

## **Climate renovation can pay off**

### **A life cycle cost analysis conducted as part of the LichtAktiv Haus experiment confirms the economic viability of modernizing a 1950s settler house**

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#### **Abstract:**

*Life Cycle Cost (LCC) calculations include both initial costs associated with an investment (purchase, modernization, new construction) and the consequential cost related to use and maintenance of the building. LCC enables a medium or long-term perspective to be applied in current decision making processes. A detailed evaluation of LCC calculations reveals significant influencing variables that should be considered in making current decisions, and can also indicate which influence future energy price trends may have on the total costs. .*

*A Life Cycle Assessment (LCA) shows that from an environmental point of view, it is better to extensively modernise an existing building than to build a conventional new house. The LCC analysis now shows that climate renovation of an old settler also pays off in economic terms. The calculation, based on a realistic cost estimate for series production, shows that, even if energy prices only rise moderately, the modernisation costs are offset after approximately 15 years, when compared with continued use and forthcoming maintenance of the existing and unchanged building. This paper analyses and discusses the economic aspects of the current case study and in the context of other sustainability aspects. The paper is a scientific publication and will present and discuss the study accordingly.*

**Keywords:** *modernisation, life cycle costing, model home 2020, net zero energy modernisation*

#### **Introduction**

Within the international building exhibition 2013 (IBA 2013), located in Wilhelmsburg, Hamburg, Germany, show case buildings demonstrating cutting edge energy efficiency and energy technologies have been realized. Different from other show cases demonstrating new buildings, Wilhelmsburg is an existing town district of Hamburg, with specific social concerns. VELUX participated in the IBA program and acquired a small single family building to be used as a model home (VELUX 2013). The Wilhelmsburg building was built in the 1950 and has not undergone significant changes ever since. It represents a rather typical settlers home, millions of these and similar buildings have been built in Germany in that period of time. As individually owned houses, many of them have undergone refurbishments,



energetic upgrades or extensions. Originating from the 50ies, many of these buildings remain un-updated and are technically and functionally not up to date, and frequently face demolition. Otherwise they would require extensive and costly modernisation, commonly assumed to be too costly.

Facing the alternatives demolition vs modernisation, VELUX developed a model home concept for modernisation, aiming to upgrade the building to a up-to-date living environment, creating open, light, healthy and energy efficient spaces that would be attractive in a market that does currently not appreciate that building type.

In the light of sustainable construction, the model home was supposed to be analysed from multiple perspectives – obviously quality of life and indoor environment issues, but also environmental aspects from a life cycle perspective. After TU Darmstadt had conducted a comparative LCA of the model home renovation vs continued operation and vs demolition and new construction, the obvious identified preference was the radical modernisation to a net zero energy standard. (Hegger et al 2011)

But what about the cost?

### Life Cycle Costing

Life cycle costing (LCC) is a standardized approach to the quantification of costs related to a building. ISO 15686-5 lays out the principles and provides the necessary elements to carry out a life cycle cost calculation. The detailed approach is left open and adaptable to the scope and preferences or concerns of the cost analyst. In that way, an LCC calculation can be adapted to the analysed building, the options at hand, or to the parameters to be studied. In that manner it is as well possible to test the reponse of displayed results to parameter variations.

Applying LCC in the context of sustainable building directs the focus to the way in which established green building labels address the subject.

- LEED (LEED v4 2014) does currently not include life cycle cost assessments
- BREEAM (BREEAM) requires a repeated and refined cost calculation at distinct project stages, the calculation results are to be considered in decision making, and are to be established according to ISO 15686-5
- DGNB (DGNB NKW'12) details a simplified LCC calculation procedure, not aiming at cost optimisation in the planning process, but establishing a calculation on common grounds, resulting in a benchmark comparison. All details except for the building cost and performance data are prescribed for the sake of comparability.

For the analysis underlying this paper, it was rapidly clear, that it should not be oriented to one of the established building labelling schemes. Rather, it aims to analyse where the modernisation shows advantages or disadvantages in comparison to a continued use (including operation and maintenance) of the existing building.

ISO15686-5 serves as the reference standard for the calculations.

## Questions to be answered

In general, the question whether or not it is worth to renovate existing small single family buildings is in focus of this study. To complicate the question, the analysed renovation case study is conducted in several case scenarios:

1. Continued operation of the existing building
2. Necessary renovation of the existing building without modernisation (scenario "REFERENCE")
3. Modernisation and medium expansion of the building, energy performance 70% below current German energy performance standards (scenario "MEDIUM")
4. Modernisation and expansion of the building, plus-energy-standard (active house) (scenario "PREMIUM")

Cases 3 and 4 are modular, where elements of the expansion and the energy technology applied in building 4 are add-ons to case study 3. Both cases follow the design philosophy of the VELUX model home, where case 4 applies energy technology that today still has a prototype character and leads to a net-plus-energy building, on the basis of a modernisation of an existing building.

The questions were:

- Is it economically reasonable to move from option 2 to 3 or even 4
- Within which time horizon do the preferences shift (if at all)
- What influence does the assumed energy price increase have on the results
- Assuming that the demonstration building could be reproduced at reasonable market prices, what would the result be

The analysis of life cycle costs and the main cost drivers was to be integrated into the overall analysis and assessment of the model home at Hamburg Wilhelmsburg. Embedded in environmental life cycle assessment, technical and functional aspects, indoor climate and user friendliness, a multi-criteria overall assessment addressing relevant sustainability parameters was to be enabled. Social studies into the experiences of the real building users complemented the approach.

## The cost model and the model home

The basic anticipation is that the additional initial investment required for the modernisation will need a medium to long time period to show a break even – if at all. On the other hand, the 60+ year old building needs frequent repairs and partial refurbishments, meaning that parts of the modernisation's disadvantage are neutralised within a short to medium time horizon. The remaining compensation for the efforts must originate from reduced operating costs. Many obvious advantages in terms of qualities provided are not measured and included in the cost calculation (development of value and income due to rent). Consequently, the LCC does not provide an answer of the ECONOMY, but only on the direct COST.

From the setup of the study, it was assumed that the modernisation would pay off in case of high increase rates for energy prices, but equally interesting it was to see whether or when it would do so for low energy price increase rates. If not paying off, how big a distance would remain? Could that price difference be reasonable at hand of the provided qualities, or would it be out of discussion?

Conceptually, a corridor for results was to be drawn up. As LCC calculations rely on many assumptions and scenarios, it was preferred to describe a “lower” scenario (with low energy price increase rates) and a “higher” one. Optimistic assumptions for the energy price development presumably lead to pessimistic associated results for the modernisation case.

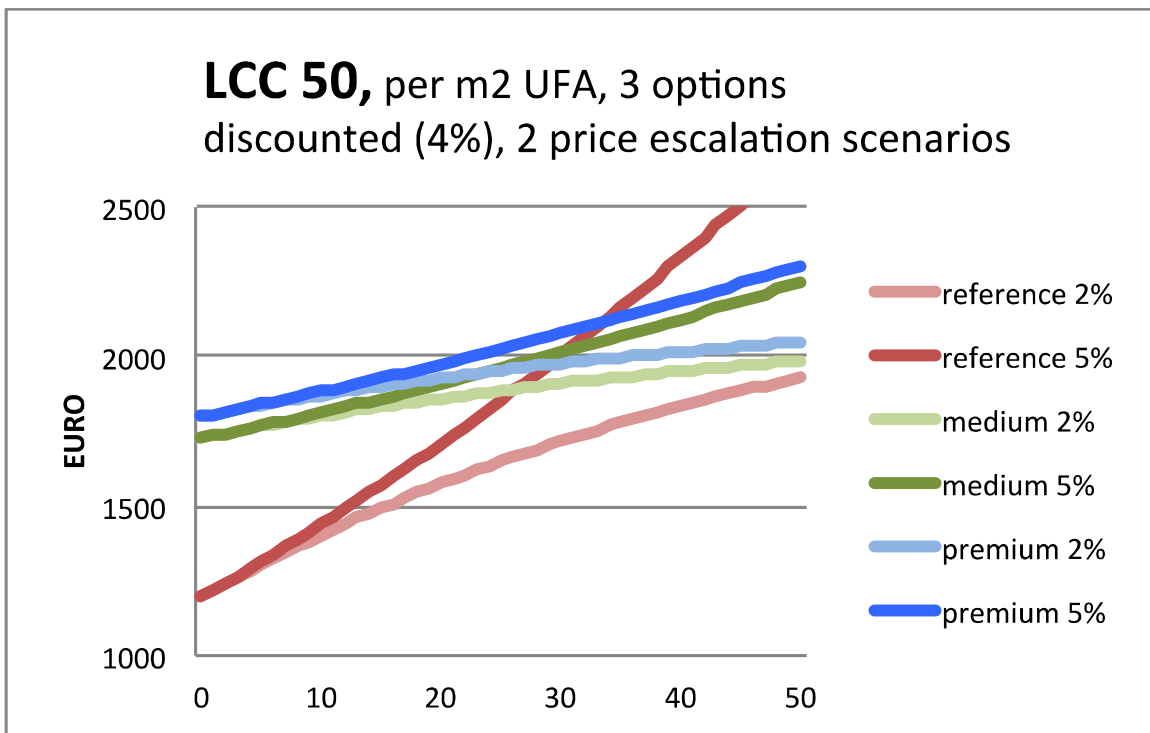


Figure 1. cost corridors resulting from investment and operation cost, applying different energy price development scenarios – conceptual illustration

Feeding that model with real project data produces the results illustrated in figure 2. At first glance it demonstrates, that the energy prices have a smaller influence on the magnitude of results than in the conceptual illustration above. Further, the inclusion of replacement scenarios and maintenance produces a stepwise but significant cost accumulation for the continued operation scenario.

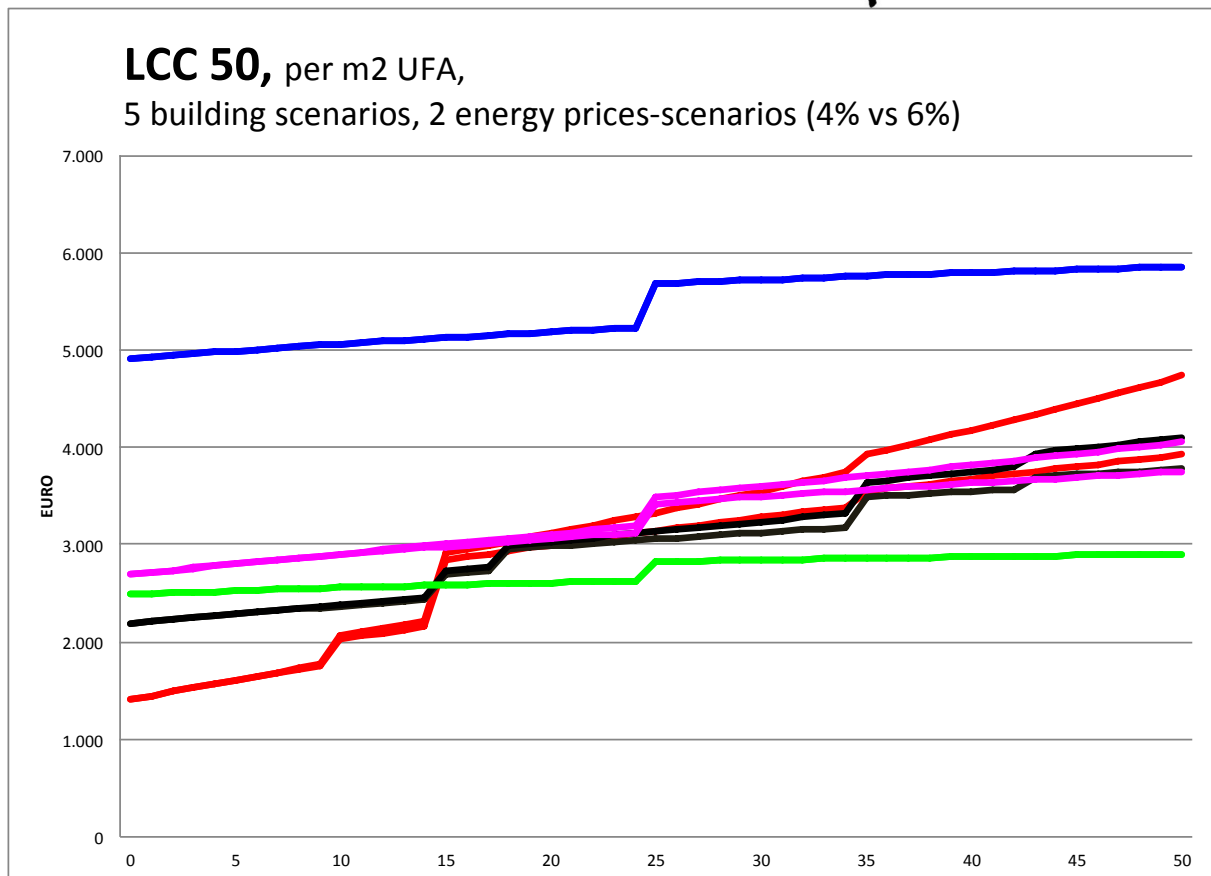


Figure 2. cost corridors resulting from investment and operation cost, applying different energy price development scenarios – building specific cost information  
with RED line: existing building; BLACK line: basic renovation; PURPLE line medium expansion and high energy efficiency standard; BLUE line: demonstration case model home 2020; GREEN line: model home 2020 as series production

The life cycle cost calculations can be applied in a highly flexible way allowing many parameters to be varied. Building scenarios, service life scenarios, price escalation scenarios can be specified and combined to define the compared “case studies”. For the inserted graphic, the above-presented building options have been included, and the increase rates for energy prices have been set to 4 and 6% respectively. These are to represent moderately low and moderately high expected escalation rates. The cost figures are discounted at 4,5%

- The energy demand of the MEDIUM and the PREMIUM option are close to zero, or equal zero. Consequently, their cost-over-time is not or nearly not affected by the energy price scenario. Consequently the lines (blue and green) do not open a gap, or a small gap only (purple)
- The MEDIUM modernisation (expansion and high energy efficiency) proves to be cost-competitive in the range of year 15 (higher energy price increase) to 30 (lower price increase)
- The PREMIUM modernisation (expansion and net-zero energy demand) can not compensate for its substantial initial cost. Given the fact, that the PREMIUM



modernisation is a show case building with prototype and demonstration character, many of the components were specifically designed and adapted to the Wilhelmsburg building

- Should such components be available to reasonable prices in a mass market, the initial cost would decrease to a magnitude half way between a current standard refurbishment (black line) and the MEDIUM modernisation. This today still fictitious scenario is illustrated by the green line. Under such conditions, the return on investment would be reached after 15 years. Over a period of analysis of 50 years, this scenario produces LCC that are between 25 and 40% below the continued operation of the existing building.

### Conclusions and discussion

The cost calculations show that the realized model home in Hamburg Wilhelmsburg is not cost-competitive when produced as a single demonstration building. If however taking the concept from prototype to repeated realisation, it would be competitive within a time horizon of roughly 15 years (compared to continued operation of the non-refurbished building).

Life cycle cost calculations are established taking into account a wide range of parameters. Each of these parameters can be defined according to the context and assumptions or expectations of the audience towards which the results are intended to be communicated. A generalisation is consequently difficult. If however displaying result spreads caused by variations of selected parameters, corridors for expected results, rather than pseudo-accurate figures can be provided and can be interpreted reflecting the drivers behind those parameters.

The key cost drivers for the reference building in this study are the assumed remaining service life and the energy cost. The corresponding key cost driver for the modernisation case is the cost of the modernisation itself. Due to the net-zero energy demand of the model home 2020, these buildings become independent of future energy price development.

The study underlying this paper does not intend to tune the data and present unrealistic potentials. It shows that under certain conditions, the model home may be competitive. The main result is consequently, that the increased quality of life and the decrease environmental impact come – with realistic expectations – with no extra cost, and when applying a long term perspective, with an assumed cost advantage.

The overall relevance of strategies directed towards settler houses is large. Different, but not scientifically validated sources estimate the total number of these houses to be of 7 digits. Considering their age and their potential to be adapted to modern living standards and high environmental performance, sustainable strategies for these buildings are needed. The model home 2020 demonstrates a radical, but sensible option.



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