A tectonic approach to energy renovation of dwellings - the case of Gellerup

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There is an urgent need for updating the energy performance of the existing social housing stock. One can argue, however, that renovation is only a truly sustainable solution if the building continues to provide quality dwellings for the people who inhabit it. As such, energy optimisation and attention to contemporary needs for dwelling go hand in hand. Nevertheless, existing research has identified an emphasis on technical, quantifiable values in contemporary renovation practice. The paper investigates if a circular tectonic approach to energy renovation can help articulate and assess to what degree the specific strategies for altering the construction serve to increase not only the energy efficiency of the building, but also the quality of living. The framework is exemplified through the case of a competition entry in Gellerup, Denmark. In closing, the paper discusses methodological challenges as well as perspectives for further development for use in interdisciplinary project teams.

1 INTRODUCTION

The majority of the existing building mass will still be in operation by 2050. As such, the task of reducing the overall energy consumption of the building sector necessarily includes a transformation of existing buildings. In Denmark, this is especially relevant within the domain of social housing. Nationally, there are approx. 600.000 social housing units, of which 60 percent were built before the national building regulations in relation to energy consumption were tightened in the late 1970's (Government 2014).

One can argue, however, that renovation is only a true sustainable solution if the building continues to provide quality dwellings for the people who inhabit it. As such, energy optimisation and attention to contemporary needs for dwelling go hand in hand. Not least in the context of social housing, where a high number of buildings face physical degradation and social stigma (Vestergaard 2017). Nevertheless, research has identified an emphasis on technical, quantifiable values in contemporary energy renovation practice - and a need to include also qualitative socio-cultural values in order to secure a more holistic approach (e.g. Madsen et al. 2015, Hvejsel et al. 2015, Peters 2015).

But how should this be approached? One suggestion is presented in the publication "Arkitektur Energi Renovering" [Architecture, Energy Renovation]. In this publication, the authors propose a design guide for working holistically with aspects related to energy consumption, indoor climate and 'improved spatiality' (Marsh et al. 2013). The format ensures a hands-on guide for practicing consultants, which to the authors of this paper represents great strength in early phases of renovation projects. However, when highlighting the more "soft" themes, such as "improved spatiality", the publication offers limited elaboration of the terms (Marsh et al. 2013). Peters (2015) in her PhD thesis investigates architectural strategies for transformation of modern housing. She advocates that renovations should take into consideration the three following aspects: 'improved daylight conditions', 'improved or new spatial experiences' and 'reconsideration of the connection to the outdoors' (Peters 2015). She offers best practice examples of how to work with these themes alongside other sustainability goals, which provides a valuable palette of inspiration for future renovation of postwar social housing. The themes related to 'improved or new spatial experiences' are, however, still quite diffuse and therefore seem difficult to operationalise directly in interdisciplinary assessments alongside quantitative parameters.

At the time of writing this paper, new decision support and evaluation methodologies related to the field of renovation are being developed. E.g. within the framework of the on-going research projects REBUS and REVALUE (of which this PhD project forms part of the latter). The tools aim to incorporate as part of their scheme also qualitative values. This gives rise to discussions about how to do this. In order to sum up on the issue at hand, we lean on the words by Madsen and colleagues, who state that there is "…*a big challenge in collecting and developing knowledge, which can qualify and describe the soft, qualitative values* [in building renovation], *in order to treat them on equal terms as quantitative data"* (Madsen et al. 2015:39 - translation by the authors). In the present paper, we address the challenge through the following two research questions:

1. *Can a circular tectonic approach to energy renovation help provide a framework in interdisciplinary teams for articulating potential synergies between energy saving and improved quality of living?*

2. *Is it possible to identify a set of more explicit themes, through which to assess the potential for synergies between energy saving and improved quality of living?*

When we talk about energy renovation in the context of this paper, we refer to all alterations, which aim to optimise the energy performance of the building. The term 'improved quality of living' ['bokvalitet'] is adopted from the renovation process in Gellerup, Denmark (Brabrand Boligforening et al. 2016) and is understood as the ability of the physical frame to support the everyday lives of the residents - spanning both pragmatic and experiential concerns related to dwelling.

2 METHODOLOGY

The first part of the paper is devoted to answering research question 1. Through a narrative literature review, the concept of 'circular tectonics' is unfolded relative to the task of energy renovation (Groat & Wang 2013, Cronin et al. 2008). In particular, we lean on the etymological studies on tectonics by Eduard Sekler and studies on the alterations of buildings by Stewart Brand.

This forms the point of departure for identifying a set of more explicit themes, through which to articulate and assess the potential for synergies between energy saving initiatives and quality of living (research question 2). The findings are based on an expanded review of literature with relevance for the field of renovation of postwar social housing in Denmark in the cross-field between engineering and architecture. In the third part of the paper, the identified themes are exemplified through the case of a competition entry for renovation of a housing block in Gellerup, Aarhus, Denmark. The exemplification is based on a research-through-design study carried out in the studio of AART architects in the winter 2016/17 (Frayling 1993, Groat & Wang 2013).

The research presented in this paper is part of the puzzle of an ongoing PhD project with the tentative title "Architectural strategies for promoting well-being in energy renovation of postwar social housing". The PhD project is conducted as part of the national research project REVALUE (value creation by energy renovation and transformation of the built environment – modelling and validating of utility and architectural value).

3 CIRCULAR TECTONICS AS AN APPROACH TO ENERGY RENOVATION?

3.1 *Circularity and the task of energy renovation*

In "Strategi for circulær økonomi" [Strategy for a circular economy], recently published by the Danish Government, the following definition is put forward: *"In a circular economy, materials and products are recirculated, their value fully exploited and the waste is minimised. Buildings and products are designed to be reused, repaired and recycled rather than thrown away"* (Government 2018:6 – translation by the authors).

When performing (energy) renovation of buildings, we alter the building to prolong its lifespan. Renovation is, generally speaking, a more resource saving alternative to new construction (Rasmussen & Birgisdóttir 2015) due to less *"embodied energy, waste and material use"* (Peters 2015:20). When considering the cycles in figure 1, we see that renovation allows us stay in the inner circles of the diagram, where we have the highest potential for resource savings.

Such potential benefits are, however, only relevant if we are able to adapt the building to *"contemporary demands for livable cities and housing for people"* (Vestergaard 2017:2). Inge Vestergaard's definition of circularity in relation to renovation of social housing resonates with the following quotation by Fred Scott: *"the purpose* [of altering a building] *is to work the existent and the ideal together through the process of intervention, to keep the existing occupied and significant* (Scott 2008:xviii).

In 1994, Stewart Brand presented a visual representation of such continuous efforts to update a building. In the diagram "Shearing layers of change", he depicted the layers of a building - the *site*, *structure*, *skin*, *services*, *space plan* and *stuff* - and how these layers are continuously changed (at different rates) throughout the life span of the building to adapt to changes (Brand 1994). We find that this is still a useful way to illustrate the circular and interdependent nature of all alterations; including energy motivated ones (fig. 1).

Most of the reviewed literature concentrates on the potential for energy savings through alterations to the building envelope and installations – or what Brand refers to as the *skin* and the *services* (e.g. Tommerup 2010, Jensen 2009). Others include initiatives related to more efficient utilisation of the *space plan* (e.g. Marsh 2013). The alteration to the *skin*, *services* and *space plan* should be seen as part of a larger system, where we continuously *'work the existent and the ideal together through the process of intervention'* to prolong the lifespan of the building (Scott 2008). In this light, energy renovation cannot be viewed as something final or static, but as one of many interventions, which the building will undergo during its lifespan to ensure the continued significance to its users. This prescribes a throughout understanding of how the alterations build on existing conditions and allow for future needs for alteration.

3.2 *Circular tectonics and the task of energy renovation*

In the previous section, we have established that energy renovation must be seen as one of many alterations, which the building will undergo through its lifetime not only for repairs, but also to adapt to the societal and technological development. In this section, we seek to combine this understanding with a tectonic approach in order to articulate the interrelation between energy saving and improved quality of living.

Through history, tectonics has been applied as a lens through which to discuss a meaningful development of architecture rooted in primordial aspects of dwelling on the one hand, and in technological inventions on the other. In current research, tectonic architectural theory has been associated also with the question of ecology (e.g. Beim & Madsen 2014).

In this paper, we lean on the etymological studies of tectonics by Eduard Sekler. The reason for doing so is that Sekler's studies represent a relatively clear theoretical basis for talking about the interrelation between technique and the perceived quality of a space. In the essay "Structure, Construction, Tectonics", he defines tectonics as *"the noble gesture which makes visible a play of forces, of load and support in column and entablature, calling forth our own empathetic participation in the experience"* (Sekler 1964:93). In the text, he establishes a link between what he refers to as the 'structural concept', and how the structural concept affects the experiencing subject through spatial 'gestures' once it is realised through concrete 'construction' (Sekler 1964). Building on the work of Hvejsel et al. (2015), we propose to apply Sekler's terms to the field of energy renovation of social housing as a means to articulate also the experiential dimension of alterations to the construction; whenever we alter a construction with the goal to increase energy efficiency, we inevitably influence the perception of the given space. If, and to what extent, this can be used positively to pursue synergies between energy efficiency and improved quality of living, depends on the level of awareness and knowledge of the involved stakeholders.

In the context of energy renovation, we suggest that Sekler's notion of 'structural concept' can be "replaced" by 'energy efficiency strategy'. We suggest that his notion of 'construction' can be used to articulate the way in which the energy efficiency strategy is realised through specific 'alterations of the existing construction'. Lastly, leaning on the work of Hvejsel et al. (2015), we suggest that his notion of 'gesture' can be understood as the way in which the alterations contribute to 'improved quality of living' through the gestures, they provide (fig. 1).

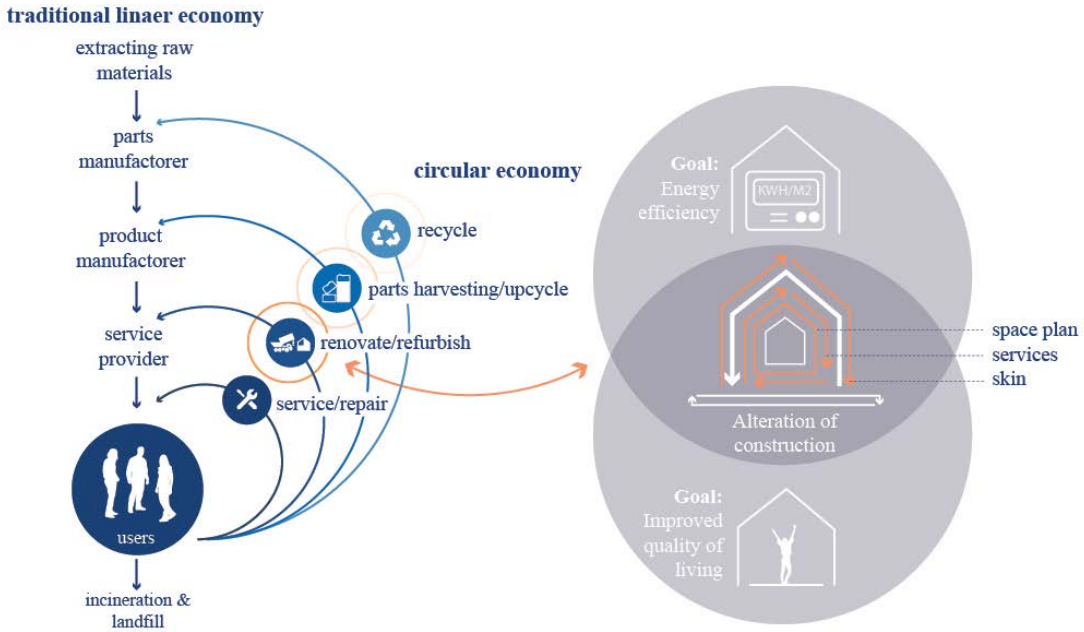
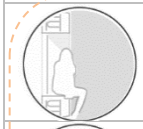
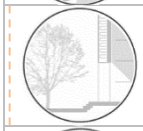


Figure 1. Energy renovation is a resource-saving alternative to building from new. Paying attention to potentials for upcycling and recycling could further help to reduce the environmental impact. However, energy renovation cannot be viewed in isolation, as it inevitably influences the way we perceive the building. If we bear this in mind when choosing the specific strategy for *alteration of the construction*, it represents a potential for creating synergies between *energy efficiency* and *quality of living*, which can secure a more long-term sustainable solution. Based on Brand (1994) and Ellen MacArthur Foundation (2017).

4 IDENTIFYING ARCHITECTONIC THEMES RELATED TO ENERGY RENOVATION

In the previous section, we have presented a rereading of the task of energy renovation through the lenses of 'circular tectonics'. In this section, we investigate if it is possible to go a step further and identify a set of more explicit architectonic themes, through which to assess the potential for synergies between *energy efficiency* and *improved quality of living*, depending on the specific strategy for *alteration of the construction*. The suggested themes are presented in table 1 and elaborated in table 2 and 3. The alterations are likely to affect people's perception of the associated spaces in different scales (Acre & Wyckmans 2014). We therefore suggest establishing themes according to where the alterations may be experienced from - from the *interior*, the *threshold* between interior and exterior on ground floor or as part of the *façade* expression.

Table 1. Tentative architectonic framework of analysis focusing on potential synergies between energy optimisation and improved quality of living in renovation of social housing.

STRATEGY IN TERMS OF QUALITY OF LIVING / STRATEGY IN TERMS OF ENERGY SAVING	SKIN	SERVICES	SPACE PLAN
 INTERIOR	Elaborated in table 2		
 THRESHOLD			
 FACADE	Elaborated in table 3		

Alterations to the *skin* could be re-insulation, attention to daylight conditions, shading and addition of solar panels. Alterations to the *services* could be ventilation and heating/cooling. Alterations to the *space plan* could include better utilisation of existing spaces and/or extensions (Marsh 2013, Smith-Jensen & Nørgaard 2011, Tommerup 2010). This brief overview only scratches the surface of possible alteration strategies. A more extensive account of potential energy saving initiatives can be found in e.g. Tommerup (2010). The overview does, however, serve to illustrate that there are multiple strategies for alteration of the existing construction, which can each be realised in different ways. This provides a space of possibilities – a space to work within and a space to challenge (exemplified in table 2). The purpose of table 3 is to elaborate on themes related to quality of living, which are likely to be influenced when performing energy-motivated alterations. Main references are listed below the table.

The list is not exhaustive and should be seen as a starting point for interdisciplinary dialogue rather than an absolute list of aspects to consider. The discussion section later in this paper includes further reflections on the tentative framework.

Table 2. Exemplification of alteration strategies under SKIN → "re-insulation" (Elaboration of table 1).

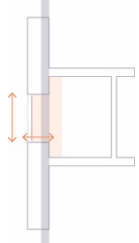
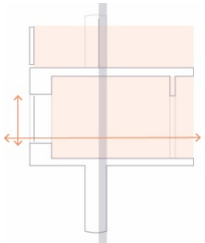
Re-insulation (interior, cavity wall insulation or exterior)	
 The available architectonic "tools" if the alterations are limited to the level of the skin ('direct' synergy): • *Geometrical alterations* • *Surface alterations (materials, colors etc.)* • *Detailing (joints etc.)*	 The available architectonic "tools" if the alterations go beyond the level of the skin ('indirect' synergy): • *Geometrical alterations* • *Surface alterations (materials, colors etc.)* • *Detailing (joints etc.)*

Table 3. Elaboration of themes related to quality of living, which are likely to be influenced by energy renovation on building scale.	
INTERIOR	
Views /privacy	• View from the interior to the exterior. • Visual privacy from the exterior to the interior.
Spatial arrangements	• Internal division of space and spatial density (ceiling height and placement of physical elements in the space) • Alternative utilisation of existing spaces and/or alteration of apartment sizes/layout. • Adaptability for future changes in use.
Indoor climate	• Visual indoor climate (access of daylight, orientation of functions and openings relative to the path of the sun). • Acoustic, thermal and atmospheric indoor climate.
THRESHOLD	
Private/public transition	• Protected and sheltered entrance to the dwelling. • Well-defined private, semi-private and public outdoor spaces, including balconies.
Permeability	• Changes in permeability, such as the size of windows and entrances.
Scale	• Alteration of the actual and perceived scale of the building(s).
FACADE	
Architectural main idea	• Restoration/preservation, reinterpretation or transformation (depending on the level of preservation value according to the national SAVE-system and/or the assessed value amongst stakeholders). • Coherence in design choices.
Density and diversity	• Contribution to alterations to the built density of the area. • Diversity in terms of formal language/materiality, functionalities and demography (offering a variety of dwelling types).
ACROSS SCALES	
Quality of construction	• Materiality (tactility, durability and patina) • Attention to joints and details (craftsmanship, adaptability). • Maintenance (cleaning/ durability/patina).
Accessibility	• Accessibility.
Acre et al. 2014, Madsen et al. 2015, Winther 2006, Bech-Danielsen, C. 2012, Bech-Danielsen & Mechlenborg 2017, Vestergaard 2017, Peters 2015, Bech-Danielsen et al. 2011, Scott 2008, Madsen & Frederiksen 2018, Nygaard 2002, Gehl 2011, Kulturarvsstyrelsen 2011, Clausen 2000, Marsh et al. 2013, Pallasmaa 1996, Frascari 1984, Smidt-Jensen & Nørgaard 2011, Tommerup 2010, Jensen & Beim 2003, Bertelsen et al 2001.	

5. THE CASE OF GELLERUP

In the previous, we have suggested a framework of architectonic themes for energy renovation of social housing. In this section, a competition entry for renovation of a housing block in Gellerup, Denmark, is used to exemplify the themes. Our intention is not to highlight the entry as particularly successful or not, but rather to use the framework to show how the interdisciplinary team work

Figure 2. Interior - existing.

Figure 3. Threshold - existing.

Figure 4. Façade - existing.

The competition call included renovation of the building envelope, bathrooms and staircases, transformation of the ground and first floors into new so-called 'town-houses', and addition of new dwellings above a new road cutting 'through' the building. For the explanatory purpose of this section, we narrow our focus to alterations to the 'skin' of the building. In terms of energy, the target was to meet the Danish building regulation BR15 by securing that altered/replaced components comply with the standards (The Danish Transport, Construction and Housing Authority 2018). The existing building was a prefabricated construction from 1968-72, built from concrete slabs and bearing walls. The loadbearing system made it relatively simple to disassemble the main parts of the existing façade – allowing for a high degree of freedom in the renovation.

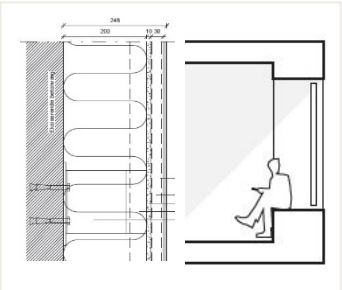


Figure 5. Detail and section.

Figure 6. Threshold - proposal.

Figure 7. Façade - proposal.

Interior (fig. 5): A focal point in the project was to provide new dwelling types, but also to heighten the quality of living in the existing ones within a limited budget. As an example of the latter, new windows were proposed in the end walls (see existing uninterrupted end wall in figure 4). The idea was to utilise the additional depth of the living room wall due to external reinsulation as a space for sitting and at the same time allowing for *views* towards the Brabrand lake from the entrance corridor. Further, the solution was expected to add sense of security, as it would allow for supervision of a current 'blind spot' in the exterior. The project included only limited refiguration of walls in the existing apartments, but throughout *new utilisation* of the ground floor dwellings and retail purposes. This gave rise to new energy related concerns, e.g. insulating the otherwise unheated spaces and relocating technical rooms, but was considered essential for improving the ground floor articulation (fig. 6). Considerations related to *indoor climate* in the dwellings focused mainly on maintaining the good daylight conditions when the façade was updated.

Threshold (fig. 6): Rethinking the *transition between the private and public* spaces on ground floor was a dominant focus – both in terms of functions and creating semi-private outdoor spaces. The proposal was to remove the existing entrance gallery and activate the relatively closed ground floor level by introducing new enlarged entrances, new 'town house'-dwellings and light retail with entrances to terrain. This was also part of a strategy to increase the sense of *permeability* and reduce the perceived *scale* of the residential block. A proposal for articulation of the transition zone included places for stays and preserving and adding plants. However, the limited budget of the project made this a subject of savings towards the submission deadline.

Façade (fig. 7): The process included extensive discussions on the *level of preservation vs. transformation of the original expression.* The building is not listed, and its value of preservation is a much-discussed topic. The proposed solution had a hierarchical approach to alteration of the building envelope: preserving the "grid" (and restoring the original pixilation on the end walls with the addition of new windows) and signaling a step change within the grid, in the base of the building and the new 'infill' above the road. This highly influenced the strategy of alteration, e.g. concerns related to thermal bridges in the concrete grid were de-emphasised in order to preserve the characteristic grid structure. The many subtasks in the project made it especially challenging to reach one coherent *architectural main idea***.** This prompted continuous iterations considering in parallel rather detailed solutions and their effect on the overall idea.

The competition project formed part of a larger masterplan for Gellerup (Aarhus Municipality and Brabrand Boligforening 2010). The competition itself included sketching the utilisation of the neighboring plot. As such, it formed part of the larger strategy to *densify* the area. The masterplan outlined intentions to go from a mono-functional more or less disconnected area to a number of diverse *multifunctional* neighborhoods within Aarhus. Such considerations were not directly connected by the alteration of the building. Nevertheless, it is relevant to note that the

building (due to its location at the 'entrance' to the area) was considered key in signaling a step change both within the area and towards the city. As such, the specific alterations to the skin of the buildings where considered essential for at new understanding of the area on neighborhood and city scales.

Across scales: 'Offered quality' was stated explicitly as an evaluation criterion in the tender documents. This supported that priority be given to materials of high quality in terms of *tactility, low maintenance and natural patina*. During the project, however, we had to continuously revisit this theme due to budget. As such, considerations on what existing components to preserve and repair– e.g. floors, handrails etc. – and what components to change - e.g. the trapezoidal profiled sheets on the end walls - became a matter of adding as much experiential value as possible whilst reducing the material resources and money spend. *Accessibility* was treated as an implicit part of the project. In relation to the alterations to the 'skin' the primary concern was to ensure equal and simple access for all in the new entrances on ground floor.

The complexity of the project in Gellerup was considerable, not least due to the number of stakeholders and the sensitive character of the area. As such, this brief account does not do it justice. It does, however, serve to exemplify the themes in the architectonic framework. In terms of circularity, the focus in the case was primarily on prolonging the service life of the building by updating it to contemporary standards. When evaluating the design process in retrospect, it is evident that there was no explicit focus on re- and upcycling of building waste in the design of renovated/new components. This represents an unexploited potential, which has been investigated more wholeheartedly in e.g. e.g. Albertslund Syd by Vandkunsten (LCCbyg). Such explorations could add an additional layer of synergies between *energy saving* and *quality of living*.

5 DISCUSSION

In this paper, we have used the notion of 'circular tectonics' as an outset for proposing a architectonic framework for articulating potential synergies between *energy saving* and *improved quality of living* in energy renovation of social housing. This section is devoted to a brief discussion of the underlying idea of establishing such themes and of using circular tectonics as a point of departure for doing so. Further, the paper discusses limitations of the framework and potentials for further development.

5.1 *The relevance of establishing explicit architectonic themes?*

In establishing a framework of architectonic themes, critical voices could claim that one risks reducing the complexity of the architectural field to a matter of checkboxes. E.g. Kirstine Brøgger Jensen states that *"…it is a widespread notion architectural quality cannot be put into formulas"* (Jensen 2015:102). This discussion in its own right deserves further elaboration (please refer also to Jensen et al. 2017). In the present paper, we lean on the words of Erik Nygaard, who states that it is possible to treat themes related to architectural quality separately in an analytical manner – keeping in mind that architecture cannot be reduced to one or a few of these themes and must always be assessed as a whole (Nygaard 2002). We are aware that establishing explicit themes may invite reductionism and formalise the analysis in unintended ways by omitting aspects of relevant to the project in question. The tentative framework presented in this paper does by no means capture the full complexity of the architectural field of renovation. The themes related to *quality of living* are selected because there is a presumed link between them and *energy saving* initiatives, depending on the chosen strategy for *alteration of the existing construction*. For now, they make up a sort of "call attention to"-list, which should be further developed.

Further research is needed to establish a meaningful operationalisation of the framework before and during the design process, as well as for critically evaluating finalised proposals.

5.2 *Product value vs. process value and the limitations of the 'physical frame'*

The current paper focuses on renovation of at building scale, focusing on specific *alterations to the construction*. It is important to consider how these alterations support the development of the

area on a neighborhood and city scale. Further, the physical transformation must always be combined with social efforts (Bech-Danielsen 2012). This lies beyond the scope of the framework here presented.

In the presented study, we have focused on value in the finalised project, or what we could refer to as 'product value' (applied in construction management by e.g. Wandahl 2005). However, in the case of social housing, attention to the users is key (Jensen 2015). In the example of Gellerup, the renovation project is depended on the acceptance of the well-developed resident democracy. Further, a considerable number of the residents will stay in their dwellings throughout the duration of the construction phase. As such, their perception of value in the final project is likely to be closely related to their perception of the process. It may therefore be relevant to include attention to 'process value' (from the perspective of the residents) in the framework.

5.3 *Circular tectonics and the task of architectural quality in energy renovation*

The paper leans on a circular tectonic understanding of the task of energy renovation of social housing. As mentioned, the themes in the framework are included, because there is a presumed correlation/ potential for synergies between them and *energy saving* initiatives, depending on the chosen strategy for alteration. The potential for synergies may be of a more 'direct' or 'indirect' character (table 2). By 'direct', we mean that there is a direct synergy between *energy savings* and *improved quality of living*. By 'indirect', we mean that we extend our focus to include alterations to the construction, which may not contribute directly to *energy savings* (and may even pose added construction costs). However, they are relevant to consider, because they are expected to improve the quality of living for the residents and may therefore contribute to prolonging the life of the building. This is for instance the case when discussing alterations to the ground floor threshold, which is a much-debated subject in relation to the often abrupt transitions between private and public in the prefabricated housing units of the 60's (e.g. Bech-Danielsen & Mechlenborg 2017) (table 3). We wish to stress the importance of the architect taking on the role of interpreting and challenging the 'space of possibilities' for *altering the construction* within the context of energy optimization.

6 CONCLUSION

This paper deals with the task of updating our existing postwar social housing stock through energy renovation. Such renovations are likely to influence the experience of the built environment dramatically, which may in turn affect the residents' quality of living. It is however, identified as a challenge to articulate 'soft', qualitative values related to the spatial experience alongside 'hard', quantifiable ones in contemporary practice.

Throughout the paper, we have leaned on circular tectonics as an outset for establishing that energy renovation cannot be viewed as an isolated act. Rather, it must be understood as one of many alterations that the building goes through during its lifespan to meet contemporary needs for dwelling. In order to save resources and secure a long-term sustainable solution, it is relevant to find a way to articulate potentials for synergies between energy savings and contemporary needs for dwelling.

Based on a literature review, this paper suggests a tentative framework of architectonic themes, which are likely to be affected by energy renovation and, as such, could be used a point of departure for articulating potential synergies between *energy efficiency* and *quality of living*. Further research is needed to develop and test the framework for use as part of the creative process.

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REFERENCES

Aarhus Municipality and Brabrand Boligforening 2010. *Forslag til dispositionsplan Gellerupparken + Toveshøj – ny multifunktionel bydel i Aarhus.*

Acre, F. & Wyckmans, A. 2014. Spatial quality determinants for residential building renovation: A methodological approach to the development of spatial quality assessment. *International Journal of Sustainable Building Technology and Urban Development*. 5:3: 183-204.

Bech-Danielsen, C. 2012. Et arkitektonisk syn på renoveringer af almene boligbebyggelser i Danmark. *Nordic Journal of Architectural research*. Issue 2:2012: 47-69.

Bech-Danielsen, C. & Mechlenborg, M. 2017. *Renovering af almene boligområder – Evaluering af fysiske indsatser gennemført i perioden 2014-2016*. SBi 2017:11. Copenhagen: Polyteknisk Boghandel og Forlag ApS

Bech-Danielsen, C., Jensen, J. O., Kirkeby, I. M., Ginnerup, S., Clementsen, A. Hansen, M. Ø. 2011. *Renovering af efterkrigstidens almene bebyggelser - Evaluering af ti renoveringer med fokus på arkitektur, kulturarv, bæredygtighed og Tilgængelighed*. SBi 2011:22. Hørsholm: Statens Byggeforskningsinstitut.

Beim, A. and Madsen, U. S. (Eds.) 2014. *Towards an Ecology of Tectonics. The Need for Rethinking Construction in Architecture*. Stuttgart & London: Edition Axel Menges.

Bertelsen, N. H., et al., 2001. *Metode til kvalitetsvurdering af alment boligbyggeri: Prøveevaluering af Hvidovrebo afd. 8* (By og Byg Resultater 006). Hørsholm: Statens Byggeforskningsinstitut.

Brabrand Boligforening [Brabrand Housing Association], Pluskontoret & Rambøll 2016. *Byggeprogram del 1: Brabrand Boligforening Afd. 4, Pilotprojekt Blok B4*

Brand, S. 1994: *How Buildings Learn: What Happens After They're Built.* London: Phoenix Illustrated.

Clausen, L. (red.) 2000. *Evaluering af kvalitet i boligbebyggelser: Vejledning for byggeriets parter*. København: By- og Boligministeriet.

Cronin, P., Ryan, F., Coughlan, M., 2008. Undertaking a literature review: a step-by-step approach. *British Journal of Nursing*. Vol 17 2008, No 1: 38-43.

The Danish Transport, Construction and Housing Authority 2018. *Bygningsreglement* [Building regulations]. Available via: http://bygningsreglementet.dk/ [Accessed 23/10 2018].

Ellen MacArthur Foundation, 2017. Infographic – Circular Economy System Diagram. Available via: https://www.ellenmacarthurfoundation.org/circular-economy/infographic [Accessed 22/02 2019].

Frascari, M. 1984. The Tell-the-Tale Detail. *VIA 7: the Building of Architecture*. Cambridge, Mass: the MIT Press: 23-37.

Frayling, C. 1993. *Research in Art and design*, Royal College of Art research papers. Royal College of Art. Great Britain

Gehl, J. 2011. *Life between Buildings: Using Public Space*. Washington DC: Island Press.

Government 2014. *Strategi for energirenovering af bygninger: Vejen til energieffektive bygninger i fremtidens Danmark*. Danish edition. Copenhagen: The Ministry of Climate, Energy and Building.

Government 2018. *Strategi for cirkulær økonomi.* Copenhagen: Miljø- og Fødevareministeriet og Erhvervsministeriet.

Groat, L. & Wang, D. 2013. *Architectural Research Methods*. Second edition. New Jersey: Wiley.

Hvejsel, M. F., Kirkegaard, P. H. and Mortensen, S. B. 2015. Towards a tectonic approach – energy renovation in a Danish context. *Nordic Journal of Architectural Research*. Issue 1:2015: 35-60.

Jensen, J. F. and Beim, A. 2003. *By og Byg Dokumentation 043: Synliggørelse af kvalitet i boligbyggeri. En pilotundersøgelse af forskellige aktørers opfattelser af standard og kvalitet i boligbyggeriet.* Hørsholm: Statens Byggeforskningsinstitut.

Jensen, K. B. 2015. How to understand architectural quality when working with social housing areas. *Boundaries|Encounters|Connection - Papers presented at the Housing & Welfare Conference, Copenhagen, 7-9 May 2015:* 98-105. Copenhagen: Danish Building Research Institute.

Jensen, O.M. 2009. *Virkemidler til at fremme energibesparelser i bygninger (Tools to promote saving of energy in buildings)*. Copenhagen: Statens Byggeforskningsinstitut.

Jensen, S.R. & Purup, P.B. & Kirkegaard, P.H. & Petersen, S. 2017. Towards a Holistic Approach to Low-Energy Building Design: Introducing Metrics for Evaluation of Spatial Quality. *Proceedings of 33rd PLEA International Conference – Design to Thrive*: 765-772. Edinburgh: NCEUB.

Kulturarvsstyrelsen 2011. *SAVE - Kortlægning og registrering af bymiljøers og bygningers bevaringsværdi*. Available via: http://slks.dk/fileadmin/user_upload/kulturarv/fysisk_planlaegning/dokumenter/SAVE_vejledning.pdf [accessed 20/9 2016].

LCCbyg: *Renovering af 1001 gårdhuse: Albertslund syd.* Available via: https://lccbyg.dk/lccipraksis/lcceksempler/1001-gaardhuse-albertslund-syd/. [accessed 26/10 2018]

Madsen, U.S, A. Beim, & A. Reitz. 2015. *Værdiskabelse i Bygningsrenovering* [Value Creation in Building Renovation]. Copenhagen: CINARK.

Madsen, U. S. & Frederiksen, L. K. (red.) 2018. *Idekatalog over designstrategier for design for disassembly i præfabrikeret byggeri*. InnoBYG and CINARK. Available via: https://issuu.com/cinark/docs/idekatalog [accessed 26/10 2018]

Marsh, R., Faurbjerg, L. M., Kongebro, S. 2013. *Arkitektur, Energi, Renovering: designguide for energi-, dagslys-, og indeklimarenovering*. Copenhagen: The Danish Building Research Institute and Henning Larsen Architects.

Nygaard, E. 2002. Arkitektonisk kvalitet – et forsøg på en kortfattet definition. *Nordisk Arkitekturforskning* 2002:1: 91-96.

Pallasmaa, J. 1996. *The Eyes of the Skin: Architecture and the Senses*. London: Academy Editions.

Peters, T. 2015. *Architectural strategies of Transformation to Modern Housing: Qualitative Parameters for Analysis of Sustainability in 1960s and 1970's Multi-story, Prefabricated Concrete Housing in Denmark*. PhD Thesis. Aarhus: Aarhus School of Architecture.

Rasmussen, F. N. and Birgisdóttir, H. 2015. *SBI 2015:29 Livscyklusvurdering af større bygningsrenoveringer miljømæssige konsekvenser belyst via casestudier*. Copenhagen: Aalborg University.

Scott, F. 2008. *On Altering Architecture*.New York: Routledge.

Sekler, E. F., 1964. Structure, construction, tectonics. *Aufbau*, Oct. p. 89- 95.

Smidt-Jensen & Nørgaard (ed.) 2011. *Arkitektur & Energirenovering – Det murede etagebyggeri fra 1920 til 1960*. Copenhagen: Danish Architecture Center.

Tommerup, H. M. 2010. *Energirenoveringstiltag: Katalog*. BYG Rapport, Nr. R-223. Copenhagen: Technical University of Denmark.

Vestergaard, I. 2017. Modern architecture in a life cycle perspective, *PHN17 - 8th Nordic Passive House Conference Proceedings : Adaptive and Interactive Buildings and Districts*. Helsinki.

Wandahl, S. 2005. *Value in Building*. PhD dissertation. Aalborg: Aalborg University.

Winther, I. W. 2006. *Hjemlighed – kulturfænomenologiske studier*. Aarhus: Danmarks Pædagogiske Universitets Forlag.