings. In Chart 1, the results of these studies are sorted by the energy demand achieved after retrofitting (horizontal mark for each study).

The following three insights emerge:

First, the full cost of refurbishment varies the most across the estimations of the different cost types (left bar for each study). This suggests that it is not advisable to provide support that is proportional to the full cost of retrofit without including an upper limit.

Second, thermal retrofits constitute only a share – on median 37.5% -- of the total cost of refurbishment (right bar for each study). This shows the benefit of a joint pursuit of thermal retrofits with general renovation work, as then only the energy related incremental costs, not the full costs, are considered in the decision on the thermal retrofit.

Third, significant variations remain in the estimates of cost for the thermal retrofit component. These variations can only partially be explained by differences in the thermal performance standards achieved after retrofit and might reflect both the different regional foci and methodologies of the studies. At this stage we cannot resolve the discrepancies and thus pursue the subsequent analysis for a range of estimates. To reach the energy performance of new buildings (ca. 85 $kWh/m^2_{livingspace}/a$ final energy per year), costs for multi-family houses are between 80 EUR/m^2 and 185 EUR/m^2. To reduce the energy demand to 55% of the standard, the incremental costs are between 105 EUR/m^2 and 230 EUR/m^2 (CPI calculations and dena/IWU, 2010; Ecofys, 2010; empirica/LUWOGE consult, 2010; IWU, 2003a; IWU, 2006a; IWU, 2006b; IWU, 2008; IWU für BSI, 2008; Schwaldt, 2010). [2,3,4]

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[2] The results for single family houses (SFH) can be found in the Annex of the full publication.
[3] In order to allow for comparisons, only studies that approximately (+/-20%) achieved the above mentioned final energy standards were included from Chart 1 into the cost ranges and the cost benefit calculations.
[4] The energy levels are based on the definitions from KfW, which implements the main public support programme for retrofits. The term "building standard of new buildings" refers to "KfW 100," the term "55% of building standard" of new buildings refers to "KfW 55." These standards refer to primary energy requirements. For the purposes of this paper, an interpretation of these standards conducted by dena was used to determine the final energy implications of these standards. They translate into KfW 100 = ca. 85 $kWh/m^2_{livingspace}/a$; KfW = ca. 41 $kWh/m^2_{livingspace}/a$ final energy requirement for MFHs (dena/IWU, 2010).

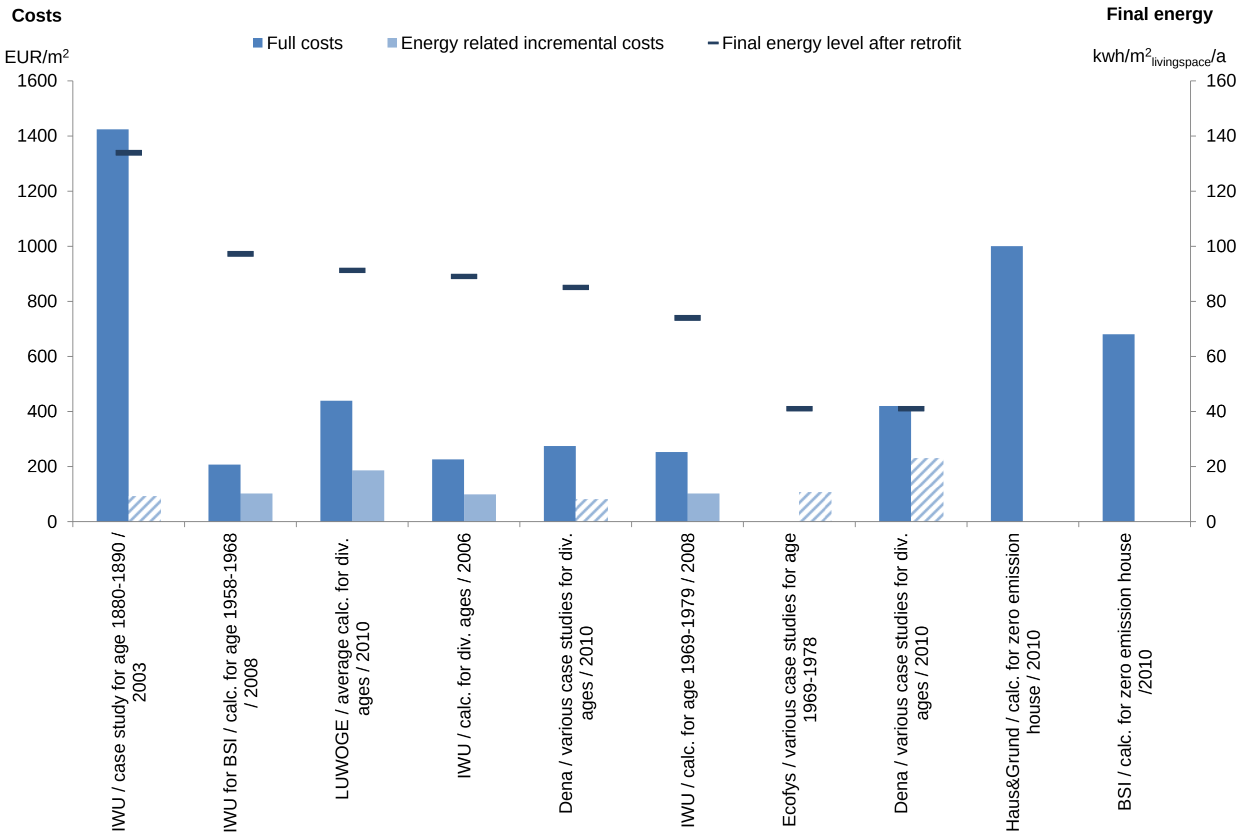

Chart 1: Cost studies on Multi-Family Houses sorted by decreasing levels of final energy demand after refurbishment (Hatched bars = ex-post analysis). Source: CPI calculations and (dena/IWU, 2010; Ecofys, 2010; empirica/LUWOGE consult, 2010; IWU, 2003b; IWU, 2006a; IWU, 2006b; IWU, 2008; IWU für BSI, 2008; Schwaldt, 2010)[5].

Savings from deep thermal retrofits

To calculate the energy savings, it is necessary to assess the energy performance of a building prior to thermal retrofit.

Chart 2 summarizes studies on the energy performance of multi-family houses in Germany in relation to their building ages (see the corresponding chart for single-family houses in Annex 1 of full publication). The bars depict the living space of the respective building age classes in $m^2_{livingspace}$, while the data points depict the energy performance of MFH cited by the respective studies.

- Buildings constructed prior to the implementation of the first heating protection ordinance in 1977 show significantly higher energy requirements. We assume that these buildings (70% of dwelling units built before 1978) are the primary target of retrofit efforts (Diefenbach, 2007).
- There is no strong time trend for buildings constructed prior to 1978. Variations across estimations are larger than across years. Therefore, we assume an average energy demand for this entire group of buildings built before 1978. In addition, the data points in the chart can

[5] For the zero emission house calculations by Haus&Grund and BSI (two special interest groups), only newspaper articles were available. As these numbers were prominent in the German discussions, they were included in this CPI Brief.

overestimate the energy consumption of the various building classes, because most of the publicly available studies include calculations for the expected energy demand of buildings rather than actual measurement. For energy inefficient buildings in particular, the calculated energy demand is argued to exceed energy consumption.

For the purpose of the cost-benefit analysis, it is assumed that the final energy consumption prior to retrofit is 220 kWh/$m^2_{livingspace}$/a. This corresponds to assumptions in dena's cost study for buildings of lower energy efficiency performance (dena/IWU, 2010).

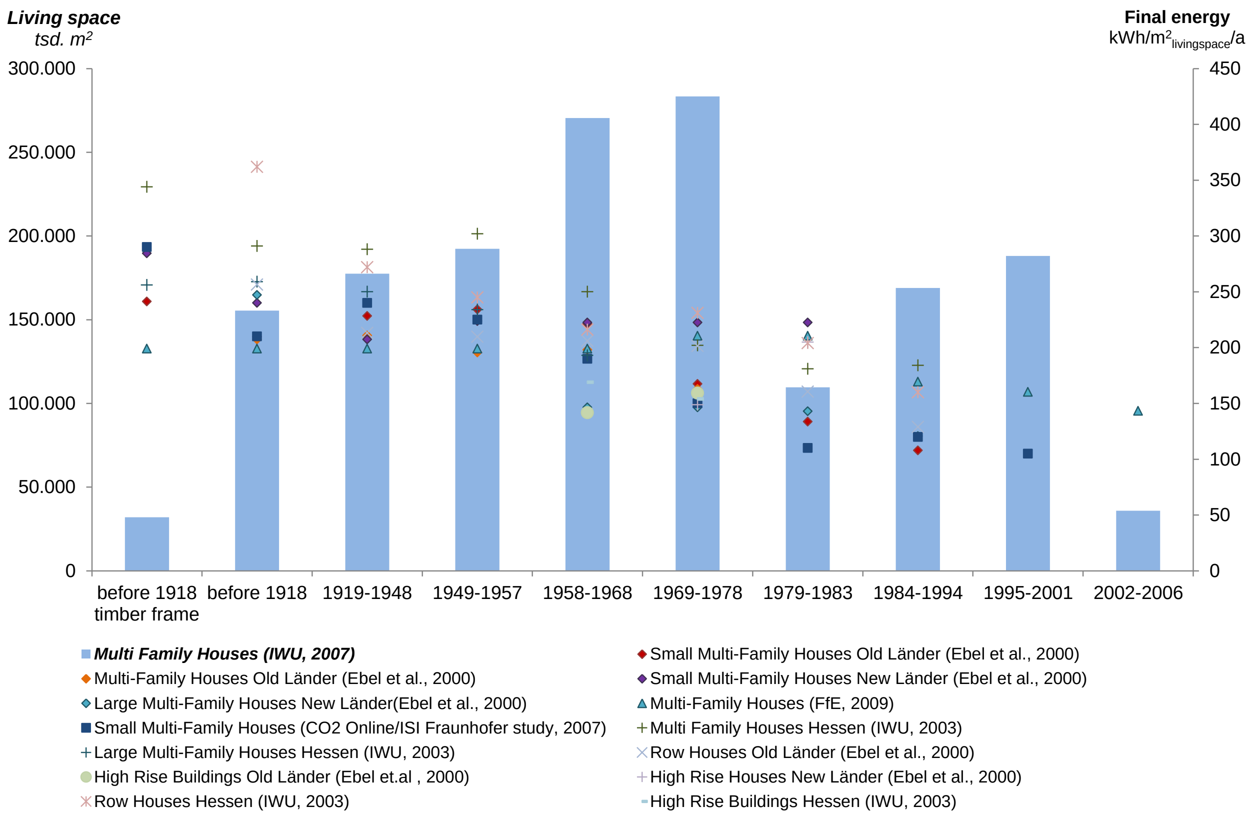

Chart 2: Graph showing various energy consumption and demand calculations for multi-family houses (MFH) for heating and warm water. Source: CPI calculations and (CO2online/Fraunhofer ISI, 2007; Ebel et al., 2000; FfE, 2009; IWU, 2003a; IWU, 2007)

Based on the energy consumption prior to retrofit and the building performance after the energy retrofit, we calculate the annual energy savings from retrofits. Using a recent final energy consumer gas price of 7 EUR cent/KWh, Chart 3 depicts energy cost savings per m^2.

As we assume that a thermal retrofit is pursued jointly with a general retrofit of the building, we only consider the incremental costs of the thermal retrofit in the cost-benefit analysis.

The up-front costs of thermal retrofit (Chart 1) are for this purpose translated into annual interest and repayment costs for a 20 year loan at market interest rates of 4%. For 5 out of the seven reviewed studies the annuitized up-front cost (blue bars) are lower than the annual energy savings (green bars) – the retrofit is economically viable for the building owner if she can capture the full benefit from energy savings.

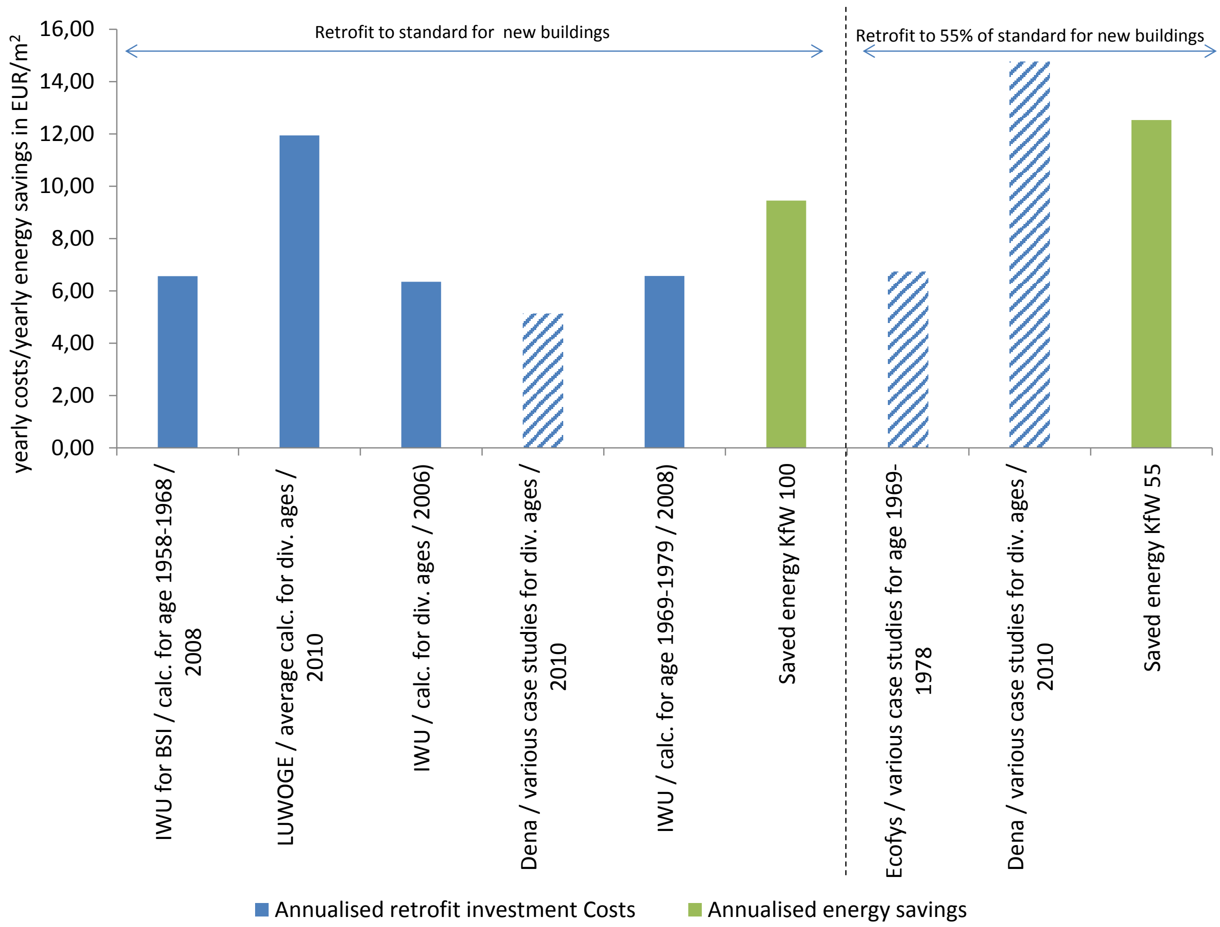

Chart 3: Costs and benefits of thermal retrofit measures for MFHs (hatched bars = ex-post analyses). Assumption: Loan with a 20 year loan period and 4% interest rate, 1.5% inflation, 7 EUR cent/kWh final energy consumer gas price (see Annex 5 of full publication for energy prices).

Section 2. What scale of financial support will be required if the thermal retrofit rate increases to 2% per year?

As described in the executive summary, only one-third of renovations include thermal retrofits, despite the availability of the German Development Bank's (KfW) low-interest loans and grants to support thermal retrofit. KfW's loan based program (151) subsidizes a third of energy related incremental costs for the retrofit of a dwelling unit to new building standard (KfW 100). For a retrofit that reduces energy demand to 55% of the standard for new buildings (KfW 55), it subsidizes 50% of the energy related incremental costs (details in Annex 4 of full publication). The reason for the current low retrofit rate could include a variety of factors, such as lack of information, landlord-tenant split, and short-termism, all of which could be addressed by targeted policies. These policies are not the focus here, but their careful development and refinement is currently being discussed and will be important for achieving the 2% thermal retrofit rate.

As one-third of households already decide to include a thermal retrofit in their renovation activities, the barriers to thermal retrofit do not seem to be inhibitive. However, the further improvement of policies and programs, and possibly increased financial support levels, are likely to be necessary to boost the retrofit rate. If a rate of 2% deep retrofits is achieved, what volume of support will then be required?

Assuming current support levels of KfW programs for retrofits to the standard for new buildings, public support would need to increase to 2-4 billion EUR per year. For retrofits to 55% of the standard for new buildings, public support would need to increase to 4-8 billion EUR per year as summarized in Table 1.

	Standard for new buildings (ca. 85 $kWh/m^2_{livingspace}/a$ for MFH/ ca. 102 $kWh/m^2_{livingspace}/a$ for SFH)			**55% of standard for new buildings** (ca. $kWh/m^2_{livingspace}/a$ for MFH/ ca. 49 $kWh/m^2_{livingspace}/a$ for SFH)		
	SFH	**MFH**	**Total**	**SFH**	**MFH**	**Total**
Energy related incremental costs (EUR/m²)	135-205	80-185		150-275	105-230	
Share supported by KfW (in %)	31	31		50	50	
Support EUR/m²	42-64	25-57		75-137	52-114	
Total support Germany, Mio EUR	1450-2202	762-1762	2212-3964	2576-4723	1599-3502	4157-8225

Table 1: Calculation of support level necessary to refurbish 2% of the total living space to reach the standard for new buildings and 55% of that standard respectively, assuming that all investors pursuing deep thermal retrofit apply for KfW support and that the support provided is sufficient to trigger the investments. The numbers represent the lower boundary of support necessary if financial mechanisms are not accompanied by other support measures.

Section 3. Calculation of energy saved by deep thermal retrofits

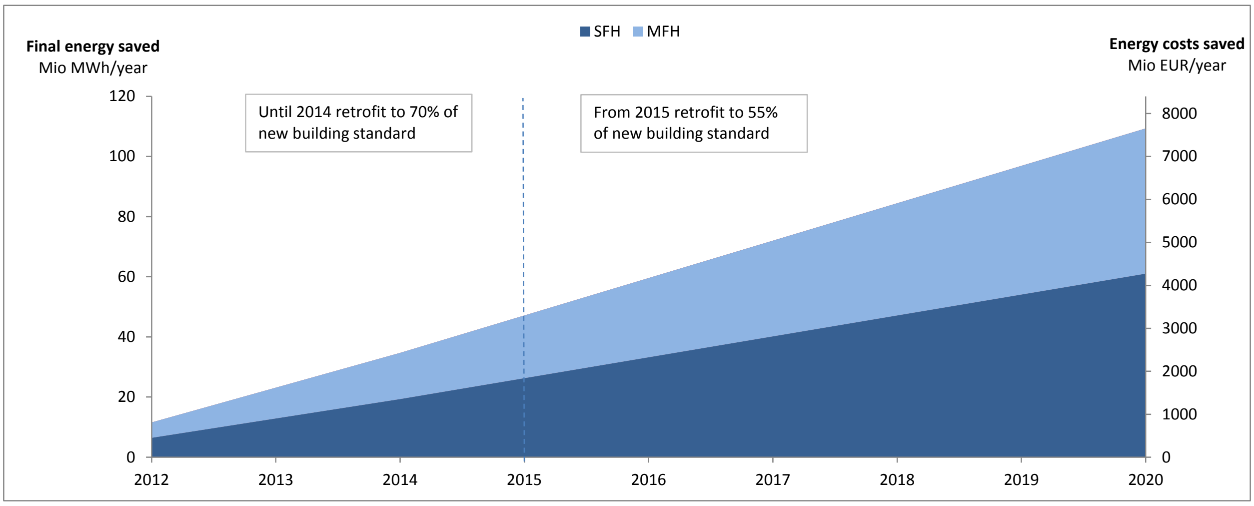

Chart 4: Annual saved energy and energy costs with the assumption of final energy price of 7 cent/kWh with a refurbishment rate of 2% to the respective KfW energy standard (for energy prices see Annex 5 of full publication).

In addition to saved costs, thermal retrofit measures reduce the demand to generate and import energy. Chart 4 shows the calculated savings in energy demand and costs in millions of MWh and millions of EUR for Germany. If average retrofits achieve a standard of 70% of the new building standard and are gradually tightened to achieve 55% of the standard by 2015, then a total of 110 TWh and 7.5 billion EUR in energy bills could be saved per year by 2020 (assuming an energy price of 7 EUR cent/kWh, Annex 5 of full publication).

Annex

Detailed calculations and results for SFHs can be found in the German version of the publication retrievable under www.cpi.org.

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