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Method for Developing and Assessing Holistic Energy Renovation of Multi-storey Buildings



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Summary

A large part of the Danish building stock is from the post-war era, and thus there is an immense need for renovation within a few years. Also there is a persistent focus on energy use in buildings as it corresponds to about 40% of the total energy use in Denmark. However to secure durable solutions a holistic approach is needed, which takes into account also other aspects than energy such as social or economical values of the buildings.

This paper presents a standardised method for developing and assessing a holistic energy renovation of multi-storey buildings. The method is intended to be used both in the design phase of renovation proposals and for evaluation of the improvements that follow from a holistic energy renovation.

The method was developed as part of a Danish research project on holistic approaches in energy renovation of multi-story buildings. In the project, nine overall indicators are established based on the aspects of “people, planet and profit”. The assessment method comprises five elements that span across the nine indicators. The elements consider the economical, architectural, technical and social values of the buildings and also include user involvement as a central element. The assessment method is tested on two case buildings, and the assessment involves all relevant stakeholders including building owner, users, and caretakers.

An element of the project looks to the development of new products and solutions for renovation for buildings. As part of the method, user involvement will be applied in order to guide and optimize the development of proper new products or solutions especially for renovation. The paper will illustrate how this is done in cooperation with manufacturers from the building industry.

Keywords: Assessment method; building renovation; multi-story buildings; holistic perspective; product development.

1. Introduction

In Denmark around 40% of the building stock is from the post-war era (1950-1979) and many buildings are built before the energy crises in the 1970s [1]. Typically the buildings have not undergone any thorough renovation and thus there is an immense need for renovation within a few years. Concurrently with the need of renovation due to wear, there is an increasing focus on energy use and energy savings, as the energy use in buildings corresponds to about 40% of the total energy use in Denmark [2]. This has led to a political agreement about energy in 2012 stating that the gross energy use in Denmark should be reduced by 7.6% before 2020, in relation to 2010. To obtain the goal, an overall strategy for energy renovation of existing buildings must be ensured, in order to secure future-proof solutions [3].

To comply with the demands concerning energy savings and to satisfy the need for renovation in general in existing buildings, a holistic approach is needed. As those buildings are typically only renovated every fifty years, the solutions must be thoroughly thought through, in order to secure future-proof solutions with a long lifetime.

Already there is a considerable range of tools available for assessment of sustainability [4]. They have developed along with demands from the surroundings, initially concerning environment as the most important factor till now, where the more recent methods equally consider environment, economy and social relations. However the role and use of the assessment methods in the construction sector is regularly discussed [5], [6] and tendency in the development is towards a more holistic approach, instead of “one fits all” methods [7].

As part of the holistic approach, stakeholders, especially the building users, should be involved early in the process.

In this paper a standardised method for developing and assessing a holistic energy renovation of multi-storey buildings is presented. The aim is that the method can be used in both the design phase of a renovation and for assessment of the improvements that follow a holistic energy renovation. The aim was to develop a method that can be used as a relative assessment showing the values added in a holistic renovation.

The method presented in this paper has been developed as part of a project on holistic energy renovation. The aim of the project was to make a holistic energy renovation, of two multi-storey apartment buildings, based on 9 overall evaluation criteria. As part of the holistic focus the users of the buildings are involved in the process and made a driving force in the renovation. Elements of the project also consider product development driven by cooperation between manufactures and users. The cooperation between these stakeholders will lead to development of products or solutions that are needed and well suited for building renovation.

In development of the method, existing Danish tools within the renovation area have been investigated and some of them are partly used. The assembly of the existing methods along with an introduction of user involvement early in the process are what makes this method holistic and different from many other development and assessment methods.

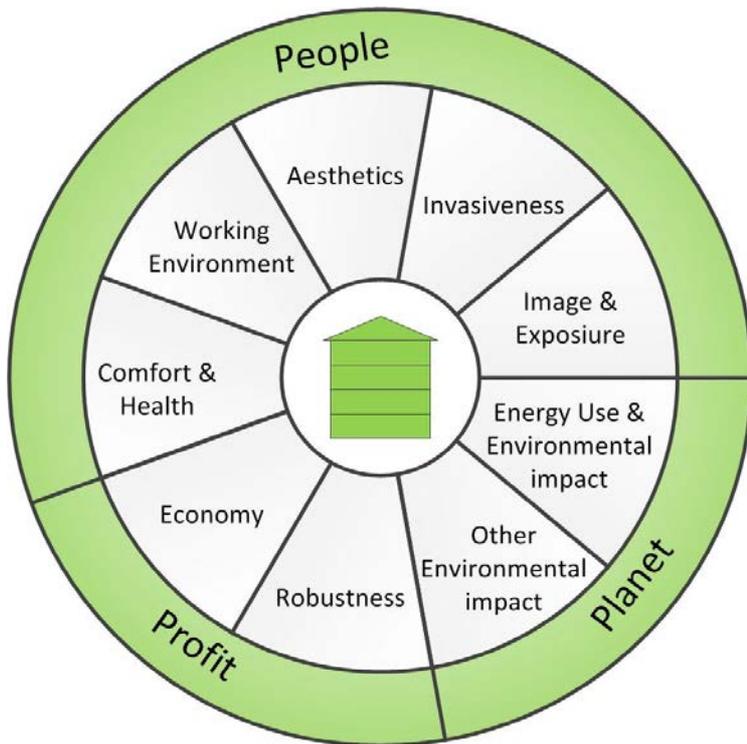
Case studies were used for both development and testing of the method. However it has only been possible to test the method as a development method, which was, to the extent possible, done successfully, leading to identification of important focus points in a renovation. The focus points derived by use of the method were used as input in the design process. The test of the method as assessment of added value after a renovation is yet to be performed.

2. Method

Development of the method is based on nine overall evaluating criteria, embedded in “people”, “plant”, “profit”, defined in the project “Holistic Energy Renovation” in which context the method has been developed. This was combined with a study of existing methods for building evaluation and registration already used in Denmark today. It was further compared to two case-buildings that were available alongside the development. Those were also used partly for testing the method as a developing method afterwards.

3. Assessment Method Development

The nine evaluation criteria that the assessment method development is based on are presented in Figure 1. Early in the project they were prioritised by the project group, comprised of researchers, engineers and architects, in order to ensure a holistic energy renovation of the building. These criteria and the prioritisation can be seen below.



Prioritisation of evaluation criteria

1. Economy
2. Energy Use & Environmental impact
Comfort & Health
Aesthetics
3. Robustness
Invasiveness
4. Image & Exposure
Other environmental impact
5. Working environment

Fig. 1 The criteria the method development is based on.

The aim was to develop a method for standardised evaluation of buildings that can be used both before and after an energy renovation. The method is not to assess if one solution is better than the other, but it should be used early in the process to specify focus areas and necessary initiatives to obtain a holistic renovation. Later on in the renovation process it shall be used to make a qualitative assessment of the value added in the performed renovation. The nine criteria from Figure 1 worked as the overall boundary conditions and underlying basis for the development. This was supplemented with parts not specified in the project, but parts that were considered important in order to make the method generic and not tailored for the test buildings used in the project. This method combines different methods that are normally used separately, with user involvement, resulting in a method that supports a holistic evaluation of a building renovation.

The structure of the developed assessment method can be seen in Figure 2. It consists of three overall parts, where the latter is subdivided into four steps. All parts and steps of the method are equally important, however one would benefit from using the chronology in the method, having the possibility to stop and evaluate after each investigation and further stop the work if, for any reason, a renovation cannot be performed, and thus avoiding unnecessary work.

Initially information is gathered about the potential building. The collected data give a basic knowledge of the building and, at an overall level, indicate if there is potential for renovation of the building. The registration form is inspired by an already existing form developed for planned maintenance by GI (The Danish property owners' investment foundation) and include among other things year of construction, the building area and floors utilised [8].

Next step is to make an investigation of the economy related to the property, to indicate the economic setting of a renovation early in the process. This investigation includes energy expenses, indicating if a reduction of energy is relevant and if the economy of the building is robust enough to perform renovation and to which extent.

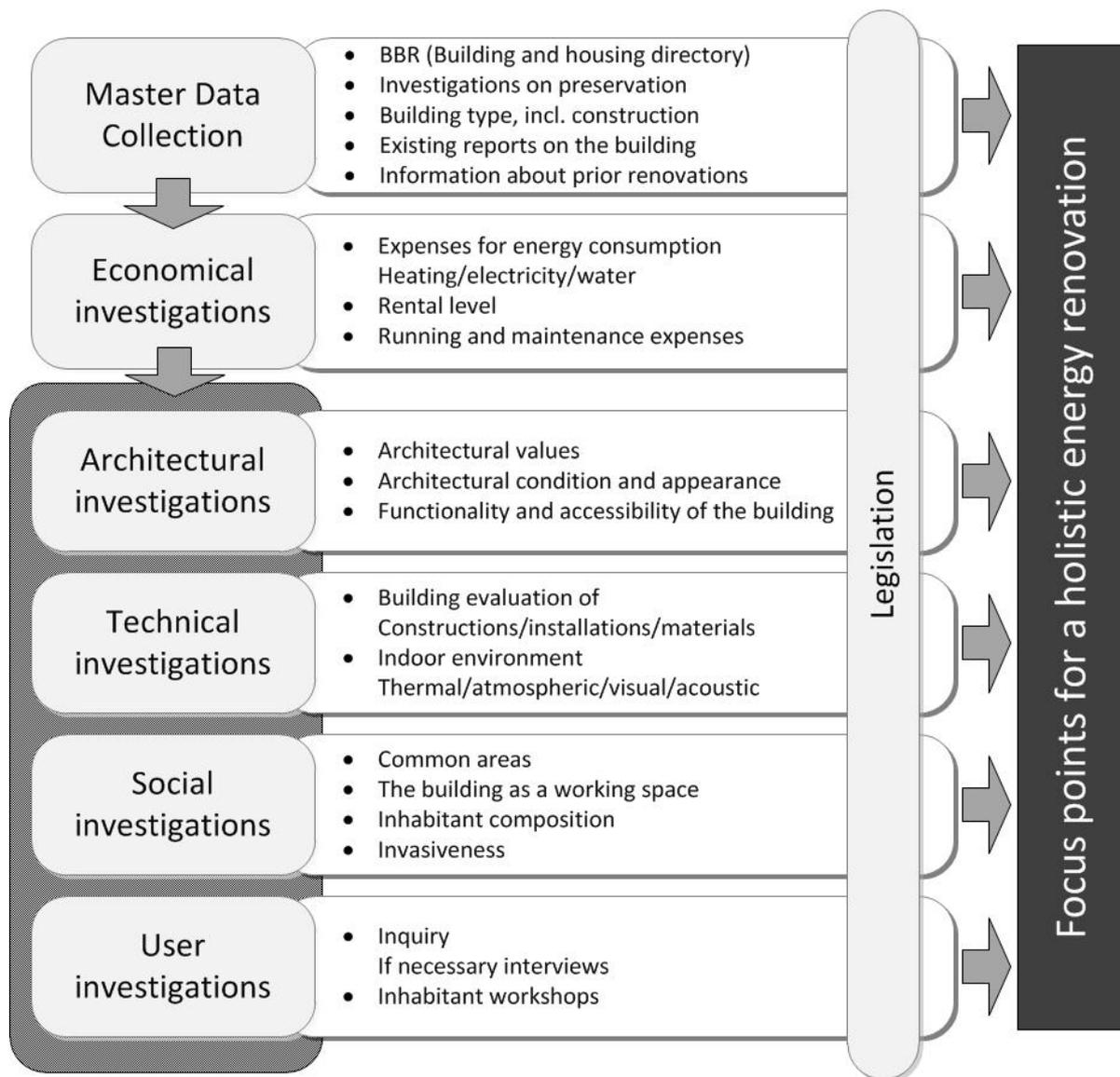


Fig. 2 The method Development and Assessment Holistic Energy Renovation

When the preliminary investigations are performed, an overall investigation of the building is started, giving a combined assessment of the building condition and needs.

The building investigation is initiated in the architectural area. This is done to identify the relevant initiatives and possible changes with respect to the architecture of the buildings. Further it addresses functionality and means of access, placing the building in the surrounding context. The elements investigated in this area are inspired by the Danish system SAVE (**S**urvey of **A**rchitectural **V**alues in the **E**nvironment), a system for mapping environment quality and appointment of buildings worthy of preservation [9]. In SAVE the evaluation on building level is quantitative, however this is not implemented in this standardised assessment method, as a qualitative evaluation of the listed items is intended.

The technical investigation is made a thorough survey of the building. The aim is to get structural insight in the state of the building, and thus be able to assess possible and necessary improvements. The form of the registration is inspired by the already existing Danish method BVB 20 point list. The list prescribes 20 building parts that should be considered in Danish urban renewal cases [10]. The investigations are presented as a technical evaluation report, addressing the relevant areas.

The social investigation briefly covers non technical areas of the building and its placement in a larger context. The investigation is to indicate if some things are of special importance for the stakeholders.

The user investigation is the last theme of the assessment method, and it is essential in several ways. It leads to an extended knowledge of the building in an everyday context. Involving the users, locates problems which are specific for the building and indicates which needs, often unspoken, the users experience with regard to the building. It increases the chance of the users feeling a sense of ownership for the existing building and the new solutions introduced, and they are very influential on how well the building performs e.g. in terms of energy performance and Indoor Environment Quality (IEQ).

Consequently also for the assessment after a renovation, user investigation is important.

As an ongoing iterative process across all the categories in the assessment method, the existing laws are consulted and if necessary registered. This step of the method is to ensure that the output of the investigations is in accordance with existing laws.

Combining all inputs from the investigations, the focus points of a holistic energy renovation can be drawn up. This will not be explicit solutions to specific problems, but points that should be treated by the group of consultants connected to the project.

4. Case-study

4.1 Test of assessment method

After development of the method, it was tested in development of renovation solutions on two multi-story buildings in Denmark. The buildings can be seen below.

The preliminary results are described in the following ending up in the focus points that can be drawn by use of the assessment method.



Fig. 3 Kretahus, the private owned case-study buildings



Fig. 4 Korngården, the council housing used in case-study

4.2 Kretahus

Kretahus is a private property located in Copenhagen Denmark, built in 1935. The part of the building used in the project comprises half a block. The building is made of brick, it is typical for the time period in Copenhagen and it is not worthy of preservation. There are 135 apartments in the building considered, distributed mainly on one- and two-room apartments. No larger renovations have been made, however smaller works as replacement of the windows have been performed.

The users have been involved early in the process, through both a questionnaire investigation and a workshop. The participation in the questionnaire was 19%. Most age ranges were equally represented, and further the investigation showed that more than 50% of the people participating

had lived in the building more than 6 years.

Investigations of the economy showed a relative low rent-level for non-retrofitted apartments, leaving a reasonable gap for a thorough renovation.

The users were asked about their perception of the rent level and the energy use compared to parameters as income, condition and size. The result was an appropriate rent-level with a tendency towards low, while the perception clearly was that the energy use is high.

The technical investigation showed a building typical for the time period, with solid uninsulated facades, wooden horizontal levels and an unheated attic. The installations are outdated, which negatively influence the indoor environment. The questionnaire survey implies that more than 60% of the users sometimes or weekly experience problems with cold in all rooms in their apartments during winter time.

As part of the user involvement, a workshop was held in the early phase of the project. For this workshop all tenants were invited along with the building owner and the caretaker. The output of the workshop was a list of wishes for a renovation from the users of the building. This output agrees with the focus points presented below.

The following focus points for a renovation of the building were found by use of the method:

- Improvements of facades
- Ventilation of the building
- The thermal indoor environment/the heating system
- Utilisation of the attic
- Flat mergers
- Improvements of balconies

4.3 Korngården

Korngården is built in 1961 and consists of four identical blocks of apartments. The blocks are linked by a surrounding common green area. Through the facing the buildings differ from other typical concrete buildings from that era. There are 248 apartments in the buildings, all with three rooms and a size between 75 m² and 79 m². Over the years the roof has been changed as well as the windows, further internal insulation has been used, which has led to problems with mould.

Also the users at Korngården have been involved early in the process through both a questionnaire and several workshops. The participation in the questionnaire was 32%. Most age ranges were equally represented and more than 70% of the people participating had lived in the building more than 4 years. Further less than 30% had plans of moving out.

Through a questionnaire it was seen that the users found the rent-level low.

The technical investigations showed a typical concrete construction with non bearing facades, having problems with thermal bridges. A smaller part of the installations has been updated, however the majority is outdated.

The questionnaire survey implies that close to 70% of the users experience problems with cold in their apartments during winter time. More than 70% users experience draft from the windows in the building sometimes or weekly.

Through a survey, it was found that the users of the buildings wished that balconies were established.

The following focus points for a renovation of the building were found by use of the method:

- Improvement of facades and end walls
- Ventilation of the building
- The thermal indoor environment/the heating system
- Establishment of balconies

In the project the developed assessment method has been tested to the extent possible. This has led to a finding of focus point for a holistic energy renovation, which for Kretahus has successfully

been used as underlying basis for the main concept of a renovation. In the process user involvement has been strongly supported, and a large user involvement and interest was seen.

4.4 Product development

Product development in relation to renovation is part of the project on holistic energy renovation, under which the assessment method has been developed. It was believed that a facilitated product development, where the manufactures were involved early in the process as the other stakeholders, would lead to better suited or even better products than normal.

On both case buildings mentioned in section 4.1, relevant manufactures have been involved in product development early in the process. With take-off in the case-study buildings and some of the information obtained through the assessment method, regarding the technical state and the uses needs, the product development has been an ongoing part of the project.

This involvement, also including the end users, has supported further development and merge of existing products. It was seen that it can be beneficial for the manufactures to be involved early in the process, however the project also showed that the consulting team could benefit from the cooperation, regarding new and untraditional solutions when working on the main concept for the buildings.

Also as foundation for product development, it seems that a holistic approach, where the development is facilitated, by use of concrete buildings and users, can lead to development of products that are needed in renovation and meet the demands of the users and the project group.

5. Discussion and conclusion

The case-study show that the output from the developed assessment method, in form of focus points for a holistic renovation can be used as underlying basis for development of the main concept of a renovation. Especially the strong involvement of the end users and manufactures, along with the other stakeholders, has led to a broader and more holistic perspective in the development of the main concept.

This holistic approach is beneficial in several aspects. For the users, as they feel ownership and involvement. For the operation of the building, as the caretaker is a part of the early phase of the process. For the economy in a longer perspective, as the solutions are robust and balanced, and thus extra expenses on unintended effects can be reduced. And finally it has been beneficial for development of products especially for renovation.

The fact that the same buildings are used for both development and test of the assessment method leads to consideration of how it will work on other buildings, and it cannot be declined that there might be a need for a further development of the method. Further, the assessment method has only been tested in development of renovation and not as an assessment of the value added through a holistic renovation, which it is expected also to be able to handle.

It can always be questioned if there is a need for yet another assessment method and if this method presented here comprises all aspects needed. However it was found that no complete method officially existed in Denmark that could do a qualitative evaluation of the parameters found relevant for a holistic renovation. Especially public accessible knowledge of how to involve the users of the buildings early in the project process was difficult to identify, even though it was known that some private companies use it.

As renovations have been performed for years, some methods for registration and evaluation already existed, and it was decided to use those as inspiration instead of developing parallel methods. It is believed that a collection and standardisation of the existing methods can lead to more holistic renovation solutions. It is however difficult to document as no parallel test buildings performing a traditional renovation is investigated.

In conclusion the method developed has so far reached the intended aim which is supporting a more holistic approach for renovation of buildings especially through user involvement the assessment method has supported reflections and considerations regarding a holistic perspective. Future studies will show if the method is also suitable for evaluation of the improvements that follow from a holistic energy renovation.

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