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Thermal Efficiency Retrofit of Residential Buildings: The German Experience

CPI Report

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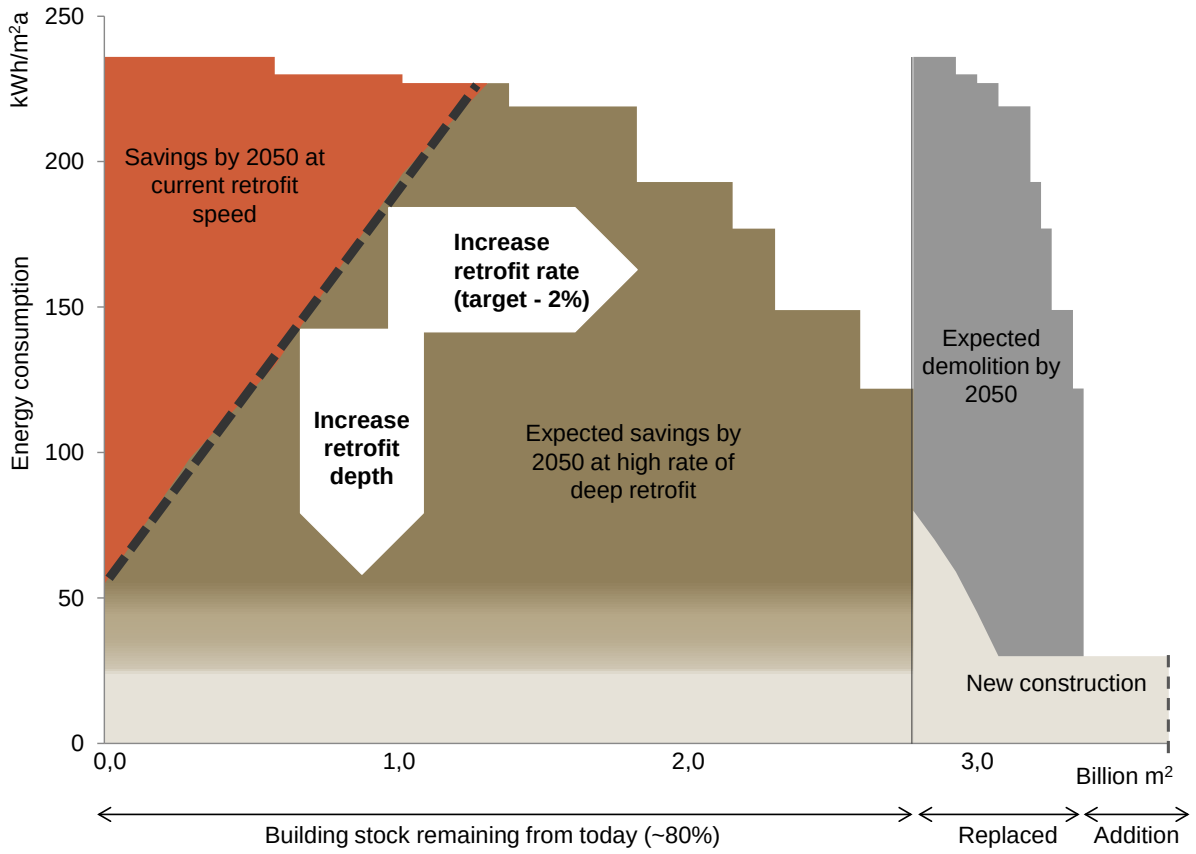
Objectives for building policies

The German government has committed to reducing the primary energy demand of buildings by 80% by 2050. Achieving this reduction will require foremost efficiency improvements, with a first milestone of a 20% reduction in heat demand levels by 2020.

Given that about 80% of today's building stock will remain in place beyond 2050, thermal retrofit of this existing building stock is essential (Figure 1). At the current rate of retrofit, however, only a fraction of the required reduction in thermal energy demand will be reached by 2050. Therefore, both scale and depth of retrofit need to be increased:

- The rate at which outer walls are being thermally retrofitted in Germany is currently ca. 0.8% per year for residential buildings; the government target for thermal retrofits is 2% [11]. Reaching this target will be more cost effective if thermal retrofits are linked to general, non-thermal retrofits that buildings owners pursue for non-energy related reasons (e.g. the current non-thermal retrofit rate, hence the retrofit rate that does not include energy efficiency improvements, for outside walls is 2.4%) [11].
- The depth of thermal retrofits today varies significantly, ranging from single measures delivering small overall improvements to deep comprehensive retrofits that may exceed the performance of new builds by up to 50%. Since a 2% retrofit rate only allows for each building to be retrofitted once before 2050, the overall efficiency improvement can only be achieved if all thermal retrofits are deep.

Figure 1: Only a fraction of energy demand will be reduced at current depth and rate of retrofit (indicated by top left triangle). The policy objective of an 80% energy demand reduction can be achieved by increasing the retrofit rate to 2%, by maintaining retrofit depth at or above today's best levels, and by energy efficient new constructions. Source: own calculations and [16]



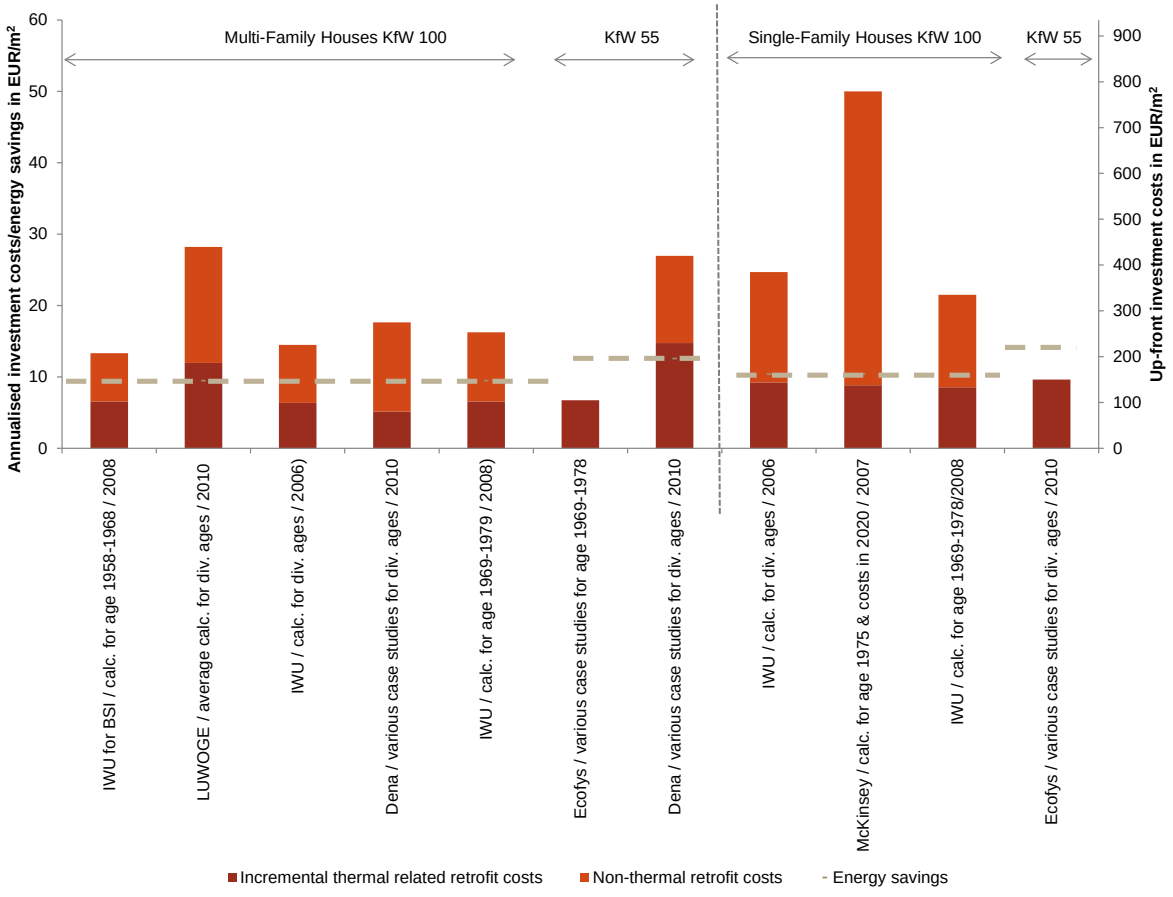
In addition to the existing building stock, new buildings constructed in the next 40 years will constitute 20-30% of the building stock in 2050 (own extrapolation of [12]). The government target is to ensure new builds are climate-neutral after 2020, by combining a reduction of final energy consumption (e.g.

to 30 kWh/m^2/a)[1] with a delivery of remaining energy needs from renewables. While this paper focuses on retrofits of existing buildings, the new technology and experience from new building construction processes will spill over to thermal retrofits, reducing their costs and improving energy performance.

Tailoring policies and programs to the needs of private decision makers

The full costs of a thermal retrofit are higher than the resulting saved energy costs (Figure 2). However, most retrofits of buildings are motivated by reasons other than energy reduction, such as improving the building appearance [4]. If a thermal component is included in a general retrofit project, its cost is reduced to about one-third of the full costs of thermal retrofits and more closely matches the resulting saved energy costs. For example, if windows need be to be replaced for appearance or maintenance reasons, the thermal component of the retrofit only comprises the incremental costs for installing a triple glazed window instead of a double glazed window. This suggests that including deep thermal retrofits as a part of general building retrofits is more economically viable than conducting standalone deep thermal retrofits.

Figure 2: Summary of several retrofit costs studies. The figure depicts thermal and other (non-thermal) retrofit costs versus saved energy costs [1]. The left axis of the graph shows the annualized costs and savings, while the right axis of the graph shows costs as up front investments.



[1] According to the Energy Concept of the German government all new buildings should be climate neutral by 2020. To achieve this, it is usually advice to supply renewable energy to a passive house of about 30 kWh/m^2/a. View for example [13]

Such an argument does not take into account, however, many of the considerations of building owners. For example, they may require a payback period for their investment shorter than the 20 years assumed in the calculations above, or they may be uncertain about energy savings [10]. Public support through grants and low-interest loans with partial debt relief (offered through KfW) was thus established to increase the economic viability of deep thermal retrofits.

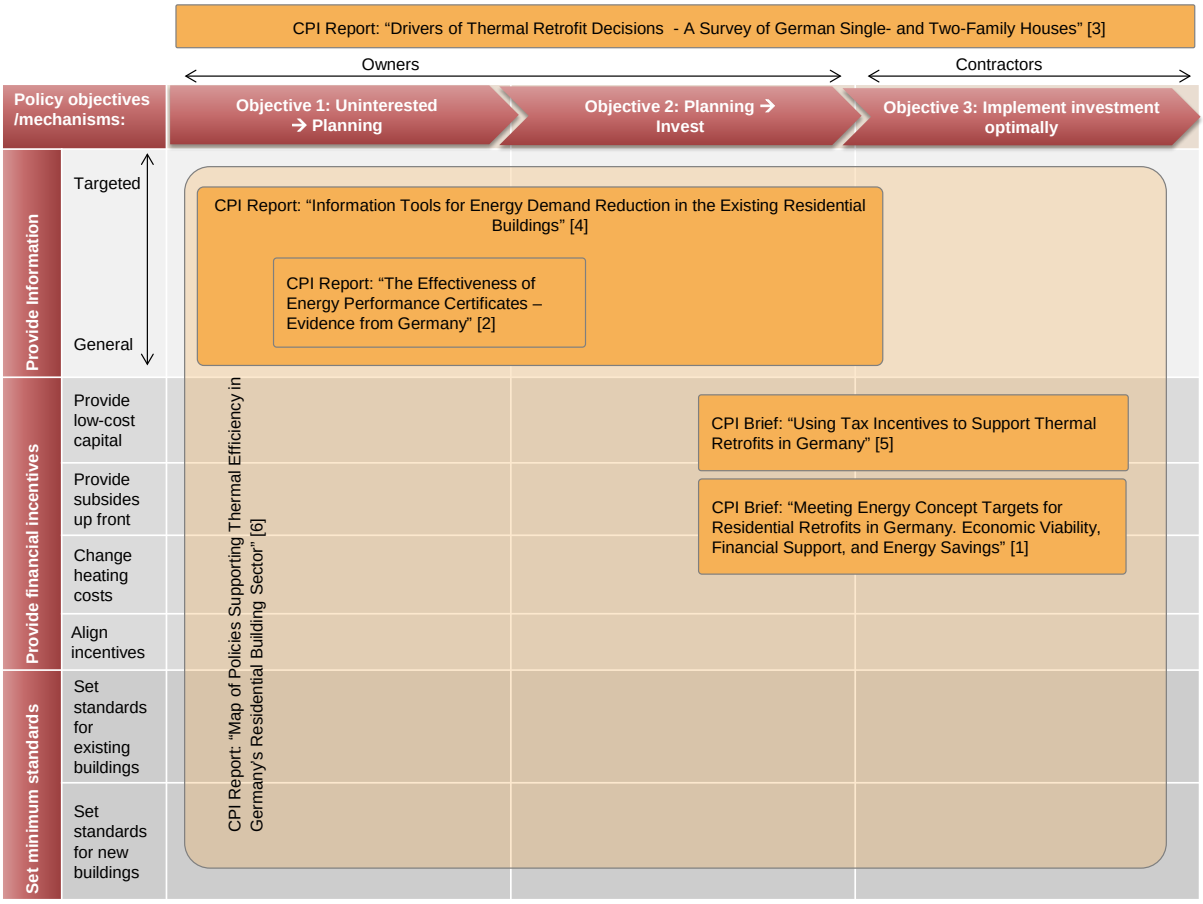
In spite of these financial incentives, both the current depth and rate of thermal retrofits are below the targets set by the German government. To understand the factors that might be impacting decisions about thermal retrofits, we surveyed 2,000 owners of single- and two-family houses in Germany [3]. Characterizing their decision-making process into three stages allowed us to identify how policies can contribute to a higher rate and depth of thermal retrofits [3]:

Objective 1: Encouraging uninterested households to consider a thermal retrofit
Objective 2: Enabling households that are considering a retrofit to plan and decide on a thermal retrofit
Objective 3: Ensuring that contractors (or craftsmen in British English) follow and correctly implement households' decisions.

The objectives formulated for the different stages of the decision-making process can be achieved with different sets of policies. Thus, homeowners are supported along the decision path in pursuing a deep retrofit.

CPI's German building policy analysis project includes papers that address the various stages of this decision-making process and different sets of policies, as illustrated below.

Figure 3: CPI analysis informing this policy summary (available at www.climatepolicyinitiative.org)



We next describe motivators and policies for each stage, based on insights from the papers.

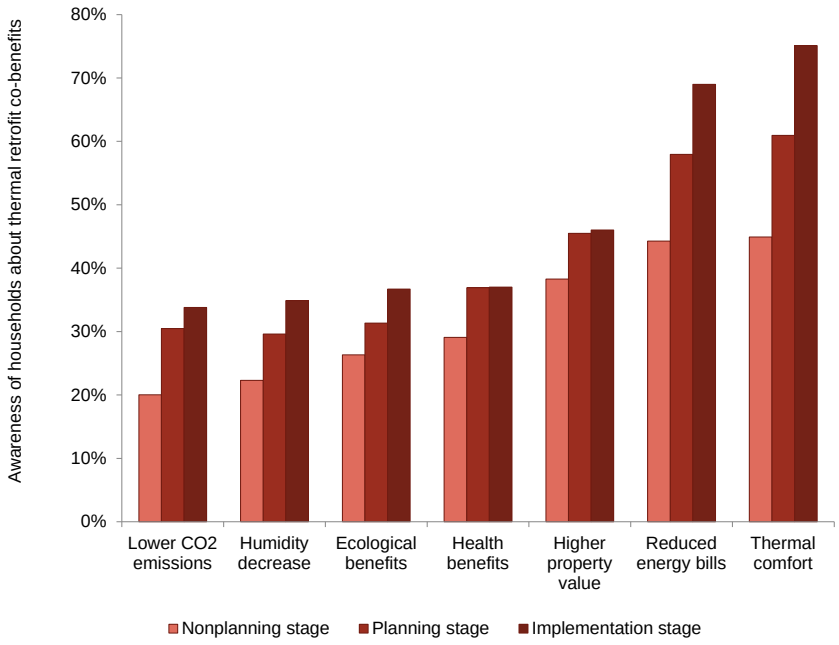
Stage 1: Encouraging uninterested households to consider a thermal retrofit

Information tools

For households that are not yet interested in pursuing a thermal retrofit, it is important to build awareness of the potential benefits of a retrofit beyond building appearance [3]. Thus, information tools and messages about the benefits of thermal retrofits are of primary importance at this stage.

Our survey asked respondents about their awareness of the benefits of thermal retrofits. Figure 4 illustrates that households in the planning and implementation stages had a higher awareness of the benefits of thermal retrofit, such as thermal comfort and reduced energy bills, than did households that were not planning retrofits. This suggests a need to increase awareness of these benefits among households that are currently not planning retrofits.

Figure 4: Households' awareness of the co-benefits associated with thermal retrofit at different stages of the retrofitting process [3]



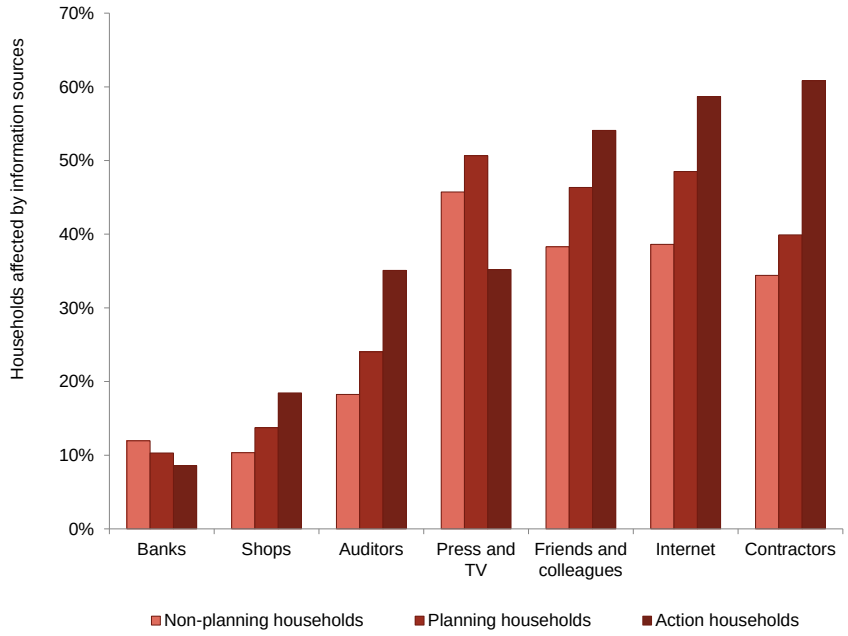
A variety of information channels can be used to inform building owners about retrofit options and benefits [3]. Figure 5 shows that the importance attributed to different instruments varies for households at different stages of the decision-making process. Print press and TV can reach households that are not yet interested in retrofits, and thus are not actively searching for such information [3]. Hence, these information sources are considered to be more important by households at the early stages of the decision process.

Building industry professionals or contractors can inform uninterested households about specific energy efficiency opportunities when they are onsite. The professionals most commonly engaged in providing information about thermal retrofit benefits at this stage are:

(i) Chimney sweeps and other contractors visiting households for checks and repairs. The information they provide is sometimes formalized as a free energy check or mini audit.
(ii) Door-to-door energy advice is offered by some municipalities.
(iii) Experts that certify building energy performance in preparation for the sale or letting of a dwelling can also include information about efficiency improvement opportunities in the Energy Performance Certificate (EPC) they issue. EPCs, however, currently have only a

minor impact, because households find it difficult to translate the energy efficiency ratings into financial implications, among other reasons [2, 4].

Figure 5: Relevance attributed to different information sources during different stages of the retrofitting process [3]

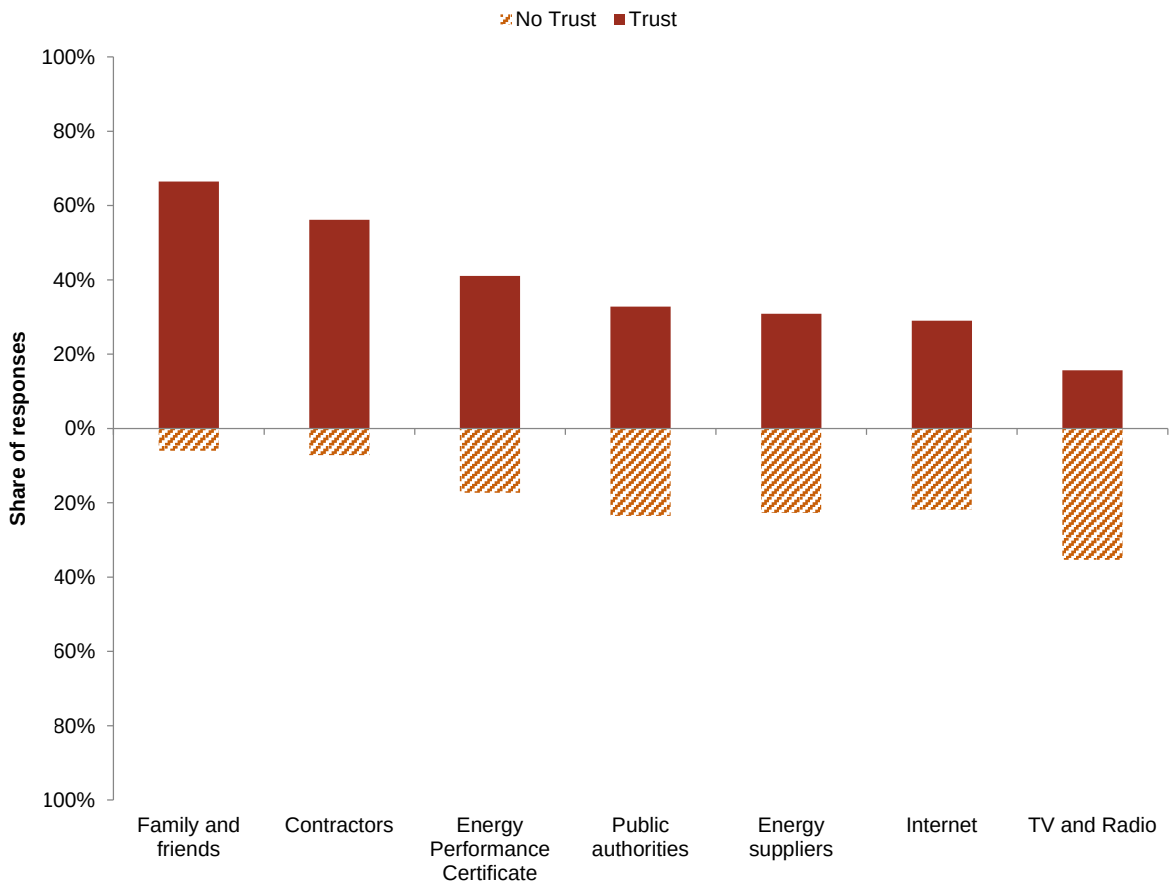


Finally, a separate CPI review suggests that heating bills may also be an important channel for creating and communicating of energy savings. Heating bills based on individual consumption in each dwelling are obligatory in Germany and display the costs of the current energy performance of a building. Some Scandinavian and US bills include information about changes in energy consumption over time and report the performance of similar buildings in the neighborhood [4]. Studies report that energy savings of 1-10% due to investment and behavioral response can be achieved just through the use of such detailed bills. The mandatory use of detailed heating bills is proposed in the new European Energy Service Directive.

Stage 2: Enabling interested households to plan and decide on a thermal retrofit

In the second stage of the decision-making process, homeowners are already interested in thermal retrofits and need to develop detailed plans and decide on thermal retrofit options. These options often involve large investments and changes to the homeowner's property; therefore, trust becomes an important issue. While Figure 3 shows the types of channels that reach homeowners at different stages of the decision-making process, Figure 6 shows the level of trust homeowners place in different information sources.

Figure 6: Trust of German homeowners in information sources about energy efficiency (own calculations based on Adjei et al. 2009) [7].



Information tools

Contractors are among the most trusted sources of information about energy efficiency issues (56% of households stated that they trusted contractors, Figure 6). Policymakers are currently evaluating whether contractors are sufficiently trained to advise on comprehensive retrofits, not just measures in their area of specialty [4].

Other studies report that certified energy advisors and auditors also enjoy high levels of trust [14]. These individuals offer comprehensive advice about retrofit options, costs, benefits, and public support programs. The government agency BAFA reimburses 50% of the costs associated with these advisors, with a maximum support level of 360 Euro per building (BAFA supported 20,000 energy audits in 2010) [4]. To prevent conflicts of interest, advisors are prohibited from subsequently executing the retrofit. The program is reported to deliver high shares of deep retrofit: 48% of audit recipients who insulated the outside wall of their building stated that they had not planned to do so prior to the audit –energy audits led to overall cost-effective savings at around 4.7 EUR/tCO_2 [9].

Public authorities, such as energy agencies and energy information centers, are also named as trusted sources of information by 56 % of German households at the retrofit planning [3]. To address this demand, public authorities provide information through their websites, via phone, and through local offices.

While the Internet is one of the two most utilized information sources (Figure 5), it is not highly trusted (Figure 6). This may be attributable to information inconsistencies across different websites. In the

US, this has led to the introduction of a standard to identify differences in building energy simulation software [4].

Regulation

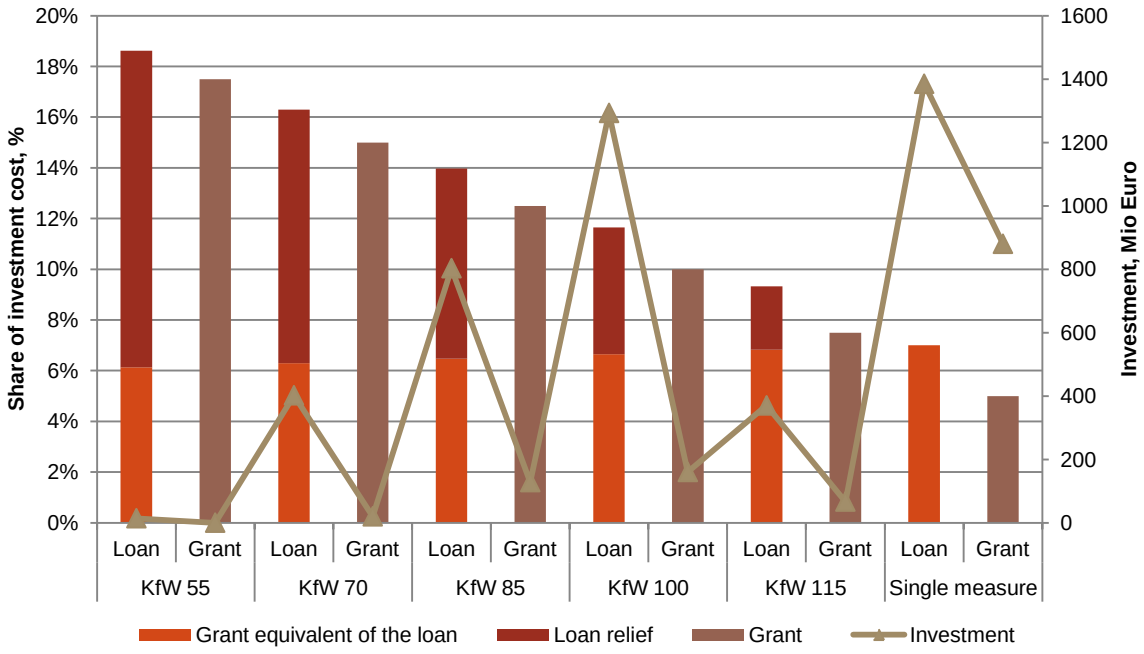
Besides information instruments, regulations are important in stage 2 of the decision-making process. They can target households that are planning to pursue a general modernization. By setting minimum performance standards, regulations can ensure that at least some level of economically viable thermal measures are installed. Of primary relevance in Germany is EnEV, the standard that requires contractors to either follow the minimum performance standards of components for existing buildings or ensure that the overall retrofit does not fall below the standards for new buildings by more than 40%.

Financial instruments: Preferential loans, grants and tax incentives

Households across all decision stages have emphasized that retrofits need to be economically attractive, and financial concerns rank highest among homeowners' concerns about retrofits [3]. Financial support mechanisms are therefore important in the planning stage as homeowners are making decisions about the retrofit and its thermal component.

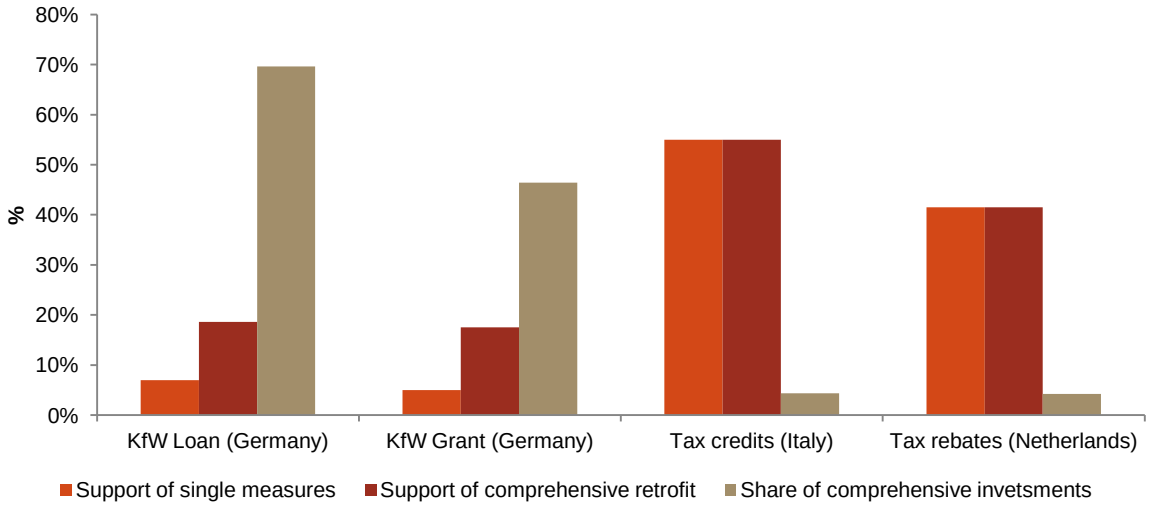
KfW provides preferential loans that are issued through private banks, as well as grants, to support thermal retrofits. The support provided by the grant or loan (preferential interest rate and loan relief) covers a share of the total retrofit costs. Figure 7 illustrates how this share increases with the building's post-retrofit thermal performance, subsequently contributing to incentives for deeper retrofit. The line in the figure approximates the volume of retrofit investments supported in 2010. The low volumes of investments under KfW 55 (45% stricter than standard for new buildings) and KfW 70 (30% stricter than standard for new buildings) standards suggest that increasing financial support from 14% (KfW 85) to 16% (KfW 70) and 18% (KfW 55) does not suffice to encourage a deeper retrofit for most building owners.

Figure 7: Share of investment costs supported by KfW for different depths of retrofit. Graph uses interest rates of May, 2011.



The progressive support of comprehensive retrofits compared to single measures, as shown in Figure 8, seems important, as countries that supported comprehensive retrofits and single measures with the same level of support received, almost exclusively, applications for single measures [5].

Figure 8: Support levels for individual measures and comprehensive retrofit, and share of comprehensive retrofit [5]



In addition to offering higher levels of support for deep retrofits, the design of the loan application process is also important [5]. Households are required to commit to an energy performance level and consult with energy auditors before and after the application for KfW loans. In our survey, households with KfW support reported that they pursued all of the initially envisaged thermal improvements, while other households often reduced the scope of the thermal retrofit during the decision-making process [3].

As an alternative to KfW support, the German parliamentary chambers are currently considering tax incentives for retrofits. To qualify the building's performance after completion of the retrofit must reach 85% of the new-build standard. Costs associated with reducing the energy demand of the building will then be tax deductible over ten years. For households in the highest income bracket, at the marginal tax rate of 42% (plus solidarity tax), the tax deduction corresponds to 35% of the full retrofit costs for self-occupied buildings (introduction of tax deductibility) and 16% of the retrofit costs for rented buildings (acceleration of tax deductibility), assuming a 4% real discount rate. The introduction of tax incentives as an additional support mechanism was motivated by the political preference for tax incentives over an increase of on-budget support for KfW, and by the expectation that some investors will consider tax saving opportunities to be more attractive than preferential loans or grants. The retrofit performance standard and parts of the compliance process of the implementation of the proposed tax incentives scheme has been aligned with KfW programs.

Stage 3: Ensuring that contractors follow and correctly implement households' decisions.

In the final stage, homeowners are already implementing thermal retrofits and have employed contractors to undertake retrofitting work. A high quality of work is essential, not only to achieve the thermal performance of the building, but because the quality will influence other households' decisions about thermal retrofits (as noted in Figure 6, 66% of households trust family and friends for energy efficiency information).

Contractor training and certification

Our survey indicated that as households move further along the decision-making process, they rely more and more on professionals for advice [3]; at the implementation stage, contractors have the most contact with households. The training and certification of contractors can help to ensure the optimal implementation of retrofits. Contractor certification requires both initial training or apprenticeships and frequent retraining to ensure appropriate installation of new building materials. As most difficulties arise at the interfaces between building components delivered by different contractors (wall, window, roof, technical installations), it is essential that all contractors are trained on thermal aspects of buildings. Until now however, most expert judgments and, few available, studies

that the basic and further education of contractors is not sufficient in relation to a) implementation, b) coordination, and c) communication of deep thermal retrofits. Accordingly, also the energy concept demands and improvement of the education of contractors.

Schemes certifying the capability of a firm to implement deep retrofits are not only necessary to help households choose a firm, but they also create incentives for firms to send their staff to training. This is particularly important in the building sector due to high staff turnover and difficulties with finding time to send staff to training during tight project deadlines. Certification schemes can also help to assure households that firms have the expertise needed to provide comprehensive and independent advice on deep thermal retrofits, thus increasing households' trust in the information provided by contractors [4]. The current negotiations of the European Energy Service Directive include a discussion of harmonized certification schemes [4].

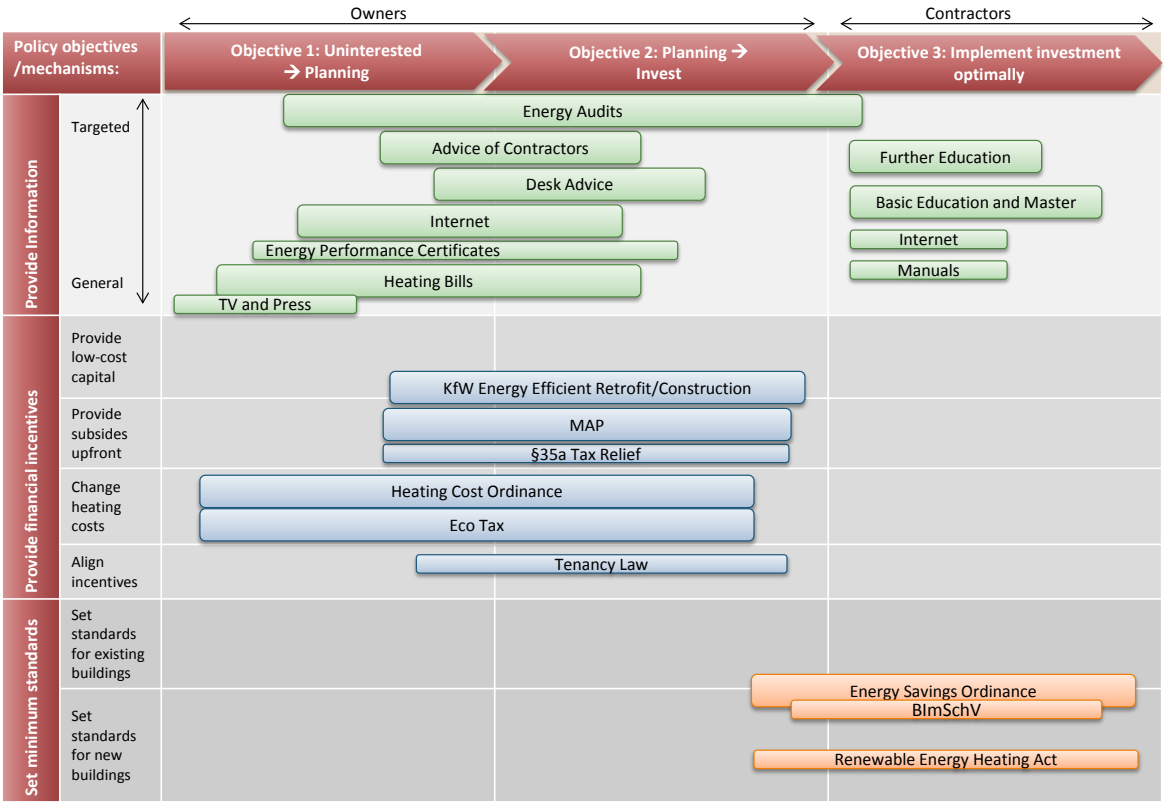
The energy advisor working on a retrofit project can both observe the quality of the work and provide training for contractors about deep retrofits [3]. Energy advisors' services are mandatory and publicly supported for retrofits to the highest energy performance standard supported by KfW (45% below new-built standard), and spot checks are carried out for all KfW programs.

Summary

Energy efficiency improvements in the residential building stock can be maximized if deep thermal retrofits are linked to general building retrofits that are pursued for other reasons, like the improvement of building appearance.

To meet goals, it is necessary to increase the rate at which thermal retrofits are delivered from the current 0.8% to 2% and to ensure that deep retrofits are foremost pursued. Ultimately, success will be determined by the investment decisions of households. Public policy can target the different stages of this decision-making process by (i) encouraging households to consider a thermal retrofit, (ii) enabling households to plan and decide on a thermal retrofit, and (iii) ensuring capacity and skill in implementing thermal retrofits. Figure 9 illustrates the varieties of information, financial support, and regulations used in Germany to achieve this objective.

Figure 9: Map of policies and programs supporting thermal energy demand reductions [6]



Future analysis

This analytical project was focused on single- and two- family houses, which constitute 47% of dwellings in Germany [15]. Multi-family houses require separate assessment because they face additional challenges. Where dwellings in a building are owned by many individuals coordination is required during the retrofitting process. Where flats are owned by a third party, the owner might want to know whether it is possible to reflect the costs of a thermal retrofit in the rent (58% of German dwellings) [8].

Further analysis is also needed to explore the drivers and performance of modular retrofit processes that can stretch over several years. Preferential loans from KfW and the new tax incentive schemes facilitate such approaches, and will be reviewed by CPI. This also relates to the question of whether deep thermal retrofit can be delivered for the entire building stock through linkages with general building retrofits.

Individual instruments supporting building energy efficiency in Germany do not currently have quantified targets. As a result, evaluations rarely assess the effectiveness of an individual instrument against its goal or the interaction across instruments. Both the German Energy Concept and the European Energy Service Directive include provisions for more frequent and detailed monitoring of the energy and climate policies, creating opportunities for better policy evaluation, learning, and ultimately implementation of building policies.

Overall, more than doubling the rate of thermal retrofit and ensuring retrofits' consistently high depth constitutes one of the major opportunities and challenges for German energy policy. The current proposals to increase public financial support through additional tax incentives are a first response. However, a key question not answered by any analysis to date is what scale of financial incentives and support is required to achieve this target?

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