Integral design method for Energy efficient Restoration

M. Vieveen[1], T. van der Schoor[1]

[1] HanzeResearch NoorderRuimte, Hanze University of Applied Sciences (HUAS), Groningen, the Netherlands.
m.c.vieveen@pl.hanze.nl; c.van.der.schoor@pl.hanze.nl.

Abstract *- Designs for improving energy efficiency in historical buildings are tailor made. For initiators the flexible character of design processes raises uncertainty about why certain energy measures are (not) allowed. How is decision making in the design process organised? And what mechanisms influence tailor made designs? In this paper we present an integral design method for Energy efficient Restoration. Our theoretical background draws on two sources. Firstly, we follow design theory with distinct generic and specific designs. Secondly we use the 'heritage-as-a-spatial-factor' approach, where participants with different backgrounds focus on adding value to heritage. By applying the integral design method, we evaluate decision making processes and reflect on heritage approaches. We suggest how the integral design method can be improved and question the parallel existence of heritage approaches.*

Keywords – Energy efficiency; historical buildings; design theory; 'Heritage-as-a-spatial-factor'-approach

1. INTRODUCTION

Owners of historical buildings are committed to sustain their property. Earlier research suggests [1] that many owners consider applying measures to improve thermal comfort and energy efficiency. Designs for energy efficient historical buildings are tailor made for two reasons: regular energy measures often are not compatible with conservation of heritage values, and preferences of initiators regarding functions and comfort levels vary considerable. Owners of historical buildings indicate that they find the design process fuzzy, because to them it is unclear why specific energy measures are (not) allowed. To improve the design process, we study what mechanisms play a role and how decision making is organised in this process. In this paper we follow the creation of tailor made designs for energy efficiency in three cases. As a method we use an integral design method developed for energy efficient restoration of historical buildings (further *integral design method ER)* [2], [3]. Our aim is both to evaluate this method and to discuss the 'heritage-as-a-spatial-factor' approach.

2. THEORETICAL BACKGROUND

2.1 Generic designs

A design process is a tool to develop a solution for something that does not yet exist in practice. In the literature different design theories are used to improve our understanding about designing: how is the design *process* organised, which *participants* are involved and what topics are taken into account to develop a *product* [4]? In general a distinction is made in two types of designs: generic designs that provide a protocol or framework (such as Design-Based Research [5], Design Science Research [6], and Design Study [7]), and specific designs that provide solutions for specific situations (such as Study by Design [7][8], [9]). Generic designs can be used as a framework to develop specific designs. The *integral design method ER* is categorised as a generic design method, and tailor made designs as specific designs. Design-based Research (DBR) characterizes generic design methods as a design-experiment methodology: It "focuses on understanding the messiness of real-world practice, with context being a core part of the story and not an extraneous variable to be trivialized. Further, (DBR) involves flexible design revision, multiple dependent variables, and capturing social interaction. In addition, participants are not "subjects" assigned to treatments but instead are considered as co-participants in both design and analysis. Lastly, given the focus on characterizing situations (as opposed to controlling variables), the focus of (DBR) may be developing a profile or theory that characterizes the design in practice (as opposed to simply testing hypotheses)" [5].

2.2 'Heritage-as-a-spatial-factor' approach

We use heritage approaches to understand how actors think about adjusting historical buildings. Heritage theory distinguishes tree approaches with different fundamental principles: 'Heritage-as-a-spatial-sector' where actors from a monodisciplinary perspective focus on preserving heritage as is or as is originally was meant to be [10], [11], [12]; 'heritage-as-a-spatial-factor' where actors from multiple perspectives define the design problem and criteria for assessing adding value [10], [11], [13], [14], for example for weighting energy measures; 'heritage-as-a-spatial-vector' where actors from an interdisciplinary perspective use heritage to improve the chance of success of 'something else' [11], for example socio-economic developments. In this paper we focus on the 'heritage-as-a-spatial-factor' approach since developing specific designs for energy efficiency in historical buildings focusses on adding value and involves discussing energy measures from multiple perspectives.

3. METHODOLOGY

Generic designs can be used to develop specific designs; also specific designs can be used to improve generic ones. By following the development of specific designs in case studies we gather data on the decision making process. As a framework for analysis we use 'CIMO-logic' from DBR theory [6]: "this logic involves a combination of a problematic **C**ontext, for which the design proposition suggests a certain **I**ntervention type, to produce, through specified generative **M**echanisms, the intended **O**utcome(s)." Regarding the *integral design method ER*, this is worked out as follows (after [6]):

- C – context: "the surrounding (…) factors and nature of the human actors that influence behavioural change." Interventions "will be affected by at least four contextual layers: the individual, the interpersonal relationships, institutional setting and the wider infrastructural system." In our analysis we describe the design problem in terms of usability (perspective of the initiators) of the built heritage (condition, values), its socio-economic context and how the design process was organised (the involved participants).

- I – intervention: an action to “influence behaviour”. In the analysis we describe proposed energy measures to influence the performance of the historical building.
- M – mechanisms: is triggered by a (proposed) intervention in a certain context. In the analysis we describe mechanisms that are addressed in decision making.
- O – outcome: the effect “of the intervention in its various aspects.” In the analysis we describe the (preliminary) results for energy efficiency in the investigated historical buildings.

We applied the *integral design method ER* (generic design) in three case studies to provide insight in decision making in the design process. One of the authors (Vieveen) took part as participant in the design team. Empirical data consists of site-visits, desk research (archival research, guidelines, technical information) and qualitative interviews. Chapter 4 describes the results of the case studies, following the components of the ‘CIMO-logic’.

4. RESULTS

4.1 Saint Peters’ church Eindhoven

Saint Peters’ church (listed for its national importance) is one of five churches in the Saint Peters’ parish in Eindhoven. The community is confronted with secularisation and decreasing income which led to the closing of churches in the region. To secure healthy operating expenses, the parish is looking for ways to increase income and decrease expenses. Urgency for energy measures arises from an outdated heating system of the Neo-Gothic church which damaged historical elements (windows, organ). Decision making is organised in two steps: a core team (the parish, supported by researchers) taking formal decisions and a more open-ended flexible team of experts from different (energy-related) fields called ‘*platform moNUmentaal*’ suggesting specific integrated designs for historical buildings in general and more specific for Saint Peters’ church.

The design process was organised in two phases. The first phase focussed on defining the design problem by a site-visit, desk research, interviewing participants and discussions on potential energy measures in the core team. Energy measures were categorised by impact on historical values: no impact (crowdfunding, control systems), low impact (measures that affect less important heritage values: a new heating system, floor isolation) and large impact (measures with major implications for important heritage values or that increased complexity in decision making: solar panels and exchanging energy in the nearby built environment) [15]. The second phase consists of co-design sessions where participants discuss their ideas and their ‘homework’ (applied research by the participants) for the follow-up session (in progress).

Mechanisms were identified during meetings and interviews. The parish board is committed to improve thermal comfort, reduce costs (energy, maintenance) and increase income (by secondary use).

The majority of the surveyed parishioners mentioned the importance of historical elements for worshiping. The diocese addressed preventing damage, healthy operating expenses and no secondary use (since other churches were closed). Heritage experts were willing to discuss adjusting the historical elements if it would secure heritage protection of the listed building (national importance) in the long term. Energy consultants advised 'invisible' energy measures: practical use and energy management, measures 'behind walls' and exchanging energy (introducing new participants with their interests).

As a result, the participants of the core team preferred measures with no or low impact on esthetical and heritage values. A list of energy measures was published in a report [15]. Together with the underlying data, the report was used as input in the co-design sessions which is still in progress.

4.2 'Dairy factory' De Groeve

Demographic transition in the region of De Groeve raised pressure on local services and businesses. Two entrepreneurs wanted to preserve the former dairy factory in 'Amsterdamse school'-style (non-listed building) by reusing it for leisure and tourism activities. Their ambition is zero-energy renovation of the historical building, supplied by renewable energy. A flexible integral design team with the initiators (entrepreneurs), architect, energy consultant, energy expert and researcher developed a tailor made design. Flexible since the composition of the design team was supplemented with other participants during the design process for example by financial and catering experts.

The design process was organised in two phases: the first phase focussed on a feasibility study for adaptive reuse [16], the second phase focussed on developing an energy efficient design. The second phase started with a brainstorm and site-visit where participants presented their view on preservation of the building and potential energy measures. Follow up meetings were used to discuss 'homework' which resulted in energy measures (insulation, indoor climate, energy supply) per space.

Mechanisms were identified by desk research and during interviews and meetings. The reuse expert advised (phase one) multiple use given the size of the building and the need to spread risks related to income. During the brainstorm and site-visit (phase two) participants used the concept *Adaptive energy efficiency* to develop tailor made solutions per space, weighting heritage values and high performance in terms of daily use (functionality), energy efficiency, and thermal comfort. For example, areas in the building with non-historical values were used for Bed & Breakfast since walls can be isolated; and the kitchen was repositioned to improve the efficiency of a heat recover system. After involving a professional kitchen consultant, the design team concluded in a relative early phase that electric ovens were too expensive, withdrawing one of the initiators main ambitions. Shortly before the plan was submitted for requesting a building permit the initiators ended the process, stating that they received insufficient support by the municipality to continue their initiative.

The first phase resulted in a business plan and pre-design for the buildings' lay-out. The second phase resulted in an historical analysis, design sketches, and calculations on thermal comfort and energy systems that would have been used to request the building permit.

4.3 Der Aa-church Groningen

The medieval Der Aa-church in Groningen is a listed building of national importance. It is let for multiple use since the 1980s. To secure a healthy business and preserve the church on the long term, the owner of the church (foundation Der Aa-church Groningen) and semi-commercial user (Special Locations Groningen) started the project 'Future for the Der Aa-church'. This project aims to preserve heritage values, improve thermal comfort, reduce energy use (zero-energy), secure safety (earthquake proof) and secure income (adding more opportunities to let the church). The design team consists of the owner, semi-commercial user, building engineers, an energy consultant, heritage experts and a researcher.

The initiators subdivided the design process in three phases: defining the design problem and exploring potential measures; developing an integral design for thermal comfort and energy efficiency (in progress), and; safety (earthquake proof). During the first phase a site-visit, brainstorm session, desk research and interviews with different actors resulted in an inventory of potential energy measures, such as separating the choir and nave, insulation, applying curtains, secondary glazing, a new heating system, and sustainable energy sources [17],[18]. In the second phase (in progress) participants discuss 'homework' during design meetings to develop a tailor made solution to improve thermal comfort and energy efficiently such as insulation, secondary glazing, indoor climate and heating systems. New actors (architect, structural expert) will be involved after the structural design for energy efficiency and thermal comfort is developed.

Mechanisms were identified during interviews and meetings. All participants agreed that the historical ambiance should be preserved, but had different ideas on protecting heritage values. For example, in the first phase participants questioned if secondary glazing should be considered as an improvement, taking into account the effects on the indoor climate (increasing humidity) and thus the protection of heritage values (organ, medieval paintings on the high vault) on the long term. As a result participants advised to consider specific measures (such as windows) in a wider context: balancing the effects of energy measures to the indoor climate and energy as an integrated whole – the starting point of the second phase. During a design meeting in this phase the initiators (owner, user) mentioned that support of the municipality and other actors (as participant in the process) contributed to success.

Inventorying measures is executed in three phases. The results of the first phase [17],[18] are used as input for the design team that developed the integral tailor made design (in progress).

5. DISCUSSION

In this paper we used the components of the 'CIMO'-logic to analyse the results of specific design process for three case studies projects that were executed following the generic design *integral design method ER*. Firstly, we evaluate the *integral design method ER* by comparing the case study results following the 'CIMO'-logic. This provides insight in how decision making in the design process is organised and what mechanism influence the development of tailor made designs. Secondly we discuss the 'heritage-as-a-spatial-factor' approach as a generic design to develop tailor made designs for energy efficiency in historical buildings.

Context. The design problems were based on *usability* (perspective of the initiators) and were underscored by topics derived from *built heritage* (prevent damage, preserve heritage values) and *socio-economic developments* (secularisation, demographic transition, sustainable development, earthquakes). All design teams were composed with experts with multiple disciplines.

Intervention. The design teams organised the design process in phases starting by a diverging phases (analysing the design problem and developing potential energy measures) and converging phases (further development of the tailor made solution). In Eindhoven, De Groeve and Groningen, the design process is fed by research leading to a wide variety of potential energy measures. For all cases a wide variety of energy measures was discussed: financial, behaviour, building, installations.

Mechanisms. According to the design teams for all cases, an important mechanism in discussing energy measures was conserving the historical atmosphere (important value for daily use) or to preserve heritage values from a legal perspective. Also participants agreed that energy measures (to improve thermal comfort and reduce energy use) are inevitable to sustain historical buildings, but that these measures should be workout with care regarding their effects on preserving historical elements on the long term. Since the function of spaces of the building in De Groeve was not fixed during the design process, participants also discussed energy measures per space. In De Groeve and Groningen support of the municipally and other actors was mentioned as important mechanism for success or failure.

Outcome. In Eindhoven and Groningen the development of the tailor made design is still in progress, the initiators of De Groeve withdraw their initiative. Research is still in progress, for example, we did not yet evaluate the design process with the involved participants.

We suggest the further development of the *integral design method ER* in the subcategorization of the 'CIMO'-logic. For example, by nuancing the design problem in: interest of participants, context of the built environment (technical condition, values and site) and general context (socio-economic developments and natural events). As a result, decision making criteria related to energy measures can be made more explicit, thereby increasing insight in why specific (proposed) energy measures are (not) allowed.

In this section we discuss the 'heritage-as-a-spatial-factor'-approach as an approach to improve energy efficiency in historical buildings. The case studies show that a generic design can be used to develop specific designs for diverse initiatives. The *integral design method ER* can be used for multifaceted design problems, with multiple targets and it allows to improve designs by involving new participants with multiple backgrounds during the design process. Also, the method can be used to make the decision making process about energy efficient in historical buildings more transparent.

Reflecting on the heritage approaches, we find that participants in all cases used the historical atmosphere and/or heritage values to frame suitable energy measures, which is the fundamental principle of the 'heritage-as-a-spatial-sector' approach. This raises several questions: do the heritage approaches coexist parallel; are these approaches layered and do they relate hierarchically to one another? However, this paper is limited in that it represents only three cases. We suggest further research is needed to provide answers to these questions.

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