Saving Energy Through Transparent Shutters – Presentation and Discussion of a Do-it-Yourself Idea

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Abstract

In Europe, the majority of heating energy is required for existing residential buildings: on the one hand, most of these buildings are well over 25 years old, and on the other, they regularly have an uninsulated or very poorly insulated building envelope. Most of the energy lost in winter is lost through the façade because it makes up the largest part of the envelope. Enormous increases in energy prices, particularly in Germany, are forcing the owners of such buildings to economise, i.e. to lower interior temperatures. This is only sensible and possible to a limited extent, which is why extensive energetic refurbishment measures are now needed even more than in 2021 or before. In view of Germany's current economic difficulties (particularly due to many insolvencies and inflation), this poses a challenge for many private owners of detached and terraced houses. The following text therefore presents a do-it-yourself idea that can be implemented at low cost to address this problem. Although transparent window shutters are only a selective measure for existing residential buildings, they are an improvement that can be implemented primarily as a cost-effective interim solution until extensive energy refurbishment is carried out. This idea is based on the historical form of the so-called front window. It avoids the physical problems of many other DIY solutions. In combination with recycled products, the consumption of resources can also be minimised for the idea presented here.

Keywords: *energy saving measurements, residential buildings, windows, transparent shutters, DIY-Idea*

1. Introduction

Homeowners want to improve the heating energy requirements of their properties, and not only for political and ecological reasons. Economic reasons are also driving this interest, with particular focus in Germany on single-family homes built between the Second World War and the first thermal insulation ordinance following the oil crisis, which have not undergone any fundamental energy-efficient renovation since then. These usually have an uninsulated facade, the weakest point of which is usually the windows. However, due to developments over the last 20 years and also the last 5 years, many owners of such buildings are no longer financially able to carry out energy-efficient renovations.

The following article explains why this situation occurs more frequently in Germany than in other European countries. Above all, the author presents a DIY idea that can serve as an interim solution to this dilemma. In the case of recycled elements, such a temporary solution would also be cost-effective and resource-saving.

2. Problems, idea and implementation example

The current problems in this context have three fundamental causes. Although these are partly interlinked, they are nevertheless presented in sections below. It also explains why they are more pronounced in Germany than in other European countries. Following the causes, the author's provisional DIY idea is presented with its three main advantages and finally, in a third section, an example of implementation in two variants is shown.

2.1 Problems and challenges

Building stock: For many years, German politics was primarily concerned with new construction. However, the vast majority of residential buildings, namely around 60%, are more than 50 years old. Of the almost 20 million residential buildings, about 13 million are single-family houses, which make up about 30% of the housing units in Germany, and about 3.1 million are two-family houses with about 16% [1]. These shares and ratios have not been subject to any significant changes so far (cf. [2]). In particular, 98% of single-family homes and buildings with one residential unit are privately owned. The aforementioned building stock was regularly planned in accordance with the specifications applicable at the time of construction, which, from today's perspective, often constitutes "no thermal insulation" in terms of thermal insulation. Furthermore, single-family houses inherently have a less favourable surface-to-volume ratio than any other type of building, which further exacerbates the unfavourable situation: they have more envelope area than other residential buildings, which is often poorly insulated or not insulated at all, as is characteristic of a large proportion of the existing building stock.

The biggest weak point of these buildings are the windows. They are regularly shown in thermographic images as the areas with the highest heat losses [3]. As can be seen in Figure 1, it particularly affects the window frames, regardless of whether the residential building is older or newer.

Energy costs: For a long time, the disadvantages described above were still manageable for the owners, who are usually also residents. In particular, the buildings constructed before 1980 were and are predominantly heated with oil and especially gas [2], p. 26. It has now been proven that the heating energy consumption of residents in old buildings is significantly lower than that of residents in new buildings; the actual consumption per square metre of living space in old buildings is usually considerably lower than the calculated consumption, while residents of energy-efficient new buildings tend to be less energy-conscious. [5].

Fig. 1. Two examples of thermographic images of the facade of single-family houses: on the left an older building [3], on the right a newer building [4] The white arrows indicate the windows (frames) with highest surface temperatures [photos modified by the author].

But in the meantime, energy prices in Germany have risen considerably. The Federal Statistical Office speaks of a price increase of about 80% since 2021 for private households [6], other sources write that in summer 2025 “gas prices … are currently about twice as high as they were five years ago” [7]. The causes are political. First of all, there are the procurement costs of the gas. The sanctions against the Russian Federation, which have so far not led to an end to the war in Ukraine and have thus missed their purpose but have made many things more expensive in Germany [8], are the main factor. Secondly, the “rising CO2 price and rising network fees” [7] are mentioned. The CO2 price or the costs of CO2 emissions trading are a levy or tax on the common good of air. Thirdly, there was a return to the increased tax rate on gas in Germany in 2024. Finally, due to the two factors of CO2 price and network fees, “further increases in gas transport can be expected” [7].

Although the new German government, in office since spring 2025, plans to reduce energy costs for citizens, it envisages a continuation of its political predecessors and not a fundamental departure from the reasons for these prices mentioned above [9]. Instead, from 2027 onwards, the import of low-cost liquefied gas from the Russian Federation will also be banned for climate protection reasons [8], although Germany has already reduced its emissions by around 50% between 1990 and 2023, which is more than most other European countries [10], p. 40. In the author's opinion, a significant reduction in the very high energy prices is currently not foreseeable, but experts from other disciplines are better able to assess this and the future will show that. In any case, German industry is increasingly relocating due to the developments described above and unpredictable energy costs [11]. The number of corporate insolvencies, which were probably also caused to a considerable extent by this situation, also rose by more than 22% in each of the last two years. More than 50,000 companies have had to file for insolvency in Germany in the last three years [12].

However, emigration or an end to production activity are generally not an option for private households. A short-term switch to other energy sources (such as electricity) is not only not possible for these people for cost reasons (Germany has the highest electricity prices in the EU, mainly due to taxes and the nuclear phase-out [13]). For residents of older buildings, which are generally less energy efficient, the situation described above means a significant increase in the cost of living, because the energy-saving measures mentioned above are limited. Already now, more than 1.8 million Germans are freezing in winter due to the increased gas prices [14]. For older people and members of vulnerable groups, this endangers the health and can even be fatal; statistically, the number of cold-related deaths worldwide exceeds that of heat-related deaths by almost 10 times [15]. Apart from a fundamental change in the overall situation, which is probably only politically possible, the only option left for the owner of one of the 13 million single-family homes is to renovate their home, which requires appropriate financing.

Financial situation: As is easy to imagine, people for whom increased heating costs represent an economic challenge usually do not have the financial means to renovate their homes. It could not be verified whether it is actually homeowners who are most affected. However, since these costs are fully borne by the taxpayer for recipients of social assistance, basic security, citizen's allowance, asylum benefits, etc., or partially in the case of low-income earners [16] (which torpedoes the incentive to save energy in society as a whole), the author assumes that homeowners are disproportionately more often affected. “Particularly in times of crisis, for example in the wake of high inflation, the distribution of wealth requires special attention. “This is because existing assets can be used to cushion crisis-related developments […],” [17]according to the German Ministry of Economic Affairs. However, this wealth is becoming less and less evenly distributed: the top 10% of the population owns 60% of the wealth. This wealth also includes owner-occupied residential property, which 45% of Germans own – a very small proportion of the population compared to other European countries [18]. Two-thirds of these homes are mortgaged. The trend towards wealth concentration had already become apparent 15 years ago [19], and inequality is greater than in almost all other European countries. The fact that wealth inequality has not become even greater is only due to the real estate holdings of the middle class [20], the value of which has risen continuously in recent years. However, this value usually only materialises in the event of a sale or inheritance, so it is an asset without income.

This proverbial "little house" of the average consumer was mostly built after the Second World War; 36% of the residential building stock dates from the period between 1945 and 1977. Another 20% of the stock dates from the years up to 1994 [2]. Often built by young couples or families with the goal of being debt-free in 20-30 years and being able to retire rent-free in financial security 10-20 years later. However, many people have not been able to make this plan a reality. Without claiming to be exhaustive, some of the main reasons for this are listed here. These may be similar in other European countries, but are much more pronounced in Germany. Firstly, the two world wars continue to have a significant and adverse impact on demographics; secondly, reunification continues to have macroeconomic consequences; and thirdly, the so-called refugee crisis of 2015 continues to place greater financial burdens on Germany than is the case in other countries. But what exactly is the situation for many builders and owners of the aforementioned more than 50% of residential buildings from the post-war period up to around 1990?

Firstly, for many, their pension is considerably lower than they expected when they were younger. “The ratio between the standard pension and average annual earnings has been declining since the end of the 1970s; since 2012, the pension level has consistently been less than half of average earnings.” [21] A pension level of almost 60% of average annual earnings in 1977 became about 48% in 2020. Secondly, pensioners could and can afford less and less due to inflation. Formally formulated, due to

"the development of consumer prices […] the real standard pension fell between 2003 and 2014 […], which means that purchasing power decreased overall in these years." [21] As early as 2006, as a result of government decisions at the time, pensions were forecast to be only a kind of basic security [22]. Thirdly, in 2005 (instead of effective measures to increase the birth rate), a gradually more extensive taxation of pensions was introduced. Anyone who retired at that time had to pay tax on 50% of their income. By 2040 it will be 100% [23]. Even before that, namely in 2036, the generation of so-called baby boomers in Germany will have completely retired from working life [24] and will be affected by the issues mentioned above.

Of course, the single-family homes discussed here are not exclusively occupied by retirees, but are now often already used by the next and/or subsequent generation: real estate is being inherited more and more frequently: currently, it accounts for 54% of inheritances; in 2018, it was still 40% [25]. Ideally, the children of the previous owners inherit. Children who inherit single-family homes they use themselves are largely exempt from inheritance tax, provided they live in the property themselves for at least 10 years (often accompanied by paying out siblings). This cannot always be linked to one's professional career. Although most of the moves are not for work-related reasons, around 2/3 of the moves are over longer distances [26]. Irrespective of this, people in working life who were able to benefit from real wage gains until around 2019 have since suffered a significant loss of purchasing power [27]. In 2024, the Ministry of Economic Affairs and Energy, headed by an often eloquent politician, published that current "sentiment and leading indicators […] do not point to a short-term economic recovery" [28]. There is also talk of significant declines in industrial production and a depressed mood among private households [28]. The latter is often the employee side of the ongoing economic downturn [29] and the already mentioned increase in bankruptcies and industrial relocation [11] [12]: the short-time work and unemployment rates are increasing and reducing the financial flexibility for many owners of single-family homes. In the event of a divorce or a sudden death, for example, the financial situation may even force employees to sell their home.

As is clearly evident to the reader, the last section, "Financial Situation," uses stereotypes. These are intended to show, based on two exemplary, by no means rare life situations of typical single-family home owners, that although the property has a nominal asset value, there are often no reserves [19] from which an energy-saving renovation could be financed. In view of potential unemployment or impending retirement, (further) creditworthiness is sometimes no longer given and thus energy-saving renovations are not affordable. Of course, and fortunately, not all homeowners are affected by the combination of all three challenges mentioned in this chapter. Life and people are too diverse to be adequately represented in stereotypes. Nevertheless, in the author's opinion, these stereotypes can illustrate that single-family homeowners in difficult economic situations in Germany are by no means isolated cases.

2.2 Idea

Even if the saying "too poor to live, too rich to die" is exaggerated in this context, an ever-increasing dilemma is opening up for the homeowners described above. Many people try to remedy this with DIY solutions. Often cheap, but disastrous in terms of building physics, unsuitable interior insulation or aluminium foil glued to the inside of walls, for example, are marketed (e.g. [30]). The author, like others before (e.g. in [31]), has pointed out the danger of mould formation in window reveals due to ill-conceived DIY solutions and has presented a structurally viable alternative in [32]. The approach presented here is a simpler, cost and resource-efficient development of this proposal published in 2023.

The aim is not to find a perfect solution, but rather a cheap temporary measure to save energy and costs until energy-efficient renovation becomes economically viable for the homeowners (or their heirs): transparent shutters made from old windows in front of the actual windows of such a house. Thanks to their transparency, they can not only function as weather and heat protection at night, but can also remain closed all day during the heating season or be opened only for ventilation purposes. Such a temporary solution may not be visually attractive, but it is accepted as a possibly temporary emergency solution in order to achieve the following advantages.

Energy saving: This goal is the top priority, although it should of course also be linked to a reduction in heating costs and thus economic benefits. Although DIN 4108 requires airtightness so that elements of the building envelope can be included in the calculations, in the case of ventilated facades, even the standard takes into account the reduced heat loss through this cladding of the building envelope. It is known from publications on casement and box windows (e.g. [33] and [32]) that the non-hermetically sealed, but almost stationary, additional air layer in front of existing windows brings about a significant improvement in thermal insulation.

Cost-effective recycling: due to the situation first described in 2.1, more and more homeowners are gradually replacing windows from the time of construction or even more recent ones with ones that meet today's requirements. The previous windows often become waste that has to be disposed of. Although there are now companies that have specialised in recycling the frame material of plastic windows (e.g. [34]), reuse is nevertheless a higher-quality way of dealing with these elements. Since the previous owners usually pay fees for disposal, the purchase should be inexpensive. The biggest problem is the dimensions: after all, the pivoting sash element, which is intended to function as a "shutter," has to fit at least roughly to the existing window. Those who avoid the time-consuming search for free elements at recycling centres might find what they are looking for at one of Germany's component exchanges (see [35]). It is undisputed that "do-it-yourself and hobby enthusiasts" are able to help themselves with the dimensions of old wooden, single-glazed, wooden windows and can implement this idea much more easily. The extent to which existing window strips can continue to be used or need to be partially replaced with new, rust-free ones must be assessed on a case-by-case basis.

Reversibility: Since the transparent shutters are only dowelled in front of/on existing exterior walls, they are also relatively easy to remove again. The author is thinking of solidly constructed post-war residential buildings without facing or facade cladding, where the strength of the masonry is usually sufficient for such fastening. This idea is primarily intended as a temporary improvement of the situation until a "real" renovation can be carried out, which is why reversibility is essential. Alternatively, the recycled elements could be supported and guided via horizontal rails. However, in order for such a sliding construction to have at least an acceptable level of durability, it must be protected from the weather, especially driving rain. This involves somewhat greater effort.

2.3 Example of implementation

Two variants of such transparent shutters are present in the residential building shown in Fig. 2. It is located in Hamburg Niendorf. On the ground floor, the transparent shutters are attached with pivoting fittings; on the upper floor, they are sliding elements whose guides are protected on the top by copper sheeting.

Fig. 2. Single-family house with transparent shutters, own photo, April 2024.

The above-mentioned fittings are can be seen well in Fig. 3 on the left. The DIY idea presented here is based on historical secondary windows. Examples of such windows can be seen in Fig. 3 on the right, on a listed residential building from the 18th/19th century in Middle Franconia. There, one of the wings of each element can be opened for ventilation purposes.

Fig. 3. Single-family house with transparent shutters, detail, own photo, April 2024 (left). In comparison, a listed farmhouse with historic bay windows, own photo, March 2023 (right).

The single-family house shown in Fig. 2 demonstrates that transparent shutters do not necessarily detract from the appearance of a building – quite the contrary. However, the execution in this case is anything but a temporary solution. On the contrary: the sheeting protecting the guide rail on the upper floor from the weather is a testament to careful planning, and the patina on the copper proves that this construction was already carried out some time ago. With temporary solutions and the use of "waste products," the result may not always be visually harmonious. However, the primary goal is to achieve a cost-effective reduction in heating losses and costs in existing residential buildings.

It is even conceivable to implement this idea as shown in Fig. 2 as a permanent solution. If, during a renovation, the existing windows, which from today's perspective are inadequately insulated, can be left in the building, this not only saves money but also resources or so-called grey energy. Currently, window replacement including the disposal of existing windows is still financially supported in Germany [36]. However, it would also be consistent to provide government support to improve the current situation of windows through alternative, resource-saving solutions such as those presented here. As with other proposals for improving building envelopes (e.g. [32], [37]), it is of course necessary in this case too to transfer the findings from the academic into the practical world of contruction.

As in a previous publication [32], the author sees the need for further research here as well. Using prototypes of various designs mounted in front of existing, uninsulated buildings, measurements could be taken regularly over a heating season to determine the

actual improvement brought about by these elements. Such an investigation on various buildings as a first step could reveal the potential of this idea.

3. Summary

This article explains why, particularly in Germany, many owners are no longer able to heat their more than 50-year-old single-family homes to comfortable indoor temperatures for economic reasons, but also often do not have the financial means necessary for comprehensive energy-saving renovations. For these people, the author presents transparent shutters as a temporary DIY idea. In the case of using elements from other buildings that would otherwise have to be disposed of, this idea is discussed as both cost-effective and resource-saving.

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