“Design adaptability of the 2ndSkin project in the Northern European market of residential buildings”

MSc 3 Building Technology, TU Delft
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Argumentation of choice of the studio:

In the studio of Building Technology it is possible to emphasize on design technology and research on how to apply those techniques for improving the construction. The subject of refurbishment fascinates me a lot and that is because aims to upgrade the existing building stock and decrease the CO₂ emissions.
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1 Introduction

1.1 Background

Buildings are the center of our social and economic activity. Yet, the energy performance of the building sector is inevitable poor as it is among the most significant CO2 emissions sources in Europe. Facts have shown that construction represents 40% of the final energy consumption in OECD (Organization for Economic Cooperation and Development) member countries (Zavadskas et al., 2008). This percentage regards the energy used in the manufacturing industry, construction and operation of buildings. Thus, the refurbishment of existing buildings in order to reduce consumption is critical (Magrini, 2014).

Europe’s target for 2020 is to have 20% less greenhouse gas emissions than it was in 1990. The European Member States have committed to 80-95% CO2 decrease in 2050 towards a low-carbon economy (BPIE, 2011a). Meanwhile only 1% of new constructions are added to the building stock (Thomsen, 2010), while the largest part refers to existing buildings which most of them seek for upgrade. In Europe, most of buildings built after World War II display low energy performance. Specifically, they are poorly insulated and being 50 years old, have reached end of life (Andeweg, 2007).

Refurbishment of the residential stock is the essential key to the rising requirements for lower energy use and high living standards (Konstantinou, 2014). Besides the energy savings, an economic and social potential supports the idea of renovating the existing building stock instead of newly built buildings (Itard et al., 2008). There is evidence that demolition does not lead to sustainability as reuse does (Thomsen et al., 2008). The CO2 exhaust in landfills has a great environmental impact, while the biggest source is construction with 30% of the total volume (Power, 2008). Improvement of the quality of building envelope is urgent. Needless to say, such an improvement requires efficient communication of all parties involved such as local authorities, housing corporations, owners, architects and civil engineers (Andeweg, 2007).
Refurbishment tackles greenhouse gas emissions by reducing the energy consumption of the building stock. There are various degrees where the refurbishment could exist. Meanwhile it has been stated that “deep” renovation could achieve 60-90% energy savings (BPIE, 2011a). Besides the energy savings there are other requirements that a refurbishment project should take into account in order to succeed. Social and economic aspects, as needs of various stakeholder groups should attract more attention towards sustainability (Zavadskas et al., 2008). As previously mentioned, refurbishment is necessary to reach the future demands of decarbonisation levels. Therefore, the existing building stock seeks for upgrade of the physical condition and energy performance, with the minimum disturbance for the interior space. Given that the refurbishment is a complex task, many aspects need to be taken into account.

Thus, the “2ndSkin” project of TU Delft presents a refurbishment approach of Dutch residence which scopes to bring all the stakeholders together by inverting the traditional decision making process, to incorporate their expertise into an innovative building technology project to achieve zero energy (2ndSkinReport, 2015). Important part of the 2ndSkin project is the elaboration of performance criteria, concerning energy consumption, occupants’ disturbance and comfort, robustness, simplicity, etc. (2ndSkinReport, 2015). The research project aims at mass-implementation solution that can be applied in a variety of cases. Therefore, the upscaling of the project in Europe is a step that needs to be done.

The post-war period is a significant turning point for construction, as there was a switch from traditional methods to fast and economical production of massive building units (2ndSkinReport, 2015). In The Netherlands the building stock accounts for approximately 7.5 million dwellings (CBS, 2015). Meanwhile, post-war dwellings represent 1/3 of the residential stock (Itard et al., 2008), from which 1.3 million account for social housing (Platform31, 2013). There are many housing associations dealing with the building stock and trying to upgrade the energy label D-E (apprx. 350-400 kWh/m2/year primary energy) of post-war residence (AgentscapNL, 2015). The annually energy consumption appears to be 20.000kWh/dwelling/year (2ndSkinReport, 2015). The renovation of residence from 1950’s to 1980’s is characterized essential, as the buildings were poorly
insulated and performed bad in airtightness due to technical, architectural and social aspects (TES, 2015). At the end of the 2ndSkin project and if applied in a national level, 3,4 Mt CO$_2$ would have been saved (2ndSkinReport, 2015).

After careful investigation the 2ndSkin team concluded in a list of different building types, according to wall, window, roof type, balcony location etc. which are in need for renovation (2ndSkinReport, 2015). For the purpose of 2ndSkin project there has been selected a building reference of post-war period, i.e. the porch apartment blocks (portieketagewoning) that it is located in Rotterdam-Zuid. The reference building considered the most common type in the area of investigation. It should be pointed though that the upscaling of the project and mass-implementation were mentioned as requirements of the 2ndSkin team.

Therefore, it would be beneficial if we could export the refurbishment concept to Europe’s market. By discussing the adaptability of the retrofit solution in other building types, the efficiency of the project could increase. Furthermore, a future upscaling could be the refurbishment of buildings in similar climate that show potential for energy upgrade. For the purpose of this research the starting point is the basis of the 2ndSkin project but the intention is to make it flexible and adaptable in order to be applied in other building types besides the reference one. At the end of the research the refurbishment strategy needs to comply with the initial requirements of the project, reflect an architectural character and high energy performance.

Germany is a potential market for the project as belongs in Continental climate region as the Netherlands. Germany has the largest population in Europe, the largest number of residential buildings and dominates the heated floor area with 67% (Inspire Report, 2014). Therefore, Germany is a key country to target the retrofit solution of 2ndSkin project. By applying the project on a German residential building of post-war period could be possible to investigate and question the flexibility and adaptability of the refurbishment approach. The analysis of specifications affecting the refurbishment project like construction and building services will lead to a design product adequate for the German market.
1.2 Thesis

1.2.1 Problem Statement
If we are to tackle the climate change, it is claimed that the most effective way to do so is through improved energy efficiency of the building sector that has a major environmental impact. Decrease in use of fossil fuels and embracement of renewable energy sources through energy upgrade of the existing buildings could attack the global phenomenon.

Refurbishment of the old residential buildings that present high energy consumption could improve their environmental footprint. Europe has committed to minimize the CO$_2$ emissions by 2050. Europe’s residential building stock has great potential for energy savings. Starting from the Netherlands, the refurbishment concept of 2ndSkin of TU Delft proposes an integrated façade system that aims to a zero energy building. The upscaling of the project in the growing market of Europe is important as could achieve better performances and improvement of the design.

By looking at the bigger picture the retrofit concept could take place in another European country than the Netherlands. Thus, the context could be different, and therefore it is important to investigate how the design of the 2ndSkin project could be flexible and adaptable to be employed in other building type regarding a variety of key elements like the building type, the building construction and the building services/installations. Moreover, the architectural character of the project in combination with building technology and high energy performance will define the final design.

1.2.2 Aim of the research

The export of the 2ndSkin project has been as an important factor and as a sharp answer in the growing market addressed. This research by having the 2ndSkin project as a starting point will discuss the design flexibility of the refurbishment concept by applying the design on a German residential building of the post-war period. The key elements of a broad analysis and comparison between the case studies would be the building type, the building construction, the building services and the architectural aspect. At the end, the aim of the
research is to explore the design adaptability of the 2ndSkin concept for achieving zero energy building and optimize the concept for future applications.

In the literature part of this study the aspects of refurbishment will be discussed. An overview of the state of the art of the refurbishment in Europe will be made by discussing characteristics, building typologies and energy performance of the residential building stock. By examining several countries in Europe, Germany would be the next target for the 2ndSkin concept as reflects the highest potential for the purpose of this research. Therefore, the literature study continues with the analysis of the German housing stock regarding key elements like the building type, the construction type and the building. In the end of the study a residential building in Germany would be the case study of this research.

A comparative study of the reference buildings will take place throughout this research. The 2ndSkin concept would be applied on the new case study. A thorough analysis and comparison between the two case studies in Netherlands and Germany will result in design variation that will discuss the flexibility and adaptability of the 2ndSkin design. The evaluation of the design will be hold regarding the advantages that the design offers at the building and the users while reflecting an architectural character.

1.2.3 Boundary conditions

The research will focus on the following aspects:

- Refurbishment of the residential buildings of post-war period.
- The research will be hold into the Northern European residential building stock.
- The reference building in the Netherlands and the 2ndSkin design will be a starting point for the research.
- Germany will be the key-country for exporting the 2ndSkin concept.
- A German residence will be the study case for the design to focus on. The results and recommendations will be applicable in European countries with similar characteristics.
• The comparison between the buildings in Netherlands and Germany will focus on key elements that can be formulate as follows:

• The first focal point will be: the building type including the number of floors and apartments and the size.

• The second focal point will be: The building construction including the wall construction, the window/wall ratio, type of balcony, roof construction and materials.

• The third and final focal point will be: The building services/installations including space heating and hot water, cooling if needed, ventilation, and further installations.

• The design will focus on the façade of the building with possible adjustments and recommendations of the interior space.

• An integrated façade design will be the final product, by focusing on the application of the 2ndSkin project.

• The evaluation of the design will be made by reflecting architectural character and offering design variation.

1.2.4 Research Question/s

Main research question

The main question of this research can be formulated as follows: “How can the 2ndSkin design be flexible and adaptable to be applied on a German residential building regarding the building type, the building construction and building services, while exploring design variation of the façade composition?”

Sub-questions

Refurbishment

Which aspects motivate a refurbishment project and which criteria considered as barriers?

Europe
Which are the main characteristics of the European residential stock regarding age, housing types, ownership and tenure, building type and construction and energy performance?

Which European country shows the highest potential for energy upgrade and why?

**Comparative study**

Which are the main differences between the reference buildings?

Which are the key elements for the research to continue with?

**Design**

How the 2ndSkin design could be flexible and adaptable when applied on the German building type?

What design elements could be combined with the 2ndSkin concept by reflecting an architectural character?

Which are the limitations of the 2ndSkin design?

**1.2.5 Methodology**

In figure 1 the structure of the thesis is illustrated. The chapters of the thesis are indicated by the numbered parts and have been divided in five sections: introduction, literature study, comparative study, design and conclusions. The first part includes the introduction and the graduation plan.

The literature study has been covered by the second section where the state of the art of refurbishment in Europe and the German housing stock are analyzed further. In the beginning of the former, the focus will be on refurbishment definitions, refurbishment motivations and barriers and challenges. Afterwards the residential stock in Europe will be presented with focus on size and age of the residential stock, ownership and tenure,
building type and construction and energy performance of housing stock. The latter is about the German housing stock. It is important to present the argumentation for choosing Germany as the next target of the 2ndSkin project. Furthermore, the context of building sector along with construction types and energy performance of German housing stock will be presented.

The comparative study includes the comparative study of reference buildings in the Netherlands and Germany. First, the 2ndSkin project description will take place by presenting key elements like building type, construction/details and building services. Subsequently, the same key elements of the German case study will be analyzed further. The design section includes the application of the 2ndSkin project on case study in Germany. At this part design adjustments along with design limitations will be hold. Next part is the designing of additional elements that can be applied on façade construction and offer design flexibility to the concept. The design samples will assess the structure adaptability based on elements such as windows, balcony, materials etc. In the end, a specific façade design will be chosen as a combination of the façade samples and the basis application of the 2ndSkin concept. Moreover, a design catalogue will be offer a design variation for the façade of the building. The design will be adequate if reflects an architectural character, all zero energy building traits of the 2ndSkin refurbishment concept and offer design flexibility.

In this research the emphasis will be on design adaptability of a refurbishment concept of Northern European residence. In that way, recommendations can be given in the last section concerning similar residence construction existing in this type of climate.
1. Introduction of research and graduation plan

2. State of the art of Refurbishment in Europe
   - Refurbishment
   - Residential Stock in Europe

3. The German housing stock
   - Characteristics
   - Building typology
   - Energy performance
   - Building Sector
   - Construction type
   - Building services

4. Comparative Study of Reference Buildings in NL & DE
   - 2ndSkin/NL
   - Case study Germany
   - Construction type
   - Building services
   - Details

5. Application of 2ndSkin on case study in DE
   - Design adjustments
   - Design adaptability
   - 2ndSkin limitations

6. Designing additional elements
   - Samples façade constructions
   - Evaluation:
     - Architectural character
     - Design flexibility

7. Conclusions
   - Design catalogue
   - Design suggestion

8. Recommendations Evaluation

Figure 1
1.2.6 Relevance

The decrease of the CO2 emissions could be tackled with refurbishment of the existing building stock. The design adaptability of a refurbishment concept for zero energy buildings will be discussed. Therefore, the export of the 2ndSkin project into the European market in correlation with energy upgrade of residential buildings will result in an efficient and adaptable design. Furthermore, by taking into account the impact of the building sector, the building construction and type and the building services sustainability becomes the directional aspect. Finally, the research contributes to the existing knowledge about design adaptability, energy performance and architecture character of a refurbishment concept.
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<td>State of the art of refurbishment in Europe</td>
<td>Refurbishment (definitions, motivation, barriers)</td>
<td>Residential stock in Europe: characteristics, building typology, energy performance</td>
<td>The German housing stock: building sector, construction type, services</td>
<td>Choice of German reference building</td>
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2 State of the art of refurbishment in Europe

2.1 Refurbishment
Definitions of refurbishment
Motivation for refurbishment
Barriers and challenges

2.2 Residential stock in Europe
2.2.1 Introduction
2.2.2 Size and age of the residential stock
2.2.3 Ownership and tenure
2.2.4 Building type and construction
2.2.5 Energy performance of residential stock

3 The German housing stock
3.1 Why Germany
3.2 Context of national building sector
3.3 The German Housing Stock
3.3.1 State of refurbishment
3.3.2 Construction types
3.3.3 Energy performance of housing stock
3.3.4 Conclusion
4 Comparative study of reference buildings (NL vs DE)

4.1 2ndSkin Project Description

Building reference

Construction

Building services/Installations

Details

Methodology

4.2 Study case Germany

Choice of reference building

Construction

Building services/Installations

Details

Methodology

5 Application of 2ndSkin project on new case study

6 Case study design and evaluation

7 Conclusions, Recommendations, Evaluation
8 Bibliography


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