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ECONOMIC FACTORS FOR SUCCESSFUL NET ZERO ENERGY REFURBISHMENT OF DUTCH TERRACED HOUSES

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Abstract
There are many smart technological solutions on the market for the zero energy refurbishment of the current building stock. The Delft University of Technology developed a zero energy renovation concept addressing 1.4 million post-war Dutch terraced houses: Prêt-à-Loger. By applying an integrated external renovation system (called the skin), the house becomes energy neutral while at the same time the living quality and the durability of the house are improved. This non-invasive renovation is designed to be applied to multiple houses. The project competed at the Solar Decathlon Europe 2014, winning five prizes, among which the first in sustainability. However, the team did not stop there; research continued in order to apply the concept in practice.
Despite the easy and fast applicability, the financial aspect still presents a barrier for large- scale implementation. This paper addresses the economic factors that can activate the investment on energy neutral house refurbishments. It summarizes the outcome of a one year interaction with public and local authorities, private companies, research institutes and end-users. The conditions created today by local subsidies and regulations for investments to take place are also addressed. Finally, the aspects that increase the value of the house, stimulating the investment are analysed.

Keywords:
Terraced house; refurbishment; economical value; net zero energy; renovation

1 INTRODUCTION

Across Europe only 1% of the building stock in any given year is newly built [1], about 70% of buildings are over 30 years old and about 35% are more than 50 years old [2]. Since the building sector is responsible for about 40% of the total Greenhouse gases (GHG) emission [3], massive refurbishment aiming at improving the performance of existing buildings seems to remain the most logical way forward towards a more sustainable and responsible usage of natural resources. Moreover, considering the new-construction rate, it is not difficult to imagine that most of the buildings present in 2050 have already been built at this moment [4]. These same buildings are in this sense responsible for achieving the required 80% reduced energy consumption compared to the 2008 levels [5]. Aiming at high standards of energy efficiency, such as zero energy, for the existing environment is essential amongst others for residential buildings as they account for 70% of the building floor space [6]. Looking across the European building stock, both the quality and the scale of refurbishment need to improve [7]. This is why the Prêt-à-Loger team of the Delft University of Technology competed in the Solar Decathlon Europe 2014 (SDE2014) presenting a renovation concept rather than a new house, aiming at reaching energy neutrality. The Prêt-à-Loger concept addresses 1.4 million terraced houses in The Netherlands. This typology provides housing for 61.2% of the Dutch population and can furthermore be found abundantly in Northwestern European countries [8]. Approximately half of these row houses have been built as a response to the post-war shortage that required fast, inexpensive housing solutions for the middle

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class in the period between 1946 and 1975 [9]. These houses are affected by a variety of issues such as high-energy expense, moisture problems and lack of liveable space. To address these problems and preserve this housing typology the renovation is designed as a noninvasive construction, an outer Skin, that allows the inhabitants to live in the house during the renovation (hence the name Prêt-à-Loger: *ready to live in*).

The skin integrates a number of measures to make the house energy neutral: roof-cavity, wall and crawlspace insulation, a mechanical ventilation system with heat recovery and Phase Changing Materials in combination with a greenhouse.

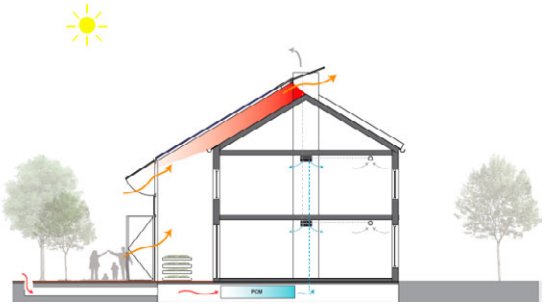

Fig. 1.1: Prêt-à-Loger climate design during summer.

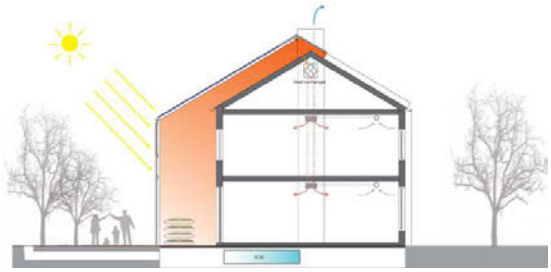

Fig. 1.2: Prêt-à-Loger climate design during winter.

A smart domotics system controls all installations in the house and provides information about its performance to inhabitants. The skin can be seen as consisting of three parts: the North side's (post) insulation, including the North-side green roof, the internal installations and systems and the South-side greenhouse structure. The insulation, heat recovery and green roof are meant to reduce energy losses through the facades, while the greenhouse harvests the energy from the sun producing electricity, hot water and warm air. In spring and autumn, the greenhouse can be used as living space, during winter as a winter garden and in summer it becomes a covered terrace connecting the garden and the living room.

Prêt-à-Loger won a total of five prizes at the SDE2014, amongst which the first prize for sustainability and the third place overall. After the competition the house was rebuilt at the TU Delft campus for research and educational purposes. The success gained after the competition (with different awards, nominations and positive feedback from visitors) stimulated the team and the university to further investigate the economic feasibility of this energy neutral renovation concept.

This paper provides a thorough overview of the factors that affect the feasibility of the Net Zero Energy Refurbishment of Dutch terraced houses. The Prêt-à-Loger team of the Delft University of Technology investigated the applicability of the renovation concept together with potential investors, public and private authorities and research institutes.

2 ECONOMIC BARRIER

Over the past few years the government in the Netherlands has stimulated the development of so-called "Nul-op-de-meter" (zero-on-the-meter" i.e. net zero energy) renovation concepts for terraced housing ('rowhouses'). The overarching organisation coordinating this stimulation, the "Stroomversnelling", proposes a target price for these renovations of €45,000 for a complete net zero energy renovation concept for a rowhouse in the private sector [10]. Because of subsidies related to this fixed target-price, cost benefits on energy savings are often taken as a main criterion by builders to decide which renovation measures will be taken. Most concepts have similar approaches: almost all renovations consist of post-insulation measures, use of a heat pump, ventilation heat recovery systems, photovoltaic and sometimes minor additional measures to improve performance. However, based on current construction methods builders are incapable of creating a renovation achieving both the energy reduction as well as the target pricing. The Prêt-à-Loger team considers the focus on energy savings alone one of the main shortcomings of the approach taken. When analysing the value of a net zero energy refurbishment (or renovation) more aspects could be considered, creating a much more attractive package. In this paper these additional factors are explored, contributing to increasing the value of NZER in the challenging environment it faces. Awareness of these additional economic factors that can contribute to a renovations value, both in the decision-making and design phases, can help contractors in creating feasible renovations.

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3 FINANCIAL FACTORS

The value of refurbishment is influenced by a number of financial factors introduced below.

3.1 Energy Savings

The first and main factor addressed by the Energiesprong, is the cashflow that is freed up by the energy savings, caused by the renovation. This cashflow is relevant for both private home-owners as well as housing associations. Homeowners of Dutch 1946-1979 rowhouses have an average energy expense of €175,- per month, which if expressed in a mortgage as suggested by the Stroomversnelling adds up to €45,000 over a 30 years period. Under certain conditions housing associations are allowed to charge residents with a so-called Energie Prestatie Vergoeding [11]. This energy performance compensation should compensate for the expenses housing associations make in reducing the energy consumption of the house. Dutch legislation allows banks to provide an additional sum in the form of a mortgage at this moment potentially up to €27,000 [12].

3.2 Property Value

Another relevant factor is the increase of property value. The appraised value depends on the type of renovation and the specific setting of the house and is normally estimated using previous valuations or by comparing the renovation to comparable interventions.

This increase of value is potentially driven by various aspects. Usually increased surface area and aesthetic aspects are main drivers. For net zero energy refurbishments the value increase will also originate in part from the energy savings and changed maintenance requirements. Particularly in respect to components needing maintenance to keep performance up to required level, such as for ventilation systems, the value increase will be more limited than of permanent components such as insulation.

The increase of property value forms a potential option of realising the renovation through refinancing the house, as long as the income of the homeowner is sufficient. To make this even more attractive, Dutch banks are allowed to provide a loan to value (LTV) of 106% for NZER opposed to a 100% LTV for normal mortgages as of 2018 [13].

3.3 Maintenance

The change in maintenance costs before and after renovation is a relevant factor as well.

New installations like PV-panels, heat exchangers and heat pumps will introduce new maintenance costs. Over the course of a 30-year mortgage all these installations have to be replaced at least once. On the other hand, the renovation itself makes up for overdue maintenance and a smart design in combination with the right choice of materials can reduce the cost of general maintenance even more.

3.4 Vacancy rate

The vacancy rate could potentially decrease, positively impacting the value of renovated houses for housing associations and other landlords. Furthermore, when selling the house the time on the market is potentially decreased.

3.5 Increase of rent

The increase of rent is the last financial factor influencing the value of NZER. If a house has a better energy label [14], or a larger surface area, housing associations or landlords can ask for a higher rent [15]. This can be expressed as an increase of rental income. It should be noted however that with regards to affordability of social housing a rental increase for housing associations might not always be desirable.

4 PRÊT-À-LOGER

Prêt-à-Loger is a NZER and an example of a refurbishment in which cost and energy reduction were not the only drivers. The main objective of the team was to find optimal technical solutions providing a usable and attractive sustainable renovation for the user, in order to win the Solar Decathlon Europe 2014 competition.

While designing the team has researched what the problems with post-war terraced houses really are and has taken into account what the wishes and needs of the homeowner are. One of those wishes was additional space on the ground floor. An extension such as a ‘serre’ (conservatory), arguably very similar to the greenhouse in our design, offers such a space at a typical price around €25,000 [16]. By integrating this with a climate buffer offered by the greenhouse, several functions are captured in one solution. By looking at what a homeowner would be willing to invest in the first place and making that part of the design, the latter became more attractive resulting in an increased value of the house.

Enthusiasm seems to exist for different types of sustainable renovations such as those offered in the Stroomversnelling deal at €45,000, based on the reduction of €175 of energy expenses in a period of 30 years [17]. However, in practice such renovations cannot be realised yet at cost level, let alone at profit, implying contractors realise such renovation with the intention to learn and potentially open up a market in a later phase. When implemented across a street some contractors estimate their cost price to be around €90,000 for their own renovation, while the Prêt-à-Loger design is estimated to be around €100,000. After valuations were performed on several stroomversnelling NZERs, including our design, the results showed a clear distinction.

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Fig. 4.1 : 1:1 Prototype of the Prêt-à-Loger house at the TU Delft Campus.

The Prêt-à-Loger house had an increased appraisal value of €37,000 compared to other renovations achieving around €5,000-€10,000 increase, mainly because of the additional space the renovation provides. Such an increase is of positive influence on the feasibility of the renovation particularly for homeowners, who can make use of additional mortgage. Banks consider characteristics such as an increase in appraisal value a key part in their risk assessments [18]. The valuation of our design shows a promising appraisal value, the costs however are still considerably higher than the increase in value, forming a clear barrier towards realisation.

Together with a main sponsor, a large contractor, several sessions were organised to attempt to decrease the price of the renovation to a more attractive level. Even with considerable up scaling of production it seems the results were still insufficient. Although the attractiveness of our proposition was recognised, NZER propositions were considered to be infeasible in general for mass application on Dutch terraced housing.

Although the design up to this point has not led to a feasible renovation seeing implementation in practice, there are other values that have come forward in our design. The more extensive exploration of adding value has not only showed in enthusiasm by visitors, but in a considerable increase in value through the renovation as well. Such value is a step towards financial feasibility, potentially forming a key part in creating a more sustainable housing stock.

Residents are mostly interested in the benefits and additional qualities they will get from sustainable renovation [19]. Extending the proposed value beyond efficiency and reducing costs into other qualities such as additional space or improved quality of living appears a sensible direction in this respect. Such additional qualities increase the willingness to pay of residents.

5 CONCLUSIONS

The Dutch Stroomversnelling project produced several prototypes for zero energy renovations, combining measures of post-insulation, new building services and efficient ventilation strategies. Compared to these the Prêt-à-Loger house of the TU Delft team, designed for the Solar Decathlon Europe 2014, added an important element that creates added value to just a lower energy bill and better indoor comfort: a glasshouse that entails extra living space, possibilities for food production and of course a heat buffer for the house's energy system.

The economic case of Prêt-à-Loger demonstrates that the financial feasibility of zero-energy refurbishment is difficult but not impossible. The large-scale renovation of millions of dwellings, which now perform poorly in energy terms, will be possible if the following conditions are met.

Firstly, current standards in financial boundary conditions need to be changed in order to facilitate energy renovations, creating investment money from the energy saved after renovation. This is a new paradigm in the financial world of mortgages and rent versus energy bills. Governments can enforce this with banks, insurance companies and other possible funding corporations.

Secondly, smart and bioclimatic design principles, using local circumstances optimally in the redesign of the house, can be applied to refurbish existing houses in an efficient and feasible manner.

Thirdly, and in conjunction with the previous, architects, technical designers and engineers should take economic factors into account when approaching existing houses. So far this has mainly been a task of the builder and developer, but with a layman commissioner as a common

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people living in these houses, some more responsibility will come to lie with the (re) designing party, for whom working in a multidisciplinary team, in a co-creation process, therefore is recommendable.

Fourthly, creating added value to the house when renovating it will be more expensive but decisive for the economic value of the object and, not least, the living quality of the home-owner or –user.

Additional research is needed as to get better grip on the actual performance of houses before and after the interventions, and the financial consequences. Honesty with these figures is recommended, as history has shown that negative results withheld from the public ricocheted in the end. The challenge the world faces in terms of climate change and energy poverty requires an open attitude, boldness to try new concepts and willingness to learn from mistakes. With that in mind, the Prêt-à-Loger project has been very valuable to the public, university and students who now go onto the market to work on a sustainable built environment.

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