Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation

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Abstract. Renovation of the existing building mass represents an important potential for energy savings in the building sector. In Denmark, this is especially relevant within the domain of social housing. Energy motivated renovations are, however, only a long-term sustainable solution if they also support the wellbeing of the residents. Failure to do so may result in homes lying idle and in need of re-renovation or demolition. On the positive side, focusing on potentials for catalyzing social value creation as part of a holistic approach to sustainability may help justify more costly energy renovation measures. The paper presents a tentative framework for articulating the relationships between material transformations and their joint environmental and social impact. The framework is based on a literature review and a synthesis of effect studies of social value creation in multifamily housing renovation. As part of the concluding perspectives, the paper discusses potentials for further development of the tentative framework into a support tool for use in early design processes, as well as potentials for visualizing financial benefits associated with the social value creation.

1. Introduction
Renovation of the existing building mass represents an important environmental potential for energy savings in the building sector [2, 3]. In Denmark, this is especially relevant within the domain of social housing, which makes up one-fifth of the total housing stock [4] and is dominated by dwellings built before the energy demands were tightened in the national building code in the 1970s [3]. However, in many cases, the costs for the needed energy-saving interventions cannot be justified by the energy savings alone. This makes it relevant to identify additional values that can help justify interventions beyond sheer energy payback economics [5, 6]. The paper is based on the hypothesis that every renovation project holds the potential for catalyzing social value creation and that articulation – and eventually, capitalization - of this potential can help promote holistic, long-term sustainable renovation solutions. The relevance of addressing social value as part of sustainable renovation also lies in the fact that energy is often not the main driver for the renovation of social housing [4, 8]. Further,

1 Cambridge Dictionary’s definition of a “catalyst” as “someone or something that causes a big change […] a catalyst to (do) sth” [7] is adopted in the context of this paper.
energy renovation may influence the perception of the built environment negatively if not viewed as part of a whole [9] - e.g., by introducing noise nuisances from a new mechanical ventilation system with heat recovery [10, 11] or compromising the expression of the building from a cultural-historical point of view by implementing exterior re-insulation [12]. As such, energy renovation cannot be viewed as an isolated act. Instead, it is crucial to apply a holistic approach, which explores how to implement the renovation measures in a careful manner that provides added value on multiple levels. The issue of sustainable renovation practices touches on several of the UN sustainable development goals (SDGs); however, in particular, goal number 11: “Make cities and human settlements inclusive, safe, resilient and sustainable” [13] which centers around the built environment. It promotes a holistic approach, including targets such as reducing the environmental impact of cities (SDG 11.6), enhancing inclusive and sustainable urbanization (SDG 11.3), and ensuring access to safe and affordable housing (SDG 11.1). The previous text has already touched on the environmental potential of renovating the social housing stock (SDG 11.1). By directing attention to the joint environmental and social impact of social housing renovation, the aim is to support the continued access to safe and affordable housing for all (SDGs 11.3 and 11.1), which are some of the very core values of the Danish social housing sector. The SDGs reflect a holistic approach to sustainability, however, existing research has questioned how this unfolds in practice. E.g., Beim and Madsen [14] have identified an emphasis on technical, quantifiable values in contemporary sustainability methodologies applicable for renovation. As these frameworks may help establish consensus among the diverse stakeholders in complex renovation projects, researchers stress a need to describe and operationalize qualitative socio-cultural values as a part of the schemes [14].

As a response, the primary aim of this paper is to provide a review of existing studies, which demonstrate relations between the renovation of multifamily housing and related social value creation. As part of the review, the study maps documented relations to environmental value creation. As a secondary aim, the paper presents and discusses the potential of displaying the identified relations in a tentative framework, which can be developed into a support tool for use in early design processes.

2. Methods

In talking about social value, the paper focuses on promoting the health and wellbeing of the residents in multifamily social housing (MSH) undergoing renovation. It takes a point of departure in WHO’s definition: “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” [15]. The rationale is that by focusing on increasing the physical, mental, and social wellbeing of the residents, we contribute to the overall societal goal of sustainability.

2.1. Theoretical outset and research approach

This paper builds on tectonic architectural theory. As suggested by Hvejsel et al. [9] and Jensen et al. [16], tectonic theory may provide a starting point for describing how specific ways of implementing energy optimization measures can induce certain experiences through the gestures they provide – for instance inviting for social interaction or allowing for privacy – and thereby enhance a sense of well-being. The literature review focuses on what Groat and Wang refer to as ‘explanatory theory’ [17] from diverse research disciplines. As such, the review excludes accounts of ‘intended gestures,’ referring to the intended/assumed impacts of architectural interventions on the wellbeing of the residents, and only includes studies that document/explain an actual relation (“lived gestures”). The terminology adopted from tectonic theory is combined with the terminology associated with ‘theory of change’ [e.g., 18, 19]. This combination is introduced to more explicitly account for the mechanisms which have led to social value creation in the given study and to synthesize the findings of the individual reviewed studies. Though often applied in the context of social interventions, later years have seen theories of change applied to interventions in the built environment [e.g., 20]. Figure 1 summarizes the simplified combined terminology adapted for use in this study. It further serves to signal the need for holistic strategies, where a given intervention adds both environmental, financial, and social value.
Architectural intervention refers to the physical measures applied to the existing construction. Context refers to the most prevailing contextual conditions of the renovation intervention, which may serve to inhibit or promote successful implementation [21]. Output refers to objectively measured outputs of architectural interventions, such as temperature or daylight factor. Outcome refers to whether the architectural intervention supports the physical, mental, and social well-being of individual residents through spatial gestures. Does the architectural intervention result in experiential or behavioral changes? Though highly simplified, this distinction between objectively measured ‘outputs’ and experienced ‘outcomes’ is found relevant in the context of this study. To use the words of Haverinen-Shaughnessy et al. about indoor environmental quality (IEQ) [10], the reason for this is that “Even objectively measured improvements in IEQ might not be regarded successful if occupants did not perceive them well” [10]. Impact refers to the accumulated impact of an architectural intervention, leading to societal value creation. The arrows in figure 1 serve to graphically indicate if the social outcome and impact of an architectural intervention have led to synergies with environmental and/or economic value creation.

2.2. Literature review

The paper presents the findings of a literature review performed as a database search in Science Direct. The search resulted in 645 hits, which were subsequently examined for relevance to the present study. The main inclusion criteria were: peer-reviewed, original research articles published within the last five years. The time frame was introduced in order to delimit the search and to focus the study on state-of-the-art within recent years. The review focused on studies on apartment and building scale; however, it included also studies on interventions to exterior spaces in residential areas. A geographical delimitation was set up for the review, including Northern Europe/Western Europe, to ensure climatic and cultural similarities. All of the above to ensure the best possible macro-contextual similarities from study to study. Priority was given to studies, which include empirical data collection related to the experienced influence of architectural interventions by the residents themselves, e.g., through interviews and questionnaires, thus excluding studies based “solely” on objective measurements. The final study included 13 main references. The findings were summarized in an annotated bibliography relative to the categories in figure 1 and subsequently synthesized in Table 1, inspired by Almeida & Ferreira [11] and with special attention to applied ‘architectural intervention’ and the related ‘outcome.’
3. Results

Table 1 presents a synthesis of identified relations between architectural interventions (vertically) and social outcomes (horizontally). As the methodological and contextual conditions for each study vary, it is recommended that readers always read the referenced study before interpreting the results in the table. The account of architectural interventions (vertically) is organized in a manner inspired by Brand’s “Shearing layers of change” [1] to the far left, followed by a more detailed account of the intervention measures. The list of interventions is derived using the wording of the identified references, and, as Table 1 shows, that it varies whether the reviewed studies describe architectural intervention measures in isolation or as part of a larger ‘package.’ The majority of the references focus on architectural interventions to the building envelope and ventilation system.

The identified related social outcomes (horizontally) are grouped in themes by the authors of this paper and subsequently reflect some degree of subjective interpretation. The identified themes are Thermal comfort, Visual comfort, Perceived air quality, Stimulating experiences, Financial safety, Safety, Pride/positive identity, Social relations, Control, Inclusion, and Health-related impacts. Table 1 shows that the majority of the reviewed studies focus on perceived indoor climate, especially thermal comfort [e.g., 10, 11, 22-25]. These studies generally focus on the physical wellbeing of residents. However, a few of the included studies touch upon the mental and social wellbeing of residents, e.g., by pointing to interventions in the facade or the landscaping that may contribute to a sense of pride/positive identity amongst residents and form inviting gestures towards the surrounding city [11, 26]. Some included studies span both physical and mental concerns – most notably studies related to the so-called “EBC Annex 56 project” [5, 11, 25, 27].

It is relevant to notice not only the identified positive relations but also the fact that some studies report on issues that have arisen after implementing the interventions, e.g., noise from mechanical ventilation systems with heat recovery (MVHR) [10, 11, 24] or loss of existing experiential qualities, such as trees, as a consequence of densification [28].

As mentioned previously, the methodological outset for the studies vary. Some of the referenced studies have a more reductionist approach, aiming to isolate single measures, e.g., the impact of MVHR-systems on the perceived indoor climate [23] or the impact of inner wall constructions on the satisfaction with sound insulation [29]. Both mentioned references aim to adjust for contextual influences as part of statistical analysis. However, most referenced studies are based on more complex case setups, including several interventions, which make such a reductionist approach less relevant, if not impossible. In such cases, mixed-methods approaches are used to identify and qualify relations [e.g., 25]. On the other end of the methodological scale, qualitative studies form the basis for capturing personal narratives [e.g., 30], which are interpreted and contextualized based on relevant theory.

The two columns to the far right in Table 1 signify if the studies explicate the related financial and/or environmental impacts of the social value creation. The studies which include attention to environmental value creation focus primarily on reduced operational energy and are generally linked to social value creation in terms of improved perceived indoor comfort [e.g., 10, 23-25], with few references demonstrating a broader range of ‘co-benefits’ [11]. There are only a few references that address the financial potential of social value creation, e.g., [5]. This is addressed in more depth in section 4. However, included references exemplify that renovation may contribute with direct financial benefits for the residents, which can add social value in its own right, e.g., through reduced household expenses for heating [30] and reduced exposure to energy price fluctuations [11]. However, renovation may have the opposite effect for so-called energy-poor households, who already keep their heating expenses at a minimum and are vulnerable to rent increases prompted by the renovation [31].

Table 1. Diagram depicting Architectural interventions vertically and Outcome horizontally. “+” signals positive associations, and “÷” signals negative associations.
### Architectural intervention

| Packages of interventions                                                                 | Thermal | Visual | Perceived at quality | Acoustic | comfort | Stimulating | Use | Financial | safety | Safety | Public positive effects | Social value | Control | Indus | health | Financial | Environmental impact |
|------------------------------------------------------------------------------------------|---------|--------|----------------------|----------|---------|------------|-----|-----------|--------|--------|------------------------|-------------|---------|-------|--------|---------|-----------------------|
| Adding insulation                                                                        | [10]    | [11]   | [10]                 |          |         |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Insulation of entire building envelope                                                   | [11, 22]| [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Facade insulation (general)                                                              |          | [11, 22]| [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Facade insulation (exterior)                                                             |          | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Facade insulation (cavity)                                                               | [22]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Facade insulation (internal)                                                             | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Roof insulation                                                                         | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Ground floor insulation                                                                  | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Celling insulation                                                                       | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Airtightness/reduced thermal bridges                                                     | [10]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Windows replacement                                                                      | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Larger window areas                                                                      | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Roof light or sun pipes                                                                  | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| External shading                                                                         | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Balcony and loggias                                                                      | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Heat pump for heating                                                                    | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Biomass heating system                                                                   | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Efficient DHW system                                                                     | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Automatic control systems                                                                 | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| MVHR systems                                                                             | [10]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Solar thermal systems                                                                     | [11]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Internal wall construction (heavy/light)                                                 | [29]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Parks and gardens                                                                        | [26]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Pathways through the neighborhood                                                       | [26]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Water pond                                                                               | [28]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Removing existing trees as part of densification of housing area                         | [28]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Energy efficiency retrofit (unspecified)                                                 | [30]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Insulation. Replacing windows                                                           |          | [10]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Glazing balconies                                                                        | [5]     | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| New brick façade. New windows and doors. Balanced MVHR. Automatic switch-off controls with presence detectors in common areas. Photovoltaic system on roof. Changes in layout (more apartments). Insulation (exterior walls, roof). Moisture and infiltration barrier in walls. Front brick to rendered facade. Windows replaced. MVHR. | [24]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
| Regeneration of neighborhood landscaping including new ownership and dwelling types Insulation (facades, roofs). New windows. Exploiting solar heating. Renovating heating system and/or supplementing with RES. | [27]    | [11]   | [11]                 | [11]     | [11]   |             |     | [11]      | [11]   |        |                        |              |          |       |        | [11]    |                      |
4. Discussion
This paper has presented the results of a literature review of existing studies on the relationship between material transformations and social value creation. In this section, the potentials and limitations of the findings - and the perspectives for further development - are discussed.

4.1. Methodological limitations and perspectives for further development
The listed architectural interventions and social outcome-themes (Table 1) are derived from the literature review. As such, Table 1 does not make up an exhaustive list of potential relations. Use of alternative search strategies, –words and extending the time frame of the included references, are likely to reveal additional relations. It is also relevant to note that it is common within the architectural field to publish findings in reports or monographs outside the academic peer review system. Despite their relevance to the topic, such references are left out of this review to respect the established search criteria. Naturally, there may also be relevant relations, which have yet not been addressed in existing research as of today. As such, this paper may serve as inspiration for future research.

The immediate perspective of the research presented in this paper is to further develop the framework (Table 1) into a decision support tool for use in early design stages. As a step on the way, the identified potentials for social value creation will be accounted for in more detail and combined with empirical findings from ongoing investigations.

4.2. Mapping and displaying joint environmental and social impacts
The review itself has focused on identifying studies with an explicit account of relations between material transformations of multifamily housing and their influence on the social value of the renovated homes. Where references include an explicit account of environmental impacts, this has been noted in Table 1. In future developments of the framework, it would be natural to examine in more depth how architectural interventions may be best implemented to ensure synergies between social and environmental value creation.

4.3. Perspectives for capitalizing the social value
Rose et al. [5] state that “It is difficult to monetize the co-benefits.” The low number of identified studies, which include capitalization of social value creation, seems to underline this statement. Rose et al. [5] do, however, exemplify that added exterior insulation might increase the usable area for an apartment with 0.5 m along the facades. Stating that this corresponds “...to an area of approximately 9 m² for an average-sized Danish apartment, and with a typical rent of 160 €/m²/year, the co-benefit is worth approximately €1,440 per year per apartment.” [5]. Haverinen-Shaughnessy et al. [10] link renovation initiatives to lower odds for reporting respiratory symptoms as well as not missing school or work due to respiratory infections. Though not linked directly to isolated renovation measures, this makes for interesting socio-economic perspectives. Almeida and Ferreira [11] include methodological considerations on how identified “co-benefits” may be qualitatively converted to ‘willingness to pay,’ which can be included in a multi-methodology alongside traditional Life Cycle Cost analysis. The references make for interesting examples of how social value creation may be monetized and thereby become more visible in economic prioritizations.

4.4. Contextual dependency
As stated in section 3, the research approaches and contextual conditions for each study vary. The renovation of multifamily housing is often a complex matter, for which no a generalizable “one size fits all”-solution is available [27, 30]. For instance, the architectural intervention measure “larger window areas” does not always create value for the users, as it may compromise the sense of privacy in the interior. To heighten the quality of a future decision support tool, contextual factors should always be accounted for. For this purpose we would recommend using a more complex cause and effect model such as the one presented in figure 1.
By also conveying methodological and contextual factors of the studies in a developed version of the framework, the aim is to allow critical interpretation and to qualify the use of the framework in similar contexts and/or adapt the findings to the local context in a holistic manner.

5. Conclusion
The paper has presented the results of a review of existing effect studies of social value creation in housing renovation in a tentative framework. The study has demonstrated that there are indeed potentials for social value creation, which can be linked to environmental upgrades. In a few cases, the social value creation has also been capitalised financially.

However, the knowledge base for joint social and environmental value creation in housing renovation is still limited and focuses primarily on physical wellbeing themes related to perceived indoor climate. As such, the tentative framework is intended as a starting point, which can be further expanded. The perspective of the presented research is to further develop the framework into a decision support tool, which can inform early-stage design processes and contribute to a development, where the evaluation of social value becomes a fully integrated part of sustainable renovation practices.

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