

PhD thesis

**ARCHITECTURAL STRATEGIES  
FOR PROMOTING WELL-BEING IN  
SUSTAINABLE RENOVATION OF  
SOCIAL HOUSING**

Stina Rask Jensen



**AART**







Thesis title	Architectural strategies for promoting well-being in sustainable renovation of social housing
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# Preface

This thesis presents the results of a three-year PhD project conducted between 2016 and 2022. The PhD project forms part of the research and innovation project ReVALUE (Value Creation by Energy Renovation, Refurbishment, and Transformation of the Built Environment - Modelling and Validating of Utility and Architectural Value) supported by Innovation Fund Denmark.

The point of departure for the PhD project was to investigate potentials for added value in energy renovation from an architectural perspective.

The PhD project was organized as a regular university PhD, with employment at the Department of Civil and Architectural Engineering at Aarhus University. However, to ensure an application-oriented research project, the PhD project was conducted in close collaboration with one of the industry partners in the ReVALUE project, AART architects.

## PERSONAL MOTIVATION

I was - and am - grateful for the opportunity to engage in a research setup reflecting my educational and professional background and interest in the intersection between architecture and engineering and between practice and reflection.

I am an architect and an engineer. In that order. I studied to become a civil engineer specializing in architecture at Aalborg University. After graduating, I was employed as an architect in Norway and Denmark before initiating the PhD study. The intersection between architecture and engineering is at the core of my professional "self-image." With the PhD, I found the opportunity to combine this interest with another core interest: how the built environment contributes to shaping our everyday lives and well-being.

This is especially relevant in the context of the home - our base in the world. The PhD study focuses on the possibilities to add value for the residents in social housing dwellings undergoing renovation while reducing the environmental impact of the housing stock. From the outside, it may not be the most flashy topic, yet it has proven tremendously meaningful at so many levels. This is a topic that affects a large number of people and holds the potential for making a real difference from an environmental perspective.

It is a complex field, of which I have only addressed parts. Nevertheless, in all modesty, I hope that the architectural strategies proposed in this PhD thesis will contribute to a holistic development of the building sector. This, by suggesting a small piece of the puzzle ensuring that we meet *"...the needs of the present without compromising the ability of future generations to meet their own needs."* (World Commission on Environment and Development, 1987).

## ACKNOWLEDGMENTS

I am deeply grateful to all the people who - in each their way - have contributed to this PhD thesis.

My personal thanks go first and foremost to my principal supervisor, Poul Henning Kirkegaard. Your guidance has kept me on track and helped me navigate unknown territory - not only in this PhD but from the very first days of studying.

As a supervisor - and a sparring partner in my years as a practicing architect - you have helped me find my professional standpoint in the intersection between architecture and engineering and between 'doing' and 'reflecting.'

Also, a warm thanks to my co-supervisors, Anders Strange and Johanne Mose Entwistle, for continuous fruitful and encouraging discussions in the architectural studio of AART, which have helped me link academia and industry in a meaningful way. Thanks for your enthusiasm and continuous belief in the relevance of the research to the development of the company and the architectural field.

A big thanks to our collaborators in the ReVALUE project, especially Charlotte Hansen Gabel, who has been an important driver in the quantitative empirical studies and always open to discussions on more general concerns related to writing a PhD thesis.

I would like to thank Brabrand Housing Association for access to data and for providing insights into the organization. Also, the people working tirelessly in the local boards of the housing departments helped us with valuable insights.

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I want to extend my gratitude to the participants in the empirical studies in Søvangen, Toveshøj, and Gellerup-parken, who opened their homes to us.

Thanks to all my colleagues at the Department of Civil and Architectural Engineering. Especially in the Tectonic design research group for encouragement. In this connection, I would like to give a special thanks to my friend and colleague in the ReVALUE project, Aliakbar Kamari, for good discussions and great travel company over the last years.

Thanks to my colleagues at AART architects for professional inspiration - and for making me feel like a colleague even in my most isolated hours of theoretical pondering. Thanks to Kenneth Thuesen Arboe and Mikkel Seier Christoffersen for collaboration on projects.

Thanks to my fellow PhD colleagues, Mia Kruse Rasmussen and Eszter Sántha, for continuous discussions and inputs. Thank you to the participants in the focus group interview, which included participants from Friis & Moltke, AART, and CEBRA architects.

A big thanks to my co-authors for collaboration on studies and papers written throughout the PhD period. Each collaboration has taught me a lot, and I look forward to extending our collaborations in the future.

A special thanks to professor Gennaro Postiglione for inviting me to stay at the Department of Architecture and Urban Studies at the Politecnico di Milano and taking the time to engage in valuable discussions. Further, to allow me into the “engine room” and partake in the planning and midterm critique of a design studio on the subject of energy renovation of social housing.

Last but not least, thanks to my family, especially my loving husband Troels, for being patient with me and always being there and for your willingness to engage in endless talks about anything and everything related to the project. Thank you! I would never have managed without you.

*Aarhus, February 2022*

  
Stina Rask Jensen

# Abstract

The post-war multi-family social housing (MSH) stock faces extensive renovation over the coming years. These prospects represent a significant potential for implementing energy savings while updating the housing stock to better support the well-being of the residents.

The two agendas are mutually dependent. The reductions needed to reach a CO<sub>2</sub>-neutral society calls for extensive energy renovations. These renovations are likely to dramatically change the built environment and thereby the human perception of it. On the positive side, extensive energy renovation may also represent an opportunity to add value for the residents that go far beyond the energy reductions in themselves.

Therefore, energy savings cannot be treated as an isolated matter. The thesis builds on the assumption that a more holistic approach to sustainability is needed to promote long-term sustainable renovation solutions.

In this connection, it is key to focus on the early design phases, as this is where defining decisions are made, and the ability to influence a project is highest. Nevertheless, the early stages also represent a high level of complexity as many concerns are to be addressed simultaneously amongst a large group of stakeholders.

In recent years, different initiatives have been proposed to meet this complexity and promote a more sustainable development of the building sector. However, the thesis has identified a gap in existing initiatives when it comes to supporting the architect's role as a promoter of well-being as part of the early phases of sustainable renovations of MSH. Especially, promoting traditionally "softer," more qualitative well-being themes as part of sustainable renovation appears under-researched.

Based on the established knowledge gap, the thesis addresses the following research question: *"How can resident well-being be promoted by architects in the early design phases of interdisciplinary sustainable renovation processes?"*

The research question is investigated through three different objectives. A mixed-methods research design is applied to shed light on these objectives.

*Objective 1:* Focuses on *articulating* synergies between energy savings and improved resident well-being in renovation from an architectural perspective. Based on a rereading of architectural theory and evaluation theory,

the thesis proposes a new conceptual framework for this purpose. The framework may be considered a contribution to the field in its own right as a vocabulary for articulating the documented impact of renovation efforts. It further forms the theoretical foundation for the remaining objectives of the thesis.

*Objective 2:* Focuses on *identifying* examples that renovation measures can impact resident well-being in a broad understanding, and that this can form synergies with energy savings. Based on architectural analysis of completed projects, empirical studies, and a literature review, the thesis identifies such examples. It proposes a categorization into "well-being themes," which may be addressed in conjunction with energy savings. The identified themes are: "The sensuous space," "The safe space," "The social space," "'My' space," "The including space," and "The functional space."

The well-being themes exemplify that a broad range of well-being aspects may be influenced as part of sustainable renovation of MSH.

*Objective 3:* Focuses on *communicating* the identified insights on potentials for documented impact back into the early stage renovation practice - focusing on "softer" well-being themes. Based on a research through design study, a literature review, and intermediate focus group interview, the thesis proposes three concepts for informing the process. The three concepts are: metrics intended for computer simulation, a catalog of impact cases, and supplementing the catalog of impact cases with examples of economic valuation. The proposed concepts should not be considered "neither or" but supplementary ways of communicating knowledge, which may bring value to the process depending on the application context. The perspective is to further develop and test the concepts in collaboration with practitioners in ongoing renovation projects.

The three objectives and related research findings constitute three strategies for promoting well-being in sustainable renovation of social housing. By proposing these strategies, the aim is to contribute to a development where the evaluation of well-being in a broad sense becomes a fully integrated part of more holistically sustainable renovation practices - hopefully leading to more long-term sustainable renovation solutions.

# Dansk resumé

Efterkrigstidens almene boliger står overfor omfattende renovering de kommende år. Det udgør et stort potentiale for at forbedre bygningernes energiregnskab. Samtidigt giver det mulighed for at gentænke hvordan boligerne bedst understøtter beboernes bo-behov.\*

De to dagsordner er tæt forbundne. For at nå målet om CO<sub>2</sub> neutralitet, er der behov for omfattende energirenovering, som nødvendigvis påvirker hvordan vi oplever boligerne. På den anden side kan omfattende energirenovering også ses som en mulighed for at tilføje værdi for beboerne, der rækker langt udover energireduktionen i sig selv.

Med andre ord kan energioptimering ikke ses som en isoleret indsats og afhandlingen bygger således på en antagelse om at langtidsholdbare løsninger kræver en helhedsorienteret tilgang til bæredygtighed.

I denne sammenhæng er det afgørende at fokusere på de tidlige designfaser, hvor mulighedsrummet traditionelt er størst og de mest afgørende beslutninger træffes for det færdige byggeri. Men netop i de tidlige faser hersker også en stor grad af kompleksitet, idet der skal tages hensyn til mange forhold blandt en stor interdisciplinær gruppe af aktører.

I de senere år, er der udviklet forskellige initiativer for at imødekomme denne kompleksitet og støtte op om en mere bæredygtig retning for byggeriet. Dog peger projektets gennemgang af eksisterende initiativer på, at der mangler tiltag der understøtter arkitektens rolle i at fremme både energioptimering og bokvalitet i det byggede miljø, når man evaluerer designalternativer i de tidlige renoverings-designfaser. Særligt er "blødere," traditionelt kvalitative aspekter af bokvalitet underrepræsenterede.

Projektet undersøger således følgende forskningsspørgsmål: "Hvordan kan arkitekter fremme bokvalitet i de tidlige designfaser af interdisciplinære, bæredygtige renoveringsprojekter?"

Forskningsspørgsmålet belyses gennem et 'mixed-methods' forskningsdesign med fokus på følgende tre målsætninger:

*Målsætning 1* fokuserer på at etablere et vokabular, hvorved man kan italesætte synergier mellem energibesparelser og bokvalitet i renovering af almene etageboliger fra et arkitektonisk perspektiv. Til dette formål foreslår afhandlingen et nyt arkitektonisk begrebsapparat baseret

på en fortolkning af arkitekturteori og evalueringsteori. Som analytisk redskab kan begrebsapparatet i sig selv betragtes som et bidrag til feltet. I projektet er begrebsapparatet desuden anvendt som teoretisk fundament for arbejdet med de to øvrige målsætninger.

*Målsætning 2* fokuserer på at identificere eksempler på at renoveringstiltag kan øge bokvaliteten i almene etageboliger, samt at synliggøre hvordan dette kan ske i synergi med energibesparelser. Baseret på arkitektonisk analyse af gennemførte renoveringer, empiriske studier samt et litteraturstudie, identificerer afhandlingen sådanne eksempler, opsummeret som "temaer for bokvalitet,"\* som kan danne synergier med energibesparelsetiltag. De identificerede temaer er: "Det sanselige rum," "Det trygge rum," "Det sociale rum," "Mit' rum," "Det inkluderende rum" og "Det funktionelle rum." Temaerne eksemplificerer at et bredt spektrum af bo-behov potentielt (kan) påvirkes når der gennemføres bæredygtig renovering af almene etageboliger.

*Målsætning 3* fokuserer på at kommunikere de identificerede dokumenterede indsigter tilbage til praksis - med et særligt fokus på blødere aspekter af bokvalitet. Baseret på et 'research through design' studie, et litteraturstudie og et indledende brugergruppe-studie, foreslår afhandlingen tre koncepter for hvordan man kan informere designprocessen. De tre koncepter er: indikatorer til brug i computersimulering, et katalog med "effekt-studier" samt at supplere effekt-studierne med eksempler på den økonomiske værdi af den forbedrede bokvalitet.

De foreslåede koncepter skal ikke ses som "enten-eller", men som kommunikationsformer der kan supplere hinanden afhængigt af hvilken kontekst de anvendes i. Koncepterne bør videreudvikles og testes i samarbejde med udførende i branchen og i nye renoveringsprojekter.

De tre målsætninger og tilhørende forskningsresultater udgør tre strategier for hvordan man kan promovere bokvalitet i bæredygtig renovering af almene etageboliger. Ved at foreslå disse strategier, er målet at bidrage til en udviklingen hvor bokvalitet (i bred forstand) evalueres på lige fod med traditionelt mere målbare temaer, som del af en mere helhedsorienteret tilgang til bæredygtig renovering.

\*I den engelske udgave af afhandlingen refereres til "resident well-being" og "spatial gestures". Da visse begreber vanskeligt lader sig oversætte, benyttes begreberne bo-behov og bokvalitet i det danske abstrakt, førstnævnte inspireret af Ingrid Gehl (Gehl 1973). Bo-behov forstås i denne afhandling som beboernes behov, som (ændringer) af det byggede miljø bør dække; altså den ønskede effekt af renoveringen. Bokvalitet forstås som hvordan boligen understøtter disse bo-behov gennem rumlige gestusser.

# Reading guide

## MONOGRAPH

This PhD thesis is submitted in partial fulfilment of the PhD degree in accordance with the GSTS Rules and Regulations (Graduate School of Technical Sciences, Aarhus University) and the Ministerial Order on the PhD Degree Programme.

The PhD thesis is formed as a monograph. It does, however, include parts of published papers, which have been edited to form a coherent part of the thesis. Co-author statements have been collected for all publications, developed as part of the PhD study.

In accordance with GSST rules, parts of this thesis were also used in the progress report for the qualifying examination.

In cases where parts of publications (besides the qualifying report) have been included in the thesis, this is noted at the chapter's beginning as a note in a grey box. Further, the body text and the methodology chapter include a more detailed description of how the text differs from the published version and an account of the distribution of roles in conducting the research and writing the paper.

The digital version of the thesis is preset to display two pages at a time. This display is recommended to enhance the readability of text and figures.

## CHAPTER OUTLINE

The thesis is structured relative to the three main objectives of the study. Following an introduction to the problem field (Part 1) and account of the applied methodology (Part 2), the thesis is, thus, divided into three main chapters:

- *Part 3: Articulation* focuses on developing a vocabulary for articulating synergies between energy savings and improved resident well-being in renovation from an architectural perspective.
- *Part 4: Identification* focuses on identifying examples that alterations of the construction may influence the well-being of residents and how these alterations may form synergies with energy savings.
- *Part 5: Communication* focuses on how to visualize potentials for synergies between energy efficiency and improved resident well-being in order to inform decision-making in the early stages of interdisciplinary renovation processes.

Together, the findings of the three main chapters constitute proposals for architectural strategies for promoting resident well-being in sustainable renovation of social housing.

## LIST OF PUBLICATIONS

### Academic publications

*Primary academic publication, partly included in the monograph:*

- Kamari, A., Jensen, S. R., Petersen, S. & Kirkegaard, P. H. 2021a. "Sustainability Key Performance Indicators' (KPIs) assessment and visualization aimed at architects in (early) renovation design processes." *Nordic Journal of Architectural Research*, 33: 41-80.
- Jensen, S. R., Gabel, C., Petersen, S. & Kirkegaard, P. H. 2021. "Potentials for increasing resident wellbeing in energy renovation of multi-family social housing." *Indoor and Built Environment*, August 2021 (Online-First): 1-21.
- Jensen, S. R., Entwistle, J. M., Hansen, H. T. R., Strange, A. & Kirkegaard, P. H. 2020. "Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation." In *IOP Conference Series: Earth and Environmental Science*, 588: 022065.
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*International conference: Design to Thrive. Volume 2.* 2132-2139. Network for Comfort and Energy Use in Buildings (NCEUB).

- Jensen, S. R., Purup, P. B., Kirkegaard, P. H., Petersen, S. & Strange, A. 2017b. "Towards a Holistic approach to Low Energy-Building Design: Introducing Metrics for Evaluation of Spatial Quality." In L. Brotas, S. Roaf & F. Nicol (eds.) *Proceedings of 33<sup>rd</sup> PLEA International conference: Design to Thrive. Volume 1.* 732-739. Network for Comfort and Energy Use in Buildings (NCEUB).
- Jensen, S. R., Kamari, A., Strange, A. & Kirkegaard, P. H. 2017a. "Towards a holistic Approach to Retrofitting: A Critical Review of State-of-the-art Evaluation Methodologies for Architectural Transformation." *World Sustainable Built Conference 2017 (WSBE17 Hong Kong) - Conference Proceedings.* 689-695. Hong Kong: Construction Industry Council and Hong Kong Green Building Council Limited.

#### Secondary academic publications:

These are more peripheral to the content of the PhD thesis and not used directly herein. Yet, they have served to position the academic work relative to the field and engage in instructive collaborations throughout the project period. If referred to, this is done similarly to other references not written by the author.

- Gabel, C., Elholm, G., Rasmussen, M. K., Broholt, T. H., Jensen, S. R., Petersen, S., Sigsgaard, T. 2022. "The HOME-Health study (HOUsing, environMEnt, and Health); Methodology, internal- and external validity of a Danish Cohort" [Manuscript submitted for publication]. Aarhus University, Department of Public Health.
- Biskjaer, M. M., Kamari, A., Jensen, S. R. & Kirkegaard, P. H. 2019. "Exploring blind spots in collaborative value creation in building design: a creativity perspective." *CoDesign - International Journal of CoCreation in Design and the Arts*, 17 (4): 374-391.
- Petersen, S., Wandahl, S., Jensen, S. R., Kirkegaard, P. H., Gabel, C., Elholm, G., Rasmussen, M. K., Neve, H. H., Kamari, A. & Sigsgaard, T. 2019. "Added values in building renovation: An interdisciplinary research agenda." In R. P. Borg & C. S. Staines (eds.) *SBE19 Malta - Sustainability and Resilience.* 138-139. Malta: SBE Malta - Sustainable Built Environment Malta.
- Wandahl, S., Lund, L., Neve, H. H. & Jensen, S. R. 2019. "Social Sustainability in Modelling of Value Creation in

Housing Refurbishment." In I. Lill & E. Witt (eds.), *10th Nordic Conference on Construction Economics and Organization.* Emerald Group Publishing, Emerald Reach Proceedings Series, vol. 2, 383-391, 10th Nordic Conference on Construction Economics and Organization, Tallinn, Estonia, 07/05/2019.

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#### Popular science publications:

- Thunbo, N. Ø., Eriksen, J. H., Entwistle, J. M., Plambech, T., Schick, L. & Jensen, S. R. 2019. *Arkitektur der fremmer bæredygtig adfærd: Samtaleværktøj og Inspirationskatalog.* 2. edn. Aarhus: AART architects.
- Wandahl, S., Jensen, S. R., Kamari, A. & Entwistle, J. M. 2019. "Almensektoren er nøgleordet for at komme i mål med klimamålene." *Jyllandsposten, JP Århus.* August 11.
- Wandahl, S., Jensen, S. R. & Kamari, A. 2020. "The social housing sector is the key to achieving climate targets." In J. Bruun (ed.), *Profile 2020.* 50-51. Aarhus: Aarhus University, Department of Engineering.

#### LIST OF ABBREVIATIONS

BBBO: Brabrand Boligforening [Brabrand Housing Association]

CAI: computer-assisted interview

CMOc: Context-Mechanism-Outcome-configuration

IEQ: Indoor environmental quality

MSH: Multi-family social housing

POE: Post occupancy evaluation

RtD: Research through design

SDGs: Sustainable development goals

SSI: Semi-structured interview

WTP: Willingness to pay

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# Part 1 : Introduction



Paragraphs in the sub-section "Architectural strategies for reaching beyond energy renovation" were previously published as part of the paper: "Potentials for increasing resident wellbeing in energy renovation of multi-family social housing" (Jensen et al. 2021). The text has been edited to form a coherent part of the thesis.

# Background

The years following the Second World War were characterized by an urgent housing shortage. This forced changes in government policies and innovative initiatives in the building industry to find ways to offer cheap accommodation for a large number of people within a very short period (Peters 2015). Changes in the legislation and subsidy schemes around 1960 marked full-hearted industrialization of the Danish building sector (Nygaard 1984), and in the course of 20 years from 1960-1979, approximately 600.000 dwellings were built (Bech-Danielsen et al. 2011; Bech-Danielsen 2012).

The building of social housing dwellings in this period was successful in many ways. New industrialized production techniques were introduced based on standardization, allowing for mass production, securing affordable rents. An experimental approach marked the period both in terms of building techniques and social aspirations (Peters 2015). Many of the dwellings had a high level of quality – even if compared to contemporary standards. Qualities such as spacious rooms, well-organized kitchens, living rooms with good daylight conditions, and large balconies can be mentioned (Bech-Danielsen 2012; Nygaard 1984). As such, the social housing dwellings of the time form an important part of the Danish housing heritage (Peters 2015; Martens Gudmand-Høyer 2018).

However, already shortly after completion, unforeseen challenges started to arise. Bech-Danielsen (2012) described these challenges in terms of constructional, social, experiential challenges and challenges related to changed norms for living. The constructional challenges included, e.g., damages in the concrete as well as leaking roofs caused by the hasty building processes and untested construction techniques. The most pronounced social challenges arose in the '80s when, for several different reasons, many areas became the homes for more vulnerable segments of society (Bech-Danielsen 2012; Peters 2015). Bech-Danielsen referred to experiential challenges concerning the repetitive character of the prefabricated dwellings modules; critics have generally picked on the rational building form and the settlements' scale. Another point of criticism has been that the universal character of the buildings has led to a 'loss of place'; the standardization principles did not leave place for adaption to local conditions and ways of building which, according to, e.g., Norberg-Schulz, is crucial for the development of personal identity (Bech-Danielsen 2012; Norberg-Schulz

1995). According to Bech-Danielsen, a part of the mentioned critique of lacking experiential qualities can be explained through changed societal norms over the years: In the wake of the youth revolution, the "low, dense" movement arose, focusing on community houses and meeting places. Later, increased individuality rather than solidarity took center stage. Where the prefabricated postwar housing had targeted an average person with 'equality' as a core ideal, focus gradually shifted towards 'diversity' and 'the individual' (Bech-Danielsen 2012).

Most social housing areas from 1960-1979 have undergone renovation at least once (Bech-Danielsen and Stender 2017). However, Bech-Danielsen et al. (2017) stated that the renovations carried out in the 1980s and 1990s often focused on building technical aspects and repairs. Damages to the concrete were repaired by covering the building in new envelopes, highly influencing the expression of the built environment. Aesthetic concerns were not the main motivation for the renovations; however, the mentioned criticism of the concrete blocks played a central role, e.g. when designing the new colorful facades adorned with art. As such, the renovations were carried out as superficial 'embellishments,' without addressing the issues of the developments more in-depth (Bech-Danielsen et al. 2017; Peters 2015).

Besides, the renovations caused new issues. The renovation work was too rushed. Further, it was criticized that old, deficient building components were replaced by new ones, with an even shorter service life than the original ones. The applied materials did not age with grace and lacked tactile qualities just as much as the original materials. In general, the durability of the renovations was questioned (Bech-Danielsen and Varming 1997) – which has been proven right, considering that the same buildings are now facing renovation once again. Evaluations have found that the housing areas face more or less the same issues today, even if integration and ethnic minorities have now gained a larger focus (Bech-Danielsen and Stender 2017; Bech-Danielsen 2012).

Another challenge related to the postwar social housing stock is energy performance. The dwellings were built before the oil crisis, in a time of inexpensive non-renewable energy, and before the introduction of demands for energy performance in the national building regulations in the late 1970s.

**Figure 1** Whereto from here? Image of building block in Gellerup, Aarhus, 2016, after the facade has been removed. Renovation of MSH offers an opportunity to add value on multiple levels.







This challenge, however, also represents a great potential in relation to contemporary discussions about how to reach the 2050 goals for a 100% coverage of the energy demand by renewable energy (Regeringen 2014). A combination of comprehensive energy efficiency measures and a massive expansion of renewable energy is needed to achieve the goal. Buildings are responsible for approximately 40% of the total energy consumption in Denmark (Mortensen et al. 2017a). The construction of new buildings is very limited compared to the total building stock (Regeringen 2014), which means that up to 90% of the existing building stock will be in operation in 2050 (Mathiesen et al. 2016). The combination of these numbers clearly demonstrates a need to drastically reduce the energy use in the existing building stock to reach the 2050 goals.

There are approximately 550.000 social housing units in Denmark, corresponding to one-fifth of the total national housing stock (Landsbyggefonden 2014). According to a study from Copenhagen Economics (2014), carried out for BL (Danish Social Housing), the largest renovation potential in the social housing sector is to be found in dwellings built in the period from 1945-1974 (Hansen et al. 2014; Pedersen and Deveci 2019). Around 280.000 dwellings were built in the period, corresponding to approximately half the total social housing units in Denmark. This need for renovation represents a large potential for implementing energy savings (Pedersen and Deveci 2019). As such, there is an identified potential for reducing the overall energy consumption in the building sector by addressing social housing dwellings from this period.

The importance of upscaling energy renovation in the social housing sector is emphasized by, e.g., Dansk Byggeri [the Danish Construction Association] in their annual report “Byggeriets Energianalyse 2019” (Pedersen and Deveci 2019). And in 2020, a political agreement was reached, allocating 30,2 billion Danish kroner for The National Building Foundation for more - and “greener” - renovations in the social housing sector in the period from 2020-2026 (Ministry of Transport and Housing 2020). In other words, energy optimization is likely to play an even bigger role in coming renovations.

## ARCHITECTURAL STRATEGIES FOR REACHING BEYOND ENERGY RENOVATION

Analyses have estimated that the energy consumption of the Danish building stock should be reduced by approx. 40-50% to meet the ambition of a CO<sub>2</sub>-neutral society (Mathiesen et al. 2016; Kragh and Wittchen 2010; Mortensen et al. 2017a). However, the financial costs for the extensive energy-saving measures needed to this end cannot be justified by the energy savings alone. Studies have estimated that cost-efficient energy renovation of the building envelope and technical installations will lead to an energy reduction of 20-35% (Wittchen 2009), i.e., around half of the needed reduction. In other words, the needed renovations are not cost-effective in terms of sheer payback economics. Therefore, it is highly beneficial to take advantage of the fact that a high number of social housing dwellings are scheduled for renovation “anyway” due to other concerns as described previously (Hansen et al. 2014).

However, the reductions needed to reach a CO<sub>2</sub>-neutral society are likely to influence the perception of the built environment dramatically (Acre and Wyckmans 2015; Beim and Stylsvig Madsen 2015; Hvejsel et al. 2015). An example could be how the implementation of a mechanical ventilation system with heat recovery takes up space in a dwelling, thus potentially affecting the ability to utilize the spaces (Johansen 2019a). Alternatively, how an added layer of exterior insulation may negatively affect the experienced coherence of a building to its neighbors from a culture-historical point of view (Martens Gudmand-Høyer 2018).

On the positive side, extensive energy renovation may also represent an opportunity to add value for the residents. An example could be that the mentioned exterior insulation is used actively to induce a new identity through a renewed expression (Peters 2015) and/or as an occasion for introducing windows, which can generate a greater sense of safety in the outdoor spaces (Nørgaard and Rudå 2021).

Hence, the challenge of transforming the social housing stock to be more energy-efficient not only calls for separate technical development and innovation. It calls for a holistic approach to sustainability and the development

of architectural strategies, through which to visualize “how to make the most” of the renovation efforts both environmentally and socially within the limited financial framework of the social housing sector.

A holistic approach is, however, more than a ‘nice to have-strategy’ motivated by economic concerns. The whole idea of performing energy renovation is to future-proof the building in terms of resource consumption. But the environmental benefits of prolonging the lifespan of the building are only ‘cashed in’ if the building is adapted to “contemporary demands for livable cities and housing for people” (Vestergaard 2017, p. 2). Failure to do so may result in homes being left lying idle and in need of re-renovation or demolition. In other words, it is crucial to ensure that the buildings continue to provide quality dwellings for the people who inhabit them in order to secure long-term sustainable solutions.

Energy savings and attention to contemporary understandings of well-being in the built environment go hand in hand. Not least in the context of postwar social housing with its identified challenges.

# The contemporary social housing renovation practice

In the previous section, the urgent need for renovation of the postwar social housing stock was demonstrated. Further, the potential for - and importance of - combining attention to environmental value creation with attention to social value creation has been stressed.

This section provides an introduction to the context of social housing renovation and the framework conditions associated with such renovation projects.

## CONTEMPORARY PRACTICE - RENOVATION WITHIN THE CONTEXT OF THE SOCIAL HOUSING SECTOR

The Danish social housing sector is concerned with providing quality dwellings at an affordable rent. The dwellings are managed by social housing organizations responsible for building, letting, administering, maintaining, and renovating the social housing dwellings and common facilities on a non-profit basis. As a common denominator, all the social housing dwellings are administered under the Danish 'Almenboligloven' (Transport og Boligministeriet 2019) [the social housing act] and receive public support (Danish Transport Construction and Housing Authority 2019; Rambøll 2018). The tenants pay mandatory contributions to Landsbyggefonden [The National Building Foundation] (Landsbyggefonden n.d.-a). When engaging in renovations, it is possible to apply for renovation support through the foundation, which in return sets certain conditions for the project (Landsbyggefonden 2018). Among other things, The National Building Foundation prescribes that a so-called overall plan [helhedsplan] is developed for the housing department (Rambøll 2018).

In general, renovation of social housing tends to be a complex task, involving a number of concerns and stakeholders (Rambøll 2018; Mortensen et al. 2017b; Kamari et al. 2019). (Figure 3) shows key stakeholders, which are often involved in renovation of multi-family social housing.

The housing association is always the client in a renovation case. This means that the housing association holds the legal and financial responsibility. However, what makes the renovation of social housing unique is that the tenants in principle own the branch. They, therefore, have a big say when it comes to making important decisions about maintenance or renovation (Rambøll 2018). Renovation actions have to be approved by the board of the housing association, by the board of the branch



**Figure 2** Extensive renovation of social housing must be approved through the tenants' democracy (based on Rambøll 2018, p. 8).

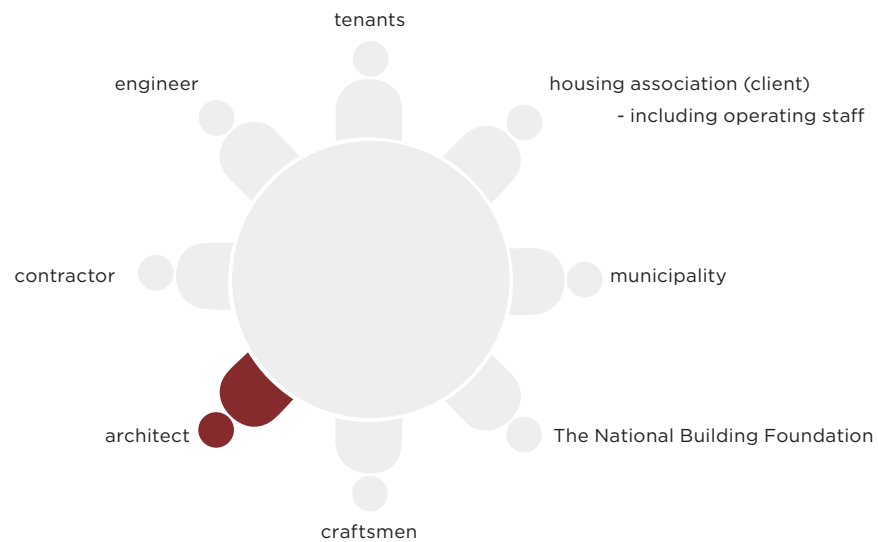
(representatives elected by the tenants), as well as by the tenants themselves on a branch meeting (Figure 2). As such, the tenants play a significant role in any extensive renovation process (Rambøll 2018).

The character of the renovation process depends on a number of factors, including the state and characteristics of the existing building, level of renovation, and the chosen tender format, to name but a few. The renovation process in its entirety spans from the first preparatory work to commissioning and follow-up (Hansen 2013). Figure 4 illustrates typical phases in the renovation of social housing relative to the framework of The National Building Foundation (the so-called schema A, B, and C) (COWI 2018).

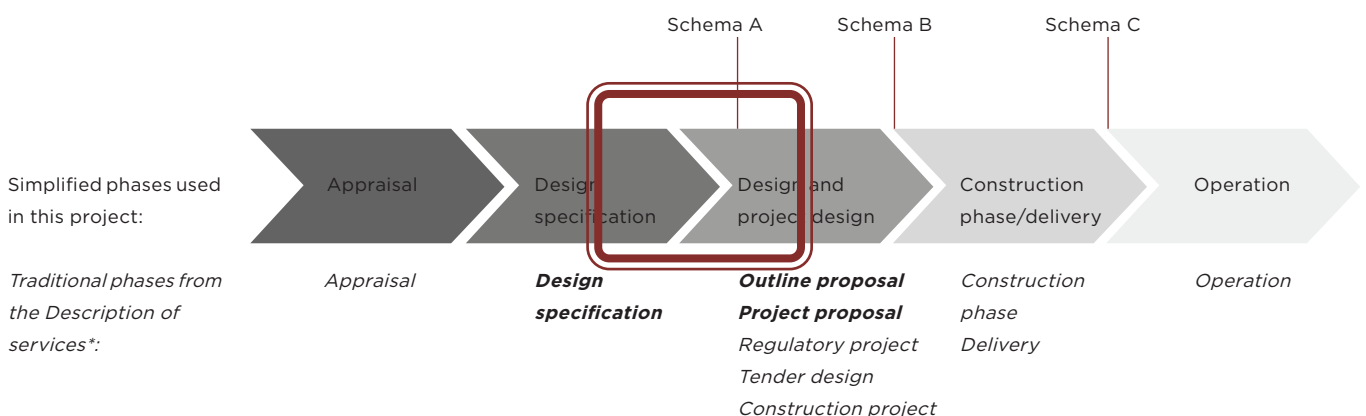
In brief, schema A marks an application for pre-approval of the renovation project from the municipality and The National Building Foundation. Schema B forms the basis for approval of the acquisition costs from the municipality before the initiation of the construction process. Schema C is to be filed to the municipality no later than six months after delivery of the project and includes the final accounts. The municipality handles schema B and C and involves The National Building Foundation in case of larger deviations (Landsbyggefonden 2018).

The color grading in Figure 4 serves to illustrate that the ability to influence the project decreases as time passes (COWI 2018). While design freedom is highest in the initial phases of a renovation project, this stage also represents a high level of complexity. This complexity may be difficult to navigate for the heterogeneous group of stakeholders (e.g., Kamari 2018; Jensen and Maslesa 2015). Despite this paradox, the interdisciplinary group of





**Figure 3** Examples of stakeholders involved in renovation of social housing (based on Rambøll 2018, p. 10; Kamari et al. 2018, p. 52; Mortensen et al. 2017b, p. 14). The focus of the thesis is to support the role of the architect as part of the interdisciplinary collaboration.



**Figure 4** Typical phases in a renovation project relative to schema A, B and C by the National Building Foundation (developed from COWI 2018, p. 9; Rambøll 2018, p. 14; Mortensen et al. 2017b, p. 13). Translation by the author based on The Danish Association of Consulting Engineers (FRI) and The Danish Association of Architectural Firms 2018). The grading of colors illustrates that the ability to influence the project decreases as the project progresses. The red square illustrates that the present research project focuses on the early design phases.

\* (The Danish Association of Consulting Engineers (FRI) and The Danish Association of Architectural Firms, 2018).

stakeholders is often obliged to make design decisions, which have high consequences for the overall outcome of the renovation (Kamari et al. 2019; Mortensen et al. 2017b).

In the context of this thesis, the focus will be on the role of the architect as part of the interdisciplinary renovation team (Figure 3). Depending on the tender format, the architect may come into the project as, e.g., a client consultant, an external consultant, or a subcontractor. This “entry” is defining for the level of design freedom. According to a guideline on tender processes in the social housing sector, “...the design specification phase may be supported by sketches, which serve to analyse and detail specific circumstances/wishes” (Rambøll 2018, p. 19, translation by author). As such, specific renovation alternatives may be investigated already at this stage. According to The National Building Foundation, the schema A-application should include an “...outline proposal for the renovation concerning construction technique, architecture, energy use, and accessibility” (Landsbyggefonden 2018, p. 8, translation by author). As such, it is custom that initial drawing material is made before handing in schema A. However, if the architect does not enter the project until after submission of schema A (e.g., as a sub-contractor to a turnkey contractor in a

tender competition, as in the case of Gellerup B4), the task may be radically different, as some defining decisions may have already been made.

This brief account only scratches the surface of different ways to organize a renovation project. Further information about tender processes can be found in, e.g., Rambøll (2018).

### Summary

This section has provided a brief introduction to the context of social housing renovation and the framework conditions associated with such renovation projects.

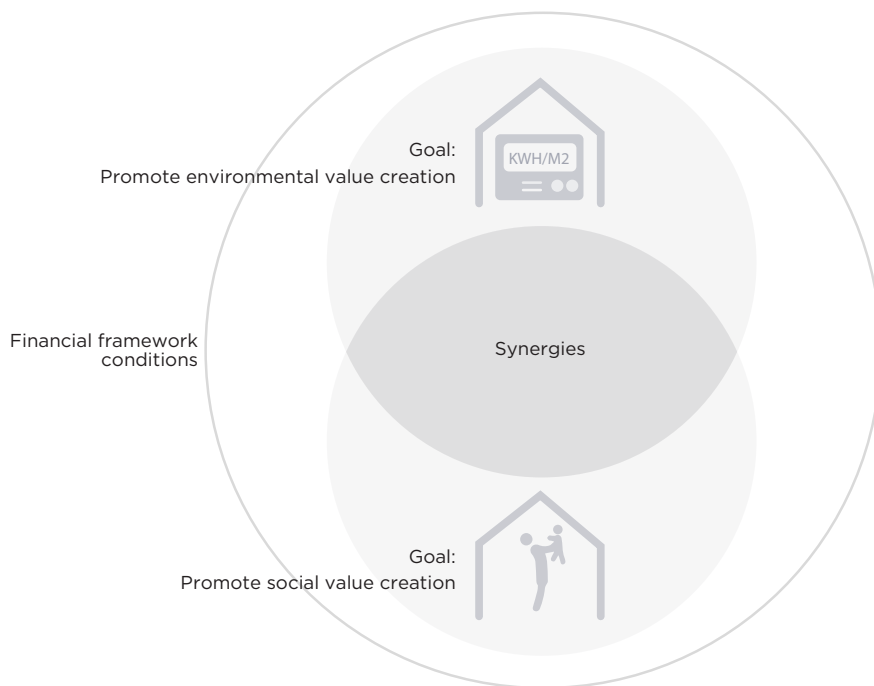
As described in the “Background” section, the postwar social housing stock faces extensive renovation over the coming years. This represents a significant potential for joint environmental and social value creation.

The ability to influence a renovation project to add environmental and social value is highest in the early renovation design phases. However, the early phases also represent a high level of complexity as many concerns are to be addressed simultaneously amongst a large interdisciplinary group of stakeholders.

Based on this account of the background for the project, the following initiating research question was proposed:

### INITIATING RESEARCH QUESTION

*How can the architect's role as a promoter of joint environmental and social value creation be promoted in the early stages of interdisciplinary renovation design processes?*



**Figure 5** The thesis is based on the assumption that attention to positive synergies between environmental value creation and social value creation can generate more long-term sustainable renovation solutions.

The clarification of the term 'Multi-family social housing' was previously published as part of the paper "Potentials for increasing resident wellbeing in energy renovation of multi-family social housing" (Jensen et al. 2021). See description of the paper in relation to the empirical studies (Objective 2).

# Energy saving and resident well-being

Before moving on to an account of existing initiatives related to the initiating research question, it is found relevant to include a brief clarification of key terms used in the thesis; 'multi-family social housing', 'sustainable renovation', 'value,' 'value creation,' 'environmental value,' 'energy savings,' 'social value,' and 'resident well-being in the built environment'.

## MULTI-FAMILY SOCIAL HOUSING

The thesis focuses on the renovation of postwar social housing. More specifically, the thesis zooms in on the renovation of multi-family social housing (MSH) built after World War Two and before the introduction of demands for energy performance in the national building regulations in the 1970s. The term multi-family social housing (MSH) is used as a key term throughout the thesis to denote a building that contains more than one dwelling and is administered under the Danish 'Almenboligloven' [the social housing act], focusing on providing affordable rental dwellings for all (Transport- og Boligministeriet 2019).

## SUSTAINABLE RENOVATION

The 1987 Brundtland report stressed the importance that humanity "...meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987, Section 27).

This understanding resonates in the term 'absolute sustainability,' which is gaining acceptance in the building sector in recent years as a way to articulate working within the absolute planetary boundaries (Ohms et al. 2019).

This 'absolute' understanding of sustainability remains difficult to operationalize in the building sector. The triple bottom line of environmental, economic, and social sustainability emanating from the Brundtland report is still a prevailing way of conceptualizing sustainability. At a rather general level, it provides common ground for articulating the relative sustainability of a building project. In a Danish context, the prevalence of the triple bottom line was supported by, e.g., Ullum et al. in "Hvidbog om bæredygtighed i byggeriet" [white paper on sustainability in construction] (Larsen and Birgisdóttir 2013) and architectural researcher Terri Peters, who stated that "[t]he current ways of discussing and evaluating the multidisciplinary concept of sustainability in design tend to rely on the three-pillar model of environment,

economy and society" (Peters 2016, p. 371). Further, the three-pillar model served as an underlay for a publication by the Danish Association of Architectural Firms about the documentation of the value of architecture (Sattrup et al. 2018), which serves to demonstrate its currency in the field.

More recently, the 11 UN sustainable development goals (SDGs) have come to play a role in articulating sustainability in the building sector (The Global Goals n.d.; Mossin et al. 2018). A number of the goals are relevant to the sector. Especially goal number 11, "*Sustainable cities and communities*" (The Global Goals n.d.), which addresses concerns related to safety, inclusion, accessibility, access to green areas, preservation value, and affordability in the built environment at the same time as promoting environmentally sustainable settlements (Udenrigsministeriet 2017). As exemplified with goal number 11, the SDGs continue the holistic approach of the triple bottom approach.

This thesis takes its point of departure in the triple bottom line understanding of sustainability. As such, sustainable renovation is understood as all efforts to update the existing housing mass to be more sustainable, both socially, environmentally, and economically. The thesis aims to push the current practice in a more holistic direction, where the social pillar is better integrated.

The underlying assumption of the thesis is that by promoting synergies between the environmental value creation (focusing on 'energy savings') and social value creation (focusing on 'resident well-being'), it is possible to contribute with a small part of the puzzle to a more holistically sustainable development of the building sector.

## VALUE

Historically, the concept of value is closely associated with economic theory, especially control of the production costs (Beim and Stylsvig Madsen 2015). This is reflected in definitions such as "*the monetary worth of something*" (Merriam-Webster 2022b, "value" entry) or "*the amount of money that can be received for something*" (Cambridge Dictionary n.d.-b, "value" entry).

However, the concept of value can also be understood more broadly. As such, Cambridge Dictionary presents a set of different meanings of the word 'value,' including "*the importance or worth of something for someone*" (Cambridge Dictionary n.d.-b, "value" entry). Merriam

Webster similarly presents the following understanding of value: “*relative worth, utility, or importance*” (Merriam-Webster 2022b, “value” entry). These broader understandings are adopted in this thesis in order to embrace the complexity of the problem field.

### VALUE CREATION

As part of the paper “Exploring blind spots in collaborative value creation in building design: a creativity perspective”, the author of this thesis, in collaboration with Michael Mose Biskjær, Aliakbar Kamari, and Poul Henning Kirkegaard, argued that “*all values emerge in complex, collaborative creative processes that dictate the final design value*” (Biskjaer et al. 2019, p. 2).

While the initial research question focuses on how to promote joint social and environmental value in the final renovated building, it is important to recognize that such value is the result of an interdisciplinary process, where the value is created, and that the evaluation of design alternatives and the final result will always depend on the experiencing subject. Le Dantec and Do define values as the ‘*principles, standards, and qualities that guide actions*’ (Le Dantec and Do 2009, p. 57). This definition is relevant in order to call attention to the fact that the stakeholders are themselves guided by values when working towards creating value as part of the renovation project. In the context of building design (and not least renovation), a severe challenge is the number of stakeholders, which are guided by differing (and sometimes conflicting) values (Beim and Stylsvig Madsen 2015; Kamari et al. 2018; Jensen and Maslesa 2015) (Figure 3 on page 19).

This thesis focuses on the architect’s perspective and on supporting his/her ability to promote joint social and environmental value creation as part of interdisciplinary collaborations in the renovation of social housing.

The two following sections serve to unfold the understanding of ‘environmental value creation’ and ‘social value creation’ respectively while underlining that these should never be addressed in isolation but always as part of a holistic approach to sustainable renovation.

### ENVIRONMENTAL VALUE - ENERGY SAVINGS

The basis for the present thesis is an identified need for promoting synergies between social and environmental value creation. In terms of environmental value, the focus is on promoting *energy savings as a sub-theme*.

Renovation focusing on energy savings is often referred to as “energy renovation” (e.g., Ministry of Transport and Housing 2020), a topic which has gained much attention in recent years due to the general focus on climate change and covers diverse meanings. The term “renovation” in itself covers a variety of interventions to a building, ranging from maintenance, over repairs, and replacements to more extensive transformation (Nygaard Rasmussen and Birgisdóttir 2015).

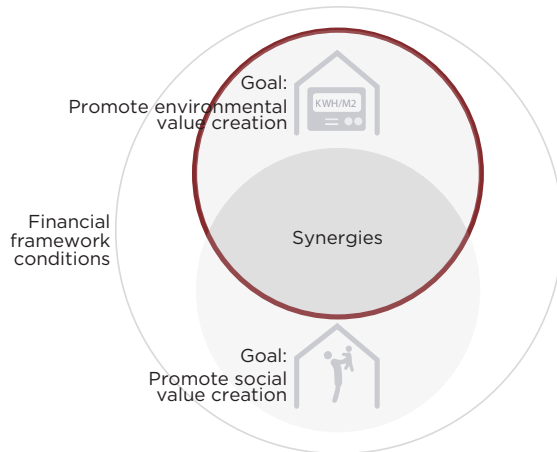
Similarly, the term “energy renovation” is ambiguous. Energy renovations are generally carried out to contribute to a more environmentally sustainable society (but may also be motivated by other concerns, e.g., economic concerns). It is implicit that an energy renovation should lead to a certain degree of kWh savings after the renovation is completed. Nevertheless, there is (yet) no clear definition of the level of these savings – not in Denmark and neither on an EU level. In Denmark, all renovation cases must comply with the national building regulations. Depending on the extent of the renovation, the national building regulations (Ministry of Transport Building and Housing 2018) puts forward different minimum requirements.

When focusing on conversions and replacements of buildings parts, the energy demands can be met by:

- Either following minimum requirements for the affected building parts (U-value and tightness)
- Or by meeting the energy frameworks of renovation class 1 or 2 (Table 1) (Ministry of Transport Building and Housing 2018, § 274).

In addition to the national building regulations, there are several definitions of volunteer approaches to energy renovation.

In 2020, a volunteer framework for sustainable building (LEVEL(S)) was launched on a European level (European Commission n.d.) and a new volunteer sustainability class was introduced in the Danish national building regulations. The Danish volunteer sustainability class will undergo testing until 2022 (Bolig og planstyrelsen 2021). It is described as part of a study of existing initiatives in Table 3 on page 30.



**Figure 6** This section focuses on clarifying the understanding of the term “environmental value” in the present thesis.

The Buildings Performance Institute Europe in 2011 presented the following definitions of energy renovation types:

- *Minor renovations* correspond to 0-30% of final energy savings
- *Moderate renovations* correspond to 30-60% of final energy savings
- *Deep renovations* correspond to 60-90% of final energy savings
- *nZEB renovations* represent savings beyond 90% (BPIE 2011)

Table 2 is included to put the numbers mentioned in the different definitions into perspective relative to the social housing sector.

As shown from the examples in Table 2, the sector contributes to the overall endeavor to reduce the energy consumption of the building industry. However, recent analyses estimate that the energy consumption of the Danish building stock should be reduced by approx. 40-50% to meet the ambition of a CO<sub>2</sub>-neutral society (Mathiesen et al. 2016; Kragh and Wittchen 2010; Mortensen et al. 2017a). Researchers argue that this reduction is not achievable for all buildings (e.g., Rose et al. 2019). As such, the projects that are able to should aim

**Table 1** Renovation classes (Ministry of Transport Building and Housing 2018, § 281)

<i>Renovation class 1</i>	<i>“When the total energy supply demand for heating, ventilation, cooling and domestic hot water per sq. metre heated floor area does not exceed 52,5 kWh/sq. metre per year plus 1.650 kWh per year divided by the heated floor area.”</i>
<i>Renovation class 2</i>	<i>“When the total energy supply demand for heating, ventilation, cooling and domestic hot water per sq. metre heated floor area does not exceed 70,0 kWh/sq. metre per year plus 2.200 kWh per year divided by the heated floor area.”</i>

for more considerable reductions, corresponding to the definition of ‘deep renovations’ by the BPIE (BPIE 2011). As a reference, only one of the included projects in Table 2 has reached this level.

This thesis leans on the more general notion of energy renovation put forward in “Hvidbog om renovering” [white paper on building renovation] published by the Danish Association of Construction Clients and Danish Landowners Investment Foundation:

*“‘Energy renovation’ include renovations, which aim to improve the building’s energy standard by reducing the energy consumption/energy supply.”*

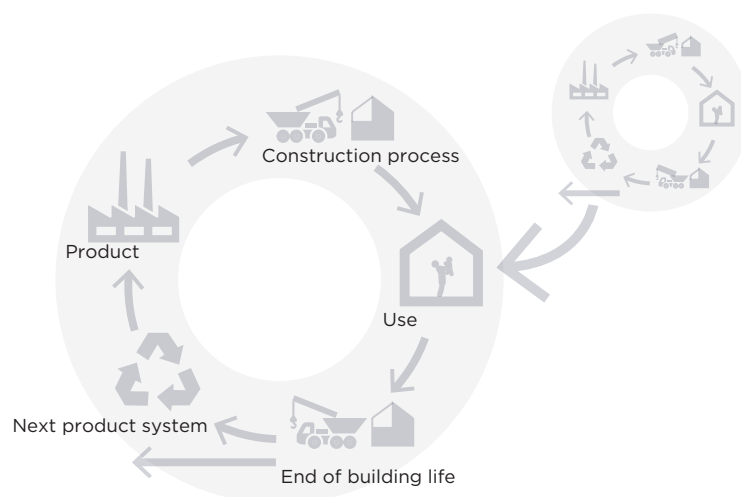
(Havelund and Simonsen 2011, p. 6, translation by author).

As such, the thesis uses a broad understanding of the term, which is not tied to a specific solution or standard.

Energy renovation may contribute to a sustainable development. However, in the context of this thesis, it is argued that efforts to improve a building’s energy standard should always be viewed as part of a holistic approach to sustainability in order to ensure long-term sustainable solutions.

**Table 2** Energy reductions in chosen reference renovation projects (Hansen et al. 2014, p. 9).

Name	No. of renovated dwellings	Energy saving %
<i>Høje Tåstrup</i>	405	29
<i>Albertslund Nord</i>	504	32
<i>Urbanplanen</i>	1.228	58
<i>Langkærparken</i>	22	90
<i>Gyldenrigsparken</i>	238	18
<i>Højbo</i>	24	
<i>Vejleåparken</i>	1.700	40
<i>Lystrup</i>	14	30



**Figure 7** Life cycle of a building (based on Nygaard Rasmussen and Birgisdóttir 2015, p. 12). Renovation introduces further concerns about life cycles for introduced or discarded materials.

Subsequently, the term ‘sustainable renovation’ is used throughout the thesis to signal a more holistic approach.

### Attention to energy savings as one approach to environmental value creation

The focus on promoting environmental value creation through attention to energy savings reflects the focus in the ReVALUE project (which this PhD project forms part of). It also reflects the original call from The Innovation Fund Denmark. Nevertheless, it is naturally important to acknowledge that the topic of environmental value creation can be addressed through different approaches. Table 3 on page 30 includes an overview of environmental themes addressed in a number of process- and assessment frameworks relevant to the Danish renovation field; for instance, local discharge of rainwater may be another sub-theme (in addition to operational energy savings), which can be linked to environmental value creation in renovation.

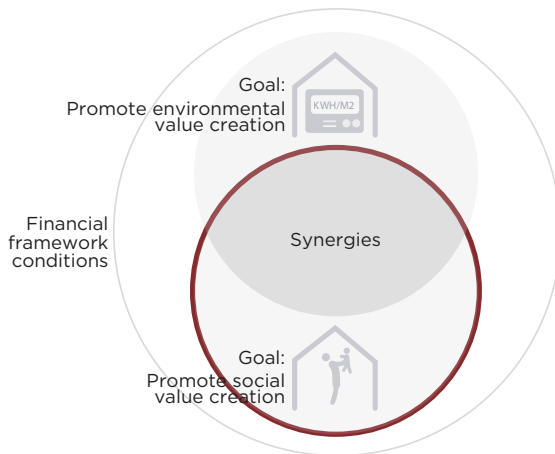
Further, when discussing how to promote environmental value creation through renovation, it is relevant to apply a life cycle perspective. This is a way to quantify the potential reduced environmental impact (including operational energy savings) in comparison with the en-

vironmental cost of the renovation and thereby give a fuller picture of the environmental value creation.

In other words, it does not make the focus on operational energy savings less relevant but illustrates that targeting operational energy savings is only part of the solution. Figure 7 illustrates how renovation contributes to the overall life cycle of the building (based on Nygaard Rasmussen and Birgisdóttir 2015). When performing renovation, the building is altered to prolong its lifespan and thus reduce the need for demolishing and building new buildings. Research shows that renovation is, generally speaking, an environmentally friendly alternative to building from new, due to savings in embodied energy (Sørensen and Mattson 2020; Nygaard Rasmussen and Birgisdóttir 2015). For the same reason, attention should be paid to upcycling and recycling and new life cycles when replacing materials during the renovation in order to reduce the environmental impact from a life cycle perspective (Kanafani et al. 2021; Petersen et al. 2021).

In light of the above, the term ‘environmental value creation’ is used to denote all efforts to manage the existing resources in the most efficient way, but with a focus on operational ‘energy savings’ in order to delimitate the study.





**Figure 8** In terms of social value, the thesis focuses on promoting the well-being of the resident.

### SOCIAL VALUE - RESIDENT WELL-BEING IN THE BUILT ENVIRONMENT

The previous section outlined the understanding of environmental value creation in this thesis and the focus on implementing operational energy savings through renovation.

The thesis argues that efforts to reduce the environmental impact of buildings should go hand in hand with attention to social value creation to promote more holistically sustainable renovation solutions. However, what is meant by social value in the context of this thesis?

In order to clarify this, attention is turned once again to the concept of sustainability.

Despite the wide prevalence of the three-pillar sustainability model emanating from the 1987 Brundtland report, contemporary researchers state that the social pillar remains poorly defined (for instance, Peters 2016; Stender and Walter 2019; Dempsey et al. 2011). The present thesis adopts the understanding of social sustainability in the built environment put forward by Woodcraft and colleagues as *“a process for creating sustainable, successful places that promote well-being, by understanding what people need from the places they live and work. Social sustainability combines design of the physical realm with design of the social world”* (Woodcraft et al. 2012, p. 16).

In the context of this thesis, the focus will thus be on *promoting well-being* as a value by investigating and communicating to practitioners what people *need* from the places in which they live. To be more specific, the focus will be on promoting the well-being of the residents (existing or new ones) in MSH dwellings which are undergoing renovation (Figure 8).

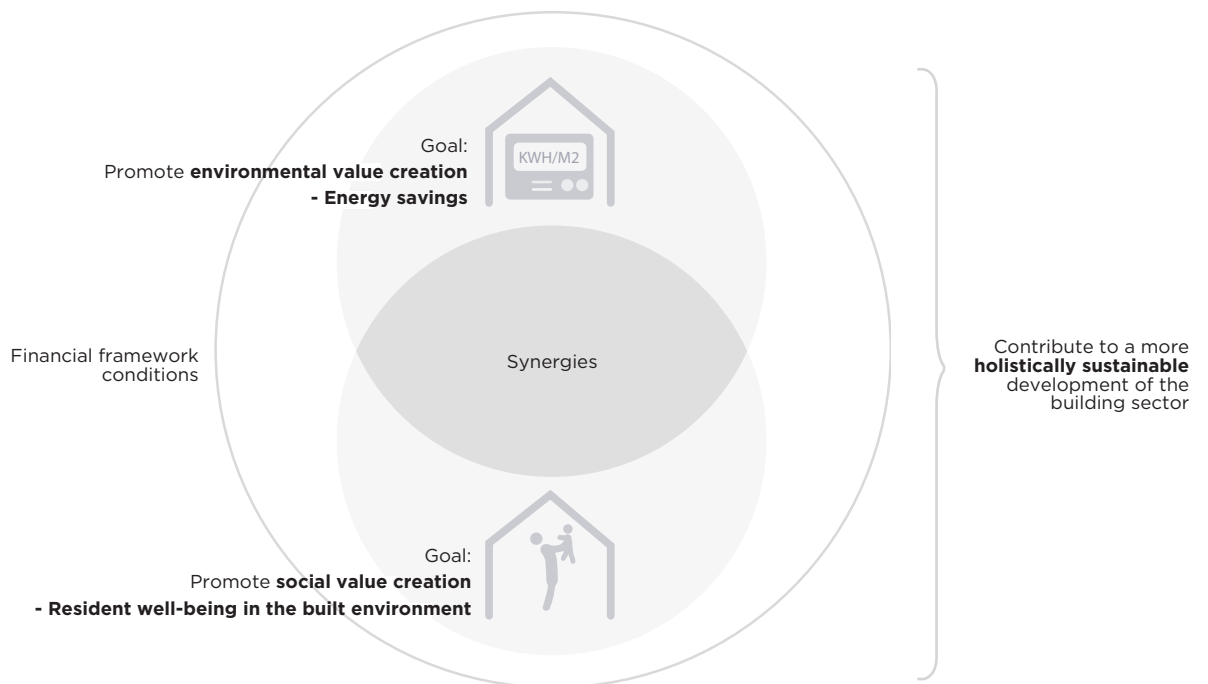
In the thesis, the efforts to promote residents' well-being are addressed relative to the environmental challenge of implementing energy savings in existing buildings.

‘Part 3: Articulation’ includes an introduction to different definitions of the term “well-being” and how this thesis relates to these existing understandings.

#### Summary

The previous section has included an introduction to key terms in the thesis. In summary, the thesis focuses on synergies between environmental value (focusing on energy savings) and social value (focusing on promoting resident well-being) in the sustainable renovation of multi-family social housing. The underlying assumption of this thesis is that by promoting such synergies, architects can contribute to a more holistically sustainable development in the building sector (Figure 9).





**Figure 9** Summary of key terms used in the thesis: The thesis is based on the assumption that attention to positive synergies between **environmental value creation** (in terms of **energy savings**) and **social value creation** (in terms of **resident well-being**) in renovation of MSH can contribute to a more holistically sustainable development of the building sector - and, therethrough, the overall societal goal of sustainability.

The section includes a development of the published paper “Towards a Holistic Approach to Retrofitting: A Critical Review of State-of-the-art Evaluation Methodologies for Architectural Transformation” (Jensen et al. 2017a). The text and figures have been edited to form a coherent part of the thesis and more frameworks have been added to the analysis.

# Existing initiatives

The previous sections included a brief introduction to the context of social housing renovation and the framework conditions associated with such renovations. After that, a clarification of key concepts followed.

This section is devoted to an introduction to existing initiatives relevant to supporting the architect’s role as a promoter of energy savings and resident well-being in the early design stages.

Firstly, the section presents an analysis of existing frameworks which can be applied in the interdisciplinary process. By ‘frameworks,’ the thesis refers broadly to tools and guidelines, relevant to assessing the value of renovation alternatives. Thereafter, the subsequent section provides an introduction to additional existing research which point towards new approaches not (yet) translated into assessment frameworks.

The existing initiatives will be evaluated with attention to environmental and social value creation. The subsequent synthesis narrows the discussion to energy savings and resident well-being in the built environment.

## EXISTING FRAMEWORKS

As mentioned before, renovations of MSH are complex. They need to consider multiple criteria, involve stakeholders across a broad spectrum of disciplines, and affect the lives of a large number of residents with different needs. In interdisciplinary renovation projects, the involved people bring different understandings of value into the project and judge design alternatives as well as the outcome according to this understanding (Beim and Stylsvig Madsen 2015; Kamari 2018). Several frameworks have been developed to navigate this complexity and push the development of the building sector (including renovation) in a more sustainable direction (Zimmermann and Birgisdóttir 2018).

In order to be able to answer the initial research question, it is relevant to understand if and how existing frameworks contribute to supporting the architect’s role as a promoter of joint environmental and social value creation in the early stages of interdisciplinary renovation design processes.

The review of existing frameworks was originally carried out in the initial phases of the PhD project and included seven assessment frameworks. The findings were presented in the paper “Towards a Holistic Approach

to Retrofitting: A Critical Review of State-of-the-art Evaluation Methodologies for Architectural Transformation” at the World Sustainable Built conference in Hong Kong 2017 (Jensen et al. 2017a). The study included the following frameworks:

- SAVE
- Evaluering af kvalitet i boligbyggeri [Evaluation of quality in housings]
- AktivHus [ActiveHouse]
- Totalværdi-modellen [the Total value model]
- DGNB
- Arkitektur, Energi, Renovering [Architecture, Energy, Renovation]
- RENO-EVALUE

Since the original study in 2017, the following schemes have been added to the review to update and extend the study:

- Arkitektur & Energirenovering
- DGNB Diamant [Diamond]
- DGNB Hjerte [Heart]
- WELL
- Trygt og skønt boligområde – en designguide til social bæredygtighed [Safe and lovely residential area – a design guide for social sustainability]
- E-SAVE
- Sociale Renoveringer [Social renovations]
- REDIS
- Den frivillige bæredygtighedsklasse
- IK-Kompas

The frameworks have been included due to their relevance to the renovation of Danish MSH and include environmental and/or social concerns. Some frameworks span both environmental and social concerns. Others are more delimited. E.g., the SAVE- and WELL-systems as well as Trygt og Skønt boligområde and Sociale renoveringer are included even if they do not include explicit environmental themes because they serve to nuance the discussion when it comes to social value creation. The WELL scheme is not widely used in a Danish context; however, it is found relevant due to its focus on social value creation. Not all of the reviewed frameworks target renovation initiatives directly. However, they do include such projects as part of their scheme.

The approach of the literature review was to identify sub-themes in the frameworks which relate to environmental and social value creation, respectively. Thereafter,

to make a synthesis of the findings. The findings were communicated through a diagram (Table 3 on page 30) and a timeline, indicating where in the renovation process the given framework is likely to be applied. Special attention was paid to social aspects and to what extent each framework addresses the implications of environmentally motivated renovation on social aspects or vice versa.

### **Evaluering af kvalitet i boligbyggerier [Evaluation of quality in housing]**

The framework was developed by the Danish Building Research Institute (SBI) in 2000 for the Ministry of Housing and Urban Affairs. The framework focused on residential buildings and aimed to provide a holistic tool for evaluating the condition and quality of residential buildings, focusing on both qualitative and quantitative indicators (SBI 2000; Beim and Stylsvig Madsen 2015). Each of the six included themes are evaluated in relation to four different scales in the building and through different methodologies, described as part of the concept. The framework includes attention to both environmental and social concerns. In terms of social value, the framework includes attention to occupant satisfaction, architecture, and indoor climate. The framework also includes attention to more qualitative experiential aspects under the headline 'architectural quality', which is to be evaluated by an expert panel. Under the headline of 'architectural quality', the framework lists suggestions for architectural quality parameters: Aesthetics, Comfort and indoor climate, Function, Spatiality and plan layout, and Extent and disposition, with each their sub-themes. As such, there is a well-articulated attention to softer aspects of architectural quality; however, at present, the framework focuses on the existing buildings rather than new initiatives (SBI, 2000) and may be considered 'heavy' in use due to the richness of data (Beim and Stylsvig Madsen 2015).

### **Arkitektur & Energirenovering [Architecture and Energy renovation]**

Arkitektur & Energirenovering was developed in 2011 by Kuben Management A/S, The Royal Danish Academy of Fine Arts, School of Architecture, Esbensen Consulting Engineers, and the Danish Architecture Centre. The framework focuses on energy renovation of multi-family housing from 1920 to 1960 made of brick. In terms of environmental value, the publication focused on energy

savings. In terms of social value creation, the publication focused on cultural heritage concerns. Further, the publication briefly mentioned the value of certain renovation measures over others in terms of limiting nuisances for the residents during the renovation process, as well as potentials for improving the indoor climate and lower household expenses for heating (Smidt-Jensen and Nørgaard 2011). The framework presented typical energy renovation measures, best-practice examples of working with energy optimization in brick buildings, and discussed the challenges and potentials of doing so. Further, the framework presented a simple way of visualizing the span of possibilities depending on the level of cultural heritage value.

Though the framework had a delimited focus on brick buildings from 1920-1960, the way of communicating energy-related aspects alongside aspects related to well-being may be valuable when assessing different design alternatives in the early stages.



### **AktivHus [ActiveHouse]**

AktivHus is a national initiative from 2015, based on the international ActiveHouse principles. The framework was intended as a design strategy and certification tool (Table 4). It targets new buildings as well as renovation projects (AktivHus Danmark 2015). There is a visible focus on environmental indicators. Social aspects here are limited to "comfort," through attention to daylight, thermal environment, indoor air quality, and acoustic quality (Table 3). The framework includes quantitative and qualitative assessment, the latter through yes/no questions and argumentation (ActiveHouse 2020).

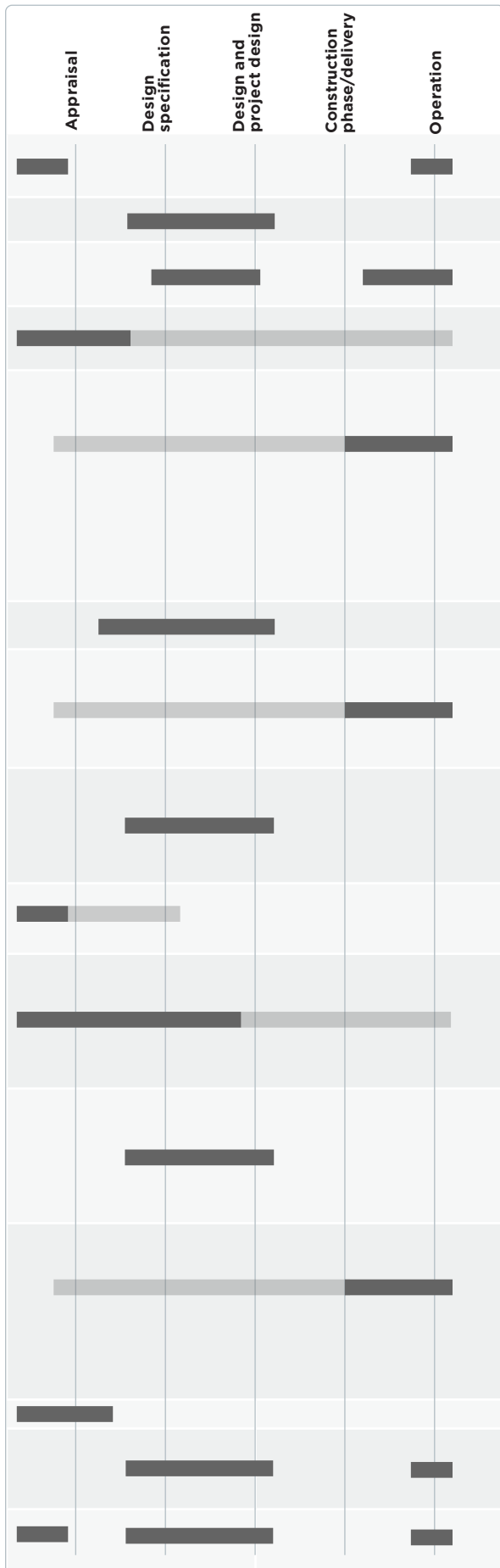
### **Totalværdi-modellen [total value model]**

Totalværdi-modellen was developed in 2012 by a partnership of local authorities and consultancy companies called Plan C. The framework focused on process management in the initial stage of an interdisciplinary renovation project rather than the comparison of specific design solutions. Totalværdi-modellen does not contain an absolute weighting system. Rather, it provides a digital framework with templates. The format of the framework potentially helps the stakeholders point out and articulate indicators as a sort of "checklist," including both quantitative and qualitative considerations. However, it is up to the stakeholders to set objectives for assessing design solutions in later phases. The framework includes both environmental and social themes as part of its

**Table 3** Listing of main themes in each framework relative to environmental or social concerns. The frameworks are listed according to their year of publication/development (newest framework at the bottom) except for DGNB Heart, which is listed with DGNB-DK.

	 <b>Environmental</b>		 <b>Social</b>	
<b>Evaluering af kvalitet i boligbyggeri</b>	Building technology Environmental impact		Occupant satisfaction Architecture Indoor climate	
<b>Arkitektur &amp; Energirenovering</b>	Energy saving		Cultural heritage	
<b>AktivHus</b>	Energy demand Energy supply Primary energy performance	Sustainable construction Freshwater consumption	Daylight Thermal environment	Indoor air quality Acoustic quality
<b>Totalværdimodellen</b>	Reductions in energy consumption	Protecting the environment Involve client strategies	Improved working conditions Indoor climate	Lifting the architectural quality Demography
<b>DGNB- DK (Themes included in the DGNB Hjerter are marked with*)</b>	Life cycle assessment Environmentally dangerous substances Responsible extraction of resources Consumption of drinking water and wastewater discharge	Area use Bio diversity Sustainability in tender Dismantling and reuse Documentation of environmental product declarations	Thermal comfort* Indoor air quality* Acoustic indoor climate* Visual comfort* Quality of outdoor areas* Universal design* Documentation for quality in the execution* Environmentally dangerous substances* Biodiversity* Flexibility* Robustness*	Building integrated art Plan layout* Fire safety and security Access to facilities in the local area* Communication with users* Procedure for architectural quality* Quality of the thermal envelope* Design for maintainance and cleaning* Local environment* Mobility infrastructure*
<b>Arkitektur, Energi, Renovering</b>	Energy saving		Functional value Architectural value	Indoor climate Daylight
<b>WELL</b>	Indirect environmental benefits from social themes, e.g., thermal comfort and attention to harmful substances.		Air Water Nourishment Light Movement Thermal comfort	Sound Materials Mind Community Innovation
<b>Trygt og skønt boligområde</b>			City fabric Scale Scale in exterior Zoning Threshold Ownership	Crime prevention Lighting Planting Architectural quality Temporality
<b>E-SAVE</b>	Energy		Architectural value Culture-historical value	Environmental value (import. of the building for its surroundings in terms of creating an entirety) Originality
<b>RENO-EVALUE</b>	Local discharge of water Water consumption Reuse of water Energy consumption Renewable energy production	Amount of waste Reuse of waste Reuse of building Materials Pollution CO2 emission	Architecture and aesthetics Function and usability Indoor climate and comfort Well-functioning estate Attractive area	Desirable dwelling Reasonable rent Collaboration between partners Mutual information Involvement of users Considerations for users during construction
<b>Sociale Renoveringer</b>			Flexibility and accessibility Room for guests Varied dwelling types Common access roads Openness in facade Exterior elements in facade Threshold on ground floor	Architectural identity Semi-private outdoor areas Semi-public outdoor areas Common facilities Common gardens Strengthen social relations through the renovation process
<b>DGNB Diamant</b>	Lasting materials Materials, patina, colors, and ornamentation contribute to extending the building's life span  (see under DGNB-DK)		Spatial connections to surroundings Identity and cultural values of the place Strengthens experiential qualities in its surroundings Multiple settings for social relations Fully develops intentions of brief Transparency in lasting/changeable materials	Experiential qualities through space, construction, and materials Detailing strengthens spatial qualities Solutions are easy to use Materials, patina, colors, and ornamentation contribute to social appreciation of the building Technical solutions reflect the construction and the building culture
<b>REDIS</b>	Flexible criteria should be identified by the user(s)		Flexible criteria should be identified by the user(s)	
<b>Frivillige bæredygtighedsklasse</b>	LCA Resources at the building site		Problematic substances Degassing to the interior Daylight	Noise from ventilation systems Room acoustics Maintainance plan for indoor climate
<b>IK-Kompas</b>			Acoustic indoor climate Atmospheric indoor climate	Thermal indoor climate Visual indoor climate

**Table 4** Timeline indicating when in the process the framework is likely to be used.



scheme, the latter including attention to indoor climate, improved working conditions, demography, and “lifting the architecture” (Table 3). However, especially the latter is not further elaborated (Schunck et al. 2011).

#### DGNB-DK

The DGNB-DK framework is a Danish version of the German DGNB tool, adapted to Danish building customs and the Danish regulatory framework by Green Building Council Denmark in 2012. The purpose of the framework was to secure quantifiable standards, making it possible to certify buildings based on a “scoring system” (Table 4), where the project can be assigned DGNB silver, gold, or platinum certification. The system is based primarily on quantitative measures, a checklist approach to the “softer” indicators, and a few qualitative indicators. The framework referred to in this analysis targets new buildings and extensive renovations (DK-GBC 2020). It includes a number of themes related to both environmental and social concerns, listed in Table 3.

#### Arkitektur, Energi, Renovering [Architecture, Energy, Renovation]

The framework was developed in 2013 by the Danish Building Research Institute, Aalborg University, in collaboration with Henning Larsen Architects. The aim was to create a design guide for architects and engineers for the early design phases. The guide was based on the understanding that a holistic approach to renovation in terms of energy, daylight, and indoor climate should also provide added functional, architectural, and/or financial value. The guide is divided into three typologies: single-family houses, multi-story dwellings, and offices. It provides simple tools, suggestions for strategies, and cases, which exemplify ‘added value’ (Marsh et al. 2013). The framework includes both environmental and social themes. However, when it comes to some of the more “soft” well-being themes, e.g., “improved spatiality,” the recommendations appear to be less explicit (Hvejsel et al. 2015; Marsh et al. 2013).

#### WELL

WELL is a certification scheme created by the International WELL Building Institute, USA. Based on a point system, a building project (including renovations) can receive a Silver, Gold, or Platinum ranking (Jensen et al. 2018). The WELL Scheme includes multi-family residential projects as part of its scheme (IWBI 2021). So far, the framework has only been used in a limited number of projects in Denmark. However, it is included here due to

its elaborate focus on social concerns and, therefore, a potential to challenge or synergize with schemes used in Denmark. The framework does not include explicit attention to environmental value creation; however, e.g., reducing harmful substances is important from an environmental perspective.

As with DGNB and Active House, the WELL framework is intended as a certification scheme (Table 4). Further, to maintain the certification, the project must adhere to ongoing requirements (Jensen et al. 2018).

#### **Trygt og skønt boligområde - en designguide til social bæredygtighed [Safe and delightful residential area - a designguide for social sustainability]**

The framework was developed by Niels Bjørn for the Municipality of Copenhagen in 2014 (Almene Boliger 2014). Based on literary references, the design guide offers 'hands-on' examples of promoting social sustainability through the built environment, which appears to be useful when seeking to increase attention to resident well-being in the early design phases. The guide focuses on multi-family residential housing and is thereby in line with the scope of this thesis. As with the WELL certification scheme, this framework deals primarily with social concerns, and the guide offers no explicit account of links to environmental concerns.

#### **E-SAVE**

E-SAVE is a development of the framework SAVE (Survey of Architectural Values in the Environment). The original SAVE framework was developed in Denmark in the late 1980s and is now administered by Slots - og Kulturstyrelsen (Beim and Stylsvig Madsen 2015; Kulturarvsstyrelsen 2011). The purpose of the SAVE framework was to assess the level of preservation value in (existing) buildings or urban environments (Kulturarvsstyrelsen 2011). The framework has a clear focus on culture-historical aspects but does not articulate the influence on resident well-being explicitly. The SAVE framework only has limited attention to environmental value (Beim and Stylsvig Madsen 2015; Kulturarvsstyrelsen 2011); however, a development of the framework from 2015, called E-save (Dahl et al. 2015), aimed to *"...ease handling of cases by the municipality, when a building owner wishes to (energy)renovate a residential building worthy of preservation"* (Dahl et al. 2015, p. 7, translation by author). The E-SAVE framework includes guidelines and knowledge on the challenges and potentials of incorporating different energy renovation measures.

#### **RENO-EVALUE**

RENO-EVALUE was developed by Centre for Facility Management at the Technical University of Denmark (Jensen and Maslesa 2015). The main purpose was to provide a process tool that can identify each stakeholder's priorities and help establish common criteria for success in the early phases of large-scale renovation projects (Jensen and Maslesa 2013). Further, it can be used for *"...evaluation during and after building renovation projects"* (Jensen and Maslesa 2015, Highlights). It includes a weighting system based on the stakeholders' subjective evaluation. The framework includes both environmental and social concerns. Attention to resident well-being (Table 3) spans themes such as Indoor climate and comfort, Involvement of users, Reasonable rent, and Attractive area; the latter is addressed through a so-called "architectural upgrading" not further elaborated upon (Jensen and Maslesa 2015).

#### **Sociale renoveringer - Hvordan skaber vi sociale renoveringer, der forebygger ensomhed? [Social renovation - How do we create social renovations, which prevent loneliness?]**

The inspirational catalog was published in 2017 as part of the initiative "Social Renovations," with a webpage as its primary communication platform. The catalog itself introduced four "themes": the dwelling, the thresholds [kantzoner], common areas, and connection to surrounding areas. Based on the themes, the publication presented inspirational cases for promoting interaction between people, particularly older people (above 65). The publication was based on experiences from different renovations of social housing dwellings and interviews in two housing areas. The themes and cases are potentially useful in the early design stages.

The catalog focuses on social aspects related to preventing loneliness and only briefly mentions that energy optimization of the façade is an opportunity to consider how, e.g., the threshold area between interior and exterior, may better support everyday life (Rambøll Arkitekter 2017).

#### **DGNB Diamant [DGNB Diamond]**

The DGNB framework has been criticized for lacking attention to architectural quality (e.g., in Beim and Stylsvig Madsen 2015). In 2018, this was addressed by implementing the so-called "DGNB Diamond"-framework. With reference to Vitruvius and by looking at the project at three different scales, the framework addresses nine



different themes (Table 3) (DK-GBC 2020).

The 'diamond' scheme is based on a qualitative, two-phased peer review of the project (A) during the process and (B) of the completed project (DK-GBC 2019). For now, the DGNB-diamond scheme is an 'add-on' and not integrated into the core framework. The Diamond certification does, however, give access to the 'bonus points' in the core framework (DK-GBC 2020). This "detachment" can be seen as a shortcoming when aiming for a holistic understanding of sustainability. The majority of themes in the DGNB diamond scheme are allocated to the social column in Table 3. This allocation is based on a preconception that attention to the themes will contribute to resident well-being (further addressed as part of the synthesis). However, attention to, e.g., lasting materials, can be seen as contributing to environmental value creation.

#### **DGNB Hjerte [DGNB Heart]**

DGNB Hjerte was introduced in 2020 to reward extraordinary efforts concerning indoor climate, health, and well-being (DK-GBC 2020). The certification is achieved by meeting the so-called Heart indicators related to the criteria marked with \* under DGNB in Table 3. As with the main DGNB scheme, the DGNB Hjerte framework focuses on quantitative measures and a checklist approach to the "softer" indicators, e.g., the theme "Procedure for architectural quality," which is evaluated by, for example, 'ticking off' that an architectural competition has been completed and that the winning proposal is actually implemented in the project.

(Note: the author participated in an industry workshop as part of the development of DGNB Heart).

#### **REDIS**

REDIS is a decision support tool targeting renovation. It was developed by Anne Nørkjær Gade in 2018 as a part of her PhD project in collaboration between University College of Northern Denmark, the Department of Energy and Environment, and Aalborg University, Department of Civil Engineering (Gade 2018). The framework is divided into the REDIS Dialogue tool and the REDIS Prioritization tool (focusing on prioritization within a portfolio) (Gade et al. 2018).

The framework is intended for use in the pre-design stages: "*REDIS provides a framework for dialogue in the pre-design stage of renovation projects, and calculates a Renovation Value Factor for each building, based on a number of criteria weights, building status data and*

*estimated renovation costs, indicating which buildings give the building owner most value for money if renovated*" (Gade et al. 2018, abstract).

The weighting is done qualitatively by the user(s). The REDIS Dialogue tool provides a flexible framework for entering criteria rather than providing a fixed set of criteria (Gade et al. 2018).

The REDIS tool focuses on dialogue and prioritization rather than the assessment of renovation alternatives. So far, the tool has only been applied in demonstration projects as part of the PhD-study, focusing on school projects (Gade et al. 2018). As such, the applicability for multi-family residential buildings is yet to be tested.

#### **Den frivillige bæredygtighedsklasse [the Volunteer sustainability class]**

The ambition of the recent volunteer sustainability class was to define and offer a readily accessible and consistent basis for constructing sustainable buildings. The framework will undergo a two-year test period, whereafter elements are expected to be implemented in the national building regulations.

The framework includes attention to both environmental and social value creation (Table 3) through nine themes, which (when dealing with dwellings) must all be complied with in order to meet the volunteer sustainability class. Social value creation is primarily addressed through attention to indoor climate (Danish Transport Construction and Housing Authority 2020).

#### **IK kompas [The IC compass]**

The IK kompas was developed as part of the project ReBUS, in a collaboration between Aalborg University, Danish Technological Institute, and industry partners. The framework was intended as a tool for evaluating the indoor climate and targets the renovation of multi-family housing (Larsen et al. 2021). It focuses on resident well-being through attention to the following aspects of indoor climate: thermal, acoustic, atmospheric, and visual indoor climate, and the users' possibilities for adjusting the indoor climate. The tool calculates a building's potential for a good indoor climate based on a total score and indicated by a so-called IndeklimaKvalitet [Indoor climate quality] with an assigned letter on a scale from A-G. The tool can be used to evaluate the indoor climate in existing buildings, when designing a new building, or to compare the indoor climate before and after renovation (Larsen et al. 2021). Environmental concerns are not an explicit part of the framework.

## Synthesis

This section is devoted to a synthesis of the findings of the review. Whereas the review has applied a broad approach to environmental and social value creation, this synthesis will focus on the delimited themes of energy savings and resident well-being.

The written summary is supplemented with Figure 10 on page 35. In Figure 10, the existing frameworks are positioned in a graphical 'landscape' in order to provide an overview over the width of their scopes and placement on the timeline for a renovation project. Vertically, the frameworks are positioned spanning from a delimited focus to frameworks including both attention to energy savings and resident well-being. Horizontally, the frameworks are listed according to what stage(s) in the renovation process they are targeting, with the left side representing frameworks which focus on the evaluation of the existing building, and the right side focusing on completed renovations and process-related tools (focusing on the early phases) allocated to the center of the axis.

### *Joint or delimited focus*

On a general level, the review confirms that the frameworks focus on different indicators. As shown in Figure 10, e.g., WELL, 'Safe and delightful residential area,' IK-kompas, and 'Social renovations' have more delimited focuses on well-being in the built environment. Especially the 'Safe and delightful residential area'- and 'Social renovations'-frameworks provide valuable 'hands-on' suggestions for how to design for increased well-being in the context of multi-family residential areas. However, the two frameworks are not coupled with environmental concerns.

The remaining frameworks have a more even distribution of themes across concerns related to resident well-being in the built environment and energy savings.

### *Early-stage process tool?*

Looking closer at the frameworks, which include attention to both energy savings and well-being, it is seen that the frameworks are likely to be used at very different stages (Table 4 on page 31). The Total Value Model and RENO-EVALUE frameworks are intended as dialogue and process management tools in the initial stage of an interdisciplinary renovation project, rather than comparing specific design alternatives. The REDIS tool builds on the same line of thought, however with specific attention to prioritization between building portfolios before renovation. The framework 'Evaluation of quality in housing' includes an elaborate setup for addressing

both quantitative and qualitative social aspects. However, the framework has not gained currency, perhaps due to the complexity in use (Beim and Stylsvig Madsen 2015). Further, in the context of this thesis, it is relevant to note that the framework is intended for evaluating the quality of existing buildings or completed renovations rather than assessing renovation alternatives as part of the interdisciplinary, creative process.

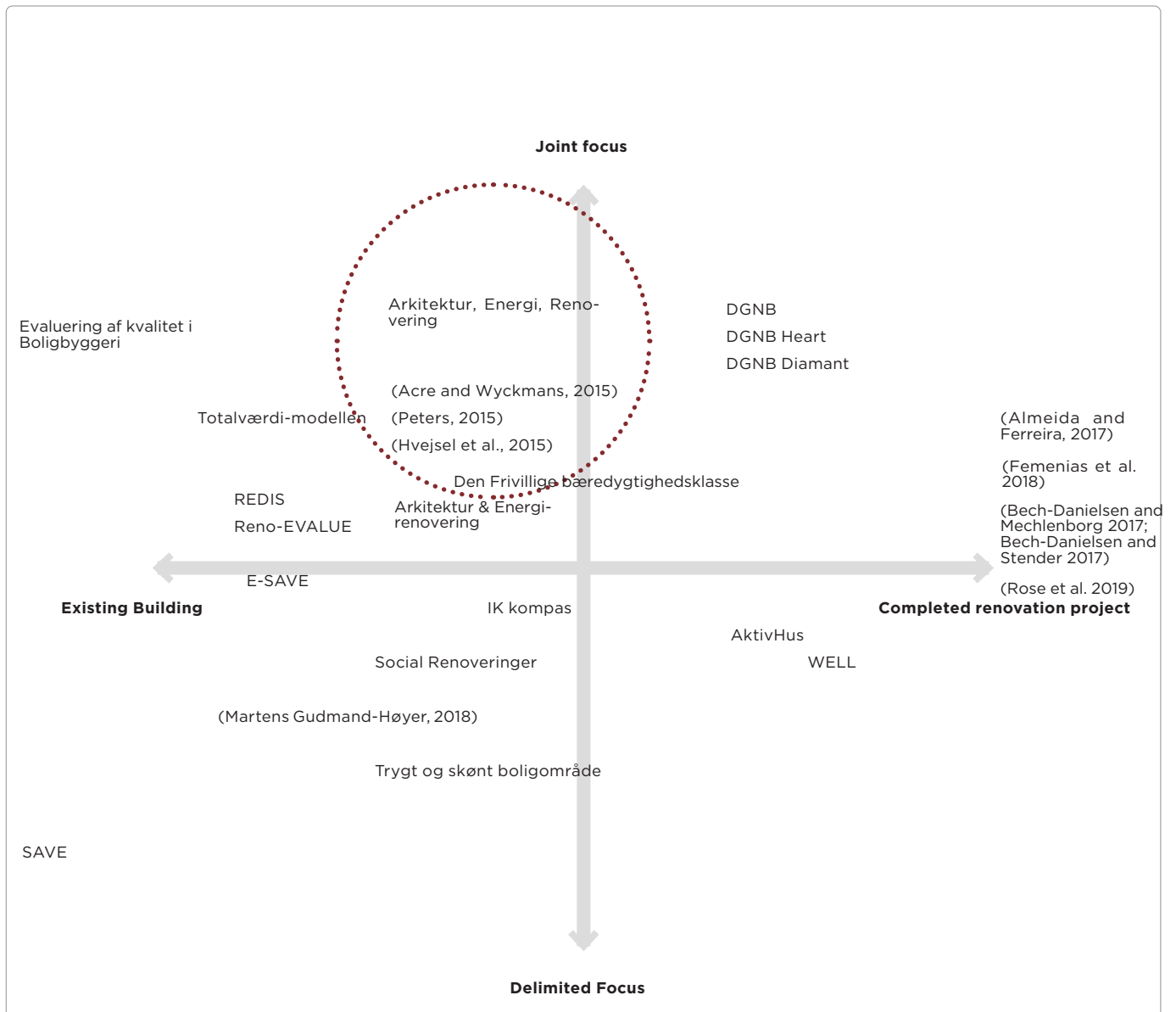
DGNB is also ranked in Figure 10 as an example of a framework that includes attention to both energy savings and resident well-being. The new initiatives under the Green Building Council, the DGNB Diamond, and DGNB Heart may further strengthen well-being aspects. However, the rather elaborate setup in DGNB can be viewed as less operational in the initial phases of a design process. The framework "Architecture, Energy, Renovation", on the other hand, is more readily accessible in the early stages of a project. The format is a hands-on guide for practicing consultants on how to work simultaneously with energy savings and resident well-being. It offers explicit guidance for "hard," quantitative themes such as energy performance and indoor climate but for evaluation of the more "soft," qualitative themes like "improved spatiality," the publication offers minimal guidelines. As such, it could be developed further to include more explicit strategies for addressing aspects related to spatial quality and related potentials for increased resident well-being.

Based on the study, there thus seems to be a challenge in the existing frameworks when it comes to supporting efforts to promote both energy savings and resident well-being in the early design phases of a renovation process when alternative renovation scenarios are developed and evaluated.

### *Means or End?*

As depicted in Table 3 on page 30, the "nature" of the included themes is very different; some frameworks explicitly refer to aspects of resident well-being, e.g., "thermal comfort" in the AktivHus framework (AktivHus Danmark 2015). In other cases, the themes can be considered implicit "means" to promote well-being, e.g. "Plan layout & Materials" in DGNB Diamond (DK-GBC 2020; DK-GBC 2019) or cultural heritage in SAVE (Kulturarvsstyrelsen 2011; Smidt-Jensen and Nørgaard 2011). Some frameworks include both "levels" and have a clear distinction between means and end. E.g., "Sociale renoveringer" focuses on supporting social interaction through a number of architectural means, hereunder accessibility and common gardens (Rambøll Arkitekter 2017).





**Figure 10** Graphical 'landscape' with the reviewed existing initiatives positioned relative to a timeline (horizontally) and to what degree they address both social and environmental value creation. The dotted circle indicates how the present thesis positions itself relative to existing initiatives.

Cultural heritage themes are included in Table 3 under social themes, e.g., in relation to E-SAVE and Arkitektur & Energirenovering, even if the frameworks do not account explicitly for the influence on residents' well-being. However, cultural heritage has previously been articulated as influential to a human sense of identity or sense of belonging and is subsequently considered highly relevant for the present thesis (Petersen et al. 2021; Femenias et al. 2018; ICOMOS 1994).

Some frameworks broadly refer to "spatial" or "architectural" quality/value or "improved spatiality" (e.g., Marsh et al. 2013; DK-GBC 2019; DK-GBC 2020). Like cultural heritage themes, these themes are included in the account of social themes in Table 3, due to the architectural basis of this thesis and an implicit, tacit understanding that such efforts would lead to improved well-being.

The mentioning of "spatial" or "architectural" quality may reflect a holistic approach implicit in the architectural field (Nygaard 2002) and be a way to articulate the importance of "softer" experiential aspects while respecting the creative dimension. However, the use of these broader terms seems less operational when aiming to visualize the potential joint environmental and social impact of renovation measures as part of interdisciplinary assessments.

#### *"Soft" well-being themes*

Well-being themes related to indoor comfort appear to have found their way into several frameworks alongside energy concerns. This is the case in, e.g., Den frivillige bæredygtighedsklasse, DGNB Hjerte and AktivHus. However, thermal comfort still takes center stage. 'Softer' themes related to resident well-being seem difficult to explicate (and quantify?), and maybe therefore difficult to 'operationalize' as a part of the frameworks on equal terms as, e.g., thermal comfort or energy consumption. As such, the findings of this review indicate a gap in the existing frameworks.

This indication is in line with the main findings of the report *"Værdiskabelse i bygningsrenovering"* (value creation in building renovation) by the Centre for Industrialized Architecture in Copenhagen. In the report, Beim and Stylsvig Madsen highlighted an apparent emphasis on technical, quantifiable values and advocate a need to include qualitative socio-cultural values in future evaluations to secure a holistic approach (Beim and Stylsvig Madsen 2015). To sum up the challenge at hand, 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"* (Beim and Stylsvig Madsen 2015, p. 39, translation by author).

#### **Summary**

To summarize, this section has included a review of existing frameworks that are found relevant for supporting the architect's role as a promoter of joint environmental and social value creation in the early stages of interdisciplinary renovation design processes. From the review of frameworks, it is seen that only a few frameworks address both energy savings and resident well-being. The following challenges are identified in relation to those who do: In some cases, the complexity of the frameworks makes it difficult to apply them as early-stage process tools for assessing alternative design scenarios. Further, the review of frameworks has pointed to an ambiguity between 'means' and 'end,' relevant when addressing the *impact* of renovation measures on energy performance and resident well-being.

Not least, there is a tendency to emphasize quantifiable well-being themes, such as thermal comfort. It appears challenging to collect and visualize how renovation measures may influence softer aspects of resident well-being. The following section includes an introduction to additional existing research initiatives related to the challenge of supporting the architect's role as a promoter of joint environmental and social value creation in the early stages of interdisciplinary renovation design processes.

#### **ADDITIONAL RESEARCH INITIATIVES**

This section includes an introduction to additional research initiatives related to the subject of this thesis. The included references are plotted into the graphical landscape in Figure 10 on page 35 next to the studied frameworks.

They are included because they represent different professions and methodologies, reflecting the interdisciplinary character of the problem field. Furthermore, they present some sort of approach for communicating the joint social and environmental value creation, not yet translated into a readily applicable framework.

Martens Gudmand-Høyer (2018) addressed how cultural values are managed in the renovation of social housing, e.g., when faced with dilemmas related to energy optimization. She suggested that valuation of the cultural value should be introduced as a standard part of the renovation process before the hand-in of the schema A-application. She further suggested that it should be mandatory for architectural consultants to explicitly express their strategies towards cultural value when participating in larger competitions for the renovation of social housing (Martens Gudmand-Høyer 2018). In this manner, culture-historical concerns could become a more integrated part of interdisciplinary discussions.

This section includes a developed account of state-of-the-art research previously published as part of the paper "Potentials for increasing resident wellbeing in energy renovation of multifamily social housing" (Jensen et al. 2021). The paper is accounted for in more depth in relation to the empirical studies (Objective 2).

Peters (2015) investigated architectural strategies for transforming modern housing and came closer to recommendations for future renovations. She advocated that renovations should consider the three following aspects: 'improved daylight conditions,' 'improved or new spatial experiences,' and 'reconsideration of the connection to the outdoors' (Peters 2015). Her research offered best practice examples of how to work with these themes alongside other sustainability goals, providing a valuable palette of inspiration for the future renovation of postwar social housing. However, the themes related to 'improved or new spatial experiences' are still quite diffuse and therefore seem difficult to operationalize directly in interdisciplinary assessments alongside quantitative parameters. Nevertheless, they serve as a valuable starting point for the present research.

Acre and Wyckmans (2014, 2015) went further in creating a more explicit framework. They did this by suggesting so-called 'spatial quality determinants' and establishing a checklist for evaluating how these determinants are influenced by different (energy) renovation measures (Acre and Wyckmans 2015; Acre and Wyckmans 2014). The idea of a checklist is in line with the principles of, e.g., DGNB; however, the work by Acre and Wyckmans targeted (energy) renovation of residential buildings more specifically, which can be seen as an advantage in the context of the present thesis.

Acre and Wyckmans went as far as to set up 'rules' for formal aspects, which may instigate discussions about whether we risk reducing the complexity of the architectural field to a matter of checkboxes in the attempt to support an equal trade-off between technical and socio-cultural concerns. E.g., Kirstine Brøgger Jensen stated that *"...it is a widespread notion that AQ [architectural quality] cannot be put into formulas"* (Jensen 2015, p. 102). As such, the level of meaningful objectification/quantification will be addressed in the thesis.

As a common denominator, the research mentioned in the paragraph above did not account explicitly for the added social value (in terms of resident well-being) of alternative renovation measures due to the spatial changes they trigger.

Hvejsel et al. addressed this from an architectural theoretical perspective. They took a first step in articulating the spatial implications of the energy-motivated renovation based on tectonic architectural theory as an analytical framework (Hvejsel et al. 2015).

The idea of articulating added social value also has a stronger presence in follow-up-studies/post-occupancy evaluation-studies, e.g., the work of Bech-Danielsen and colleagues. They evaluated the quality of completed

physical renovations of postwar social housing, based on literature reviews, physical registration and documentation, interviews with consultants and housing associations, as well as focus group interviews with residents (Bech-Danielsen and Mechlenborg 2017; Bech-Danielsen and Stender 2017). The researchers addressed physical measures under the themes: Integration in the city, Architectural diversity, New types of dwellings, Scaling down and dwelling improvements, Safety, Façade renovation, Outdoor spaces, Energy optimization, and Indoor climate (Bech-Danielsen and Mechlenborg 2017). This provided a valuable insight into the interrelation between environmental and social concerns in completed projects.

Whereas Bech-Danielsen et al. took an architectural/anthropological point of departure – and mentioned energy as a sub-theme to the overall renovation effort – research related to the so-called Annex 56-project (Almeida and Ferreira 2017) put energy in the center and pointed to potential 'co-benefits' to energy renovation. They schematically summarized potential co-benefits relative to energy renovation measures, i.e., Thermal comfort, Natural lighting and contact with the outside, Indoor Air Quality, Internal and external noise, Pride, prestige, reputation, and Ease of installation and reduced annoyance (Almeida and Ferreira 2017). They also indicated that energy-related efforts could negatively influence the well-being of the residents, e.g., in the form of sound and noise from the technical installations. Rose et al. (2019) and Femenias et al. (2018) are examples of researchers addressing the monetary value of the added social value; the former by exemplifying the value of extra usable floor area due to increased thermal comfort after re-insulation of the façade (Rose et al. 2019). And the latter by pointing to residents' willingness to pay for cultural heritage values (Femenias et al. 2018).

### Summary

This section has included an introduction to additional research initiatives related to the problem field of this thesis. In summary, the mentioned researchers represented different perspectives to the problem field. Despite their different professional bases and focus, they all acknowledge that energy and social value are closely related entities. The research makes for highly inspiring catalogs of 'state-of-the-art' with dawning insights into the impact of physical renovation efforts. However, as a common denominator, the findings have not been summarized into guidelines for use in the creative process. The following section summarizes 'Part 1: Introduction', including the identified knowledge gap, and presents the research question, aim, and objectives for the research.

# Research question, aims and objectives

The introduction has served to position the research of the present thesis. The first section gave an introduction to the development of the post-war social housing stock – and its current challenges. The post-war social housing stock faces extensive renovation over the coming years. This represents a significant potential for implementing energy savings while updating the housing stock to support the well-being of existing and new residents.

The introduction to the contemporary social housing renovation practice illustrated that the ability to influence a project is highest in the early stages. Nevertheless, the early stages also represent a high level of complexity as many concerns are to be addressed simultaneously amongst a large group of stakeholders.

This led to a preliminary study of existing initiatives relevant to supporting the architect's role as a promoter of joint environmental and social value creation in the early stages of interdisciplinary renovation design processes. Further, the introduction included a clarification and delimitation of key concepts; sustainable renovation is understood as all efforts to update the existing housing mass to be more sustainable, both socially, environmentally, and economically. The thesis seeks to push the current practice in a more holistic direction, where the social pillar is better integrated. The underlying assumption of the thesis is that by promoting synergies between the environmental value creation (focusing on 'energy savings') and social value creation (focusing on 'resident well-being'), it is possible to contribute with a small part of the puzzle to a more holistically sustainable development of the building sector.

Overall, the preliminary study indicated that only a few existing frameworks address both energy savings and resident well-being. The following main challenges were identified for those that do: the complexity of the frameworks makes it difficult to use them as early-stage process tools. Further, there is a tendency to emphasize quantifiable well-being themes, such as thermal comfort. The recommendations in the frameworks are less explicit when it comes to "softer" well-being themes, and there appears to be an ambiguity between 'means' and 'end.' The study of additional research initiatives included examples of emerging research from different professions that address the impact of renovation on resident well-being and the building's energy performance. Nevertheless, as a common denominator, the findings of the identified studies have not been summarized into

guidelines for use in the creative process.

This translates into a research gap in terms of supporting the architect's role as a promoter of synergies between energy savings and resident well-being in the early renovation design phases. Especially, there is an identified need to focus on promoting (a broad understanding of) resident well-being to contribute to more holistically sustainable renovation solutions.

Based on the identified research gap, the following research question was formulated: *How can resident well-being be promoted by architects in the early design phases of interdisciplinary, sustainable renovation processes?*

The grey circle in the graphical landscape in Figure 10 on page 35 indicates how the present thesis positions itself relative to existing initiatives.

The research presented in this thesis aims to develop architectural strategies for *articulating, identifying, and visualizing* synergies between energy savings and resident well-being in the early design phases of renovation of social housing.

Three objectives have been developed, directing how to achieve the research aim (Figure 11).

*Objective 1* focuses on developing a conceptual framework for articulating synergies between energy savings and improved resident well-being in renovation from an architectural perspective. The thesis focuses on the perspective of the architect engaging in a highly interdisciplinary field. Objective 1 should help gain a stronger theoretical foothold from an architectural perspective and lay the foundation for the two remaining objectives, focusing on identifying and visualizing synergies.

*Objective 2* focuses on identifying examples of how renovation actions can impact (a broad understanding of) resident well-being and how this may form synergies with energy savings. This objective should help lay the foundation for the last objective, focusing on visualizing potentials for synergies.

Lastly, *Objective 3* focuses on exemplifying how a framework could be developed to visualize potentials for synergies between energy savings and improved resident well-being as part of the early design process, in a manner where traditionally "soft," qualitative aspects are treated on equal terms as "hard," quantitative aspects.

Together, the three objectives contribute with architectural strategies for promoting well-being in the sustainable renovation of multi-family social housing.

**RESEARCH QUESTION**

*How can resident well-being be promoted by architects in the early design phases of interdisciplinary, sustainable renovation processes?*

**RESEARCH AIM**

To develop architectural strategies for articulating, identifying, and visualizing synergies between energy savings and resident well-being in the early design phases of renovation of social housing.

**OBJECTIVE 1**

To develop a conceptual framework for articulating synergies between energy savings and improved resident well-being in renovation from an architectural perspective.

**OBJECTIVE 2**

2a. To identify examples that renovation measures can impact resident well-being in a broad understanding.

2b. To identify examples for synergies between increased well-being and energy savings.

**OBJECTIVE 3**

3a. To describe typical characteristics of the early stages of renovation of multi-family social housing.

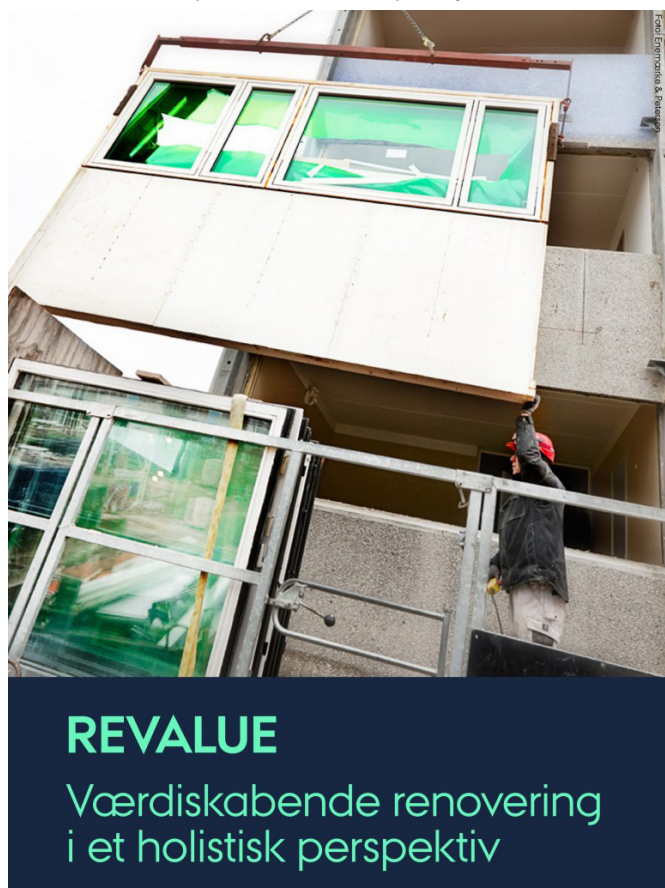
3b. To exemplify how a framework could be developed to visualize potentials for synergies between energy savings and improved resident well-being, in a manner where traditionally “soft,” qualitative aspects are treated on equal terms as “hard,” quantitative aspects (to be used by architects when engaging in dialogue with other stakeholders in the early design process).

**Figure 11** Research question, aim and objectives.





**Figure 12** The PhD project takes its point of departure in the architectural discipline and interdisciplinary collaborations.



**Figure 13** This PhD project is conducted as part of the research and innovation project ReVALUE (Wandahl and Hansen 2018).

### REVALUE

The PhD project is conducted as part of the national research and innovation project REVALUE (value creation by energy renovation and transformation of the built environment - modeling and validating of utility and architectural value), funded by Innovation Fund Denmark. The ReVALUE project is conducted as a collaboration between Aarhus University, the Department of Engineering (now Department of Civil and Architectural Engineering), and eleven partners from the building industry, representing different parts of the value chain. The involved partners are Aarhus University, Brabrand Boligforening, Deas, Enemærke & Petersen A/S, AART architects, Develco products, Amplex, Wicotec Kirkebjerg, Airmaster, Racell, Idealcombi, and MT Højgaard.

The main partners involved in the PhD project are the Department of Civil and Architectural Engineering at Aarhus University and AART architects.

### DELIMITATION

The journey of the PhD study has taken a windy road in order to navigate the complexity of the field, not to mention the dynamic character of ongoing cases. In order to make the project amenable, continuous delimitation has proven necessary. Below follows a listing of the main delimitations in the project:



### **Physical transformation – but the physical transformation is not enough**

The thesis focuses on physical alterations to the buildings and the potential to create value through these alterations. It is essential that such physical efforts are combined with social efforts (Bech-Danielsen 2012). In some renovation projects, the physical overall plan is supplemented with a “boligsocial helhedsplan” [social overall plan] (Landsbyggefonden n.d.-b). Such initiatives can be critical to the development of an area. However, it is important to emphasize that the present thesis focuses on the potential for synergies between resident well-being and energy savings based on the physical alterations – and attention to “non-physical” social efforts lie beyond the scope of this thesis.

### **Building scale**

The thesis investigates renovation efforts at apartment and building scales. It is important to consider how these alterations support the development of the area as a whole (including how the alterations fit into overall plans, mandatory to develop when working within the framework of the Danish National Building Foundation) (Landsbyggefonden 2018). However, this thesis focuses on physical measures in apartment and building scales in order to target synergies with typical energy renovation measures and to delimit the study.

### **Product value**

The thesis focuses on the perception of value in the finalized project, or what we could refer to as ‘product value’ (applied in construction management by, e.g., Bejder et al. (2008). However, especially in the case of social housing, attention to the users during the design and building process is crucial (Jensen 2015). For instance, the renovation project is dependent on the acceptance of the resident democracy (Saaby et al. 2008). Further, some renovations are carried out while the residents stay in their dwellings. As such, their perception of value in the final project is likely to be closely related to their perception of the process. Themes related to ‘process value’ are treated indirectly as part of the thesis. Still, the emphasis is placed on supporting design decisions which promote resident well-being and energy savings in the finalized building.

### **Focus on the influence of renovation on resident well-being – not on the influence of resident behavior on the energy consumption**

Residents influence the energy consumption in buildings through their behavior. As such, the often-found deviation between the calculated and actual energy consumption for heating in a building – the so-called ‘the energy-performance gap’ – can be explained in part by resident behavior (van den Brom et al. 2018). Research indicates that part of the potential for energy reductions for heating is changed into increased comfort (people turning up the heat) (Energistyrelsen 2016; Hansen et al. 2018). Knowledge about practices and preferences may be used to better predict outcomes but also to actively ‘nudge’ residents to a ‘greener’ behavior. The idea of ‘nudging’ through the built environment could be seen as a strategy in addition to, e.g., exterior re-insulation Figure 41 on page 86. Though this subject is highly important, it lies beyond the scope of this thesis. Nevertheless, the PhD student has contributed to the development of the popular science publication on the subject: “Arkitektur der fremmer bæredygtig adfærd” [Architecture that promotes sustainable behavior] in collaboration between Aarhus University, AART architects, and The Alexandra Institute (Thunbo et al. 2019).

### **A general focus on the renovation of social housing – not a particular focus on marginalized residential areas**

During recent years, the so-called ‘ghetto’s’ (marginalized residential areas) have received intensive attention in the media, not least due to the yearly published ‘ghetto-list.’ The list includes areas that meet a number of criteria in terms of demography, crime rate, income, level of education, and employment (Transport og Boligministeriet n.d.). Being on the list triggers financial support; however, it is also being criticized for causing stigmatization of the areas (Nielsen 2017a). In 2021 a list of ‘prevention areas’ [forebyggelsesområder], ‘marginalized residential areas’ [udsatte boligområder], and ‘transformation areas’ [omdannelsesområder] substituted the ‘ghetto list’ (BL - Danmarks Almene boliger 2021). Being on the list can influence the physical development of an area. As such, the general efforts to renovate the Danish social housing stock are closely connected with the issue of marginalized resident areas. However, this thesis does not specifically target marginalized residential areas. Rather, it broadly targets the physical renovation of multi-family social housing (MSH).

# Part 2 : Methodology

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# Methodology

The following chapter is devoted to an account of the methodological approach applied in the project in order to answer the research question and reach the objectives of the project.

The first part of the chapter focuses on the overall research design. Thereafter follows an account of the sub-strategies and tactics applied in addressing each of the project's three objectives.

The chapter leans on a conceptual model developed by Groat and Wang (2013) in order to describe the methodological approach of this thesis in more depth. The model consists of concentric frames which reflect different levels of methodological concerns (Groat and Wang 2013) (Figure 14).

Groat and Wang refer to a research strategy (or research design) as *"...the overall research plan or structure of the research study"* (Groat and Wang 2013, p. 10). They explain the concept of tactics as *"...a more detailed deployment of specific techniques, such as data collection devices, response formats, archival treatment, analytical procedures, and so on"* (Groat and Wang 2013, p. 10).

According to the researchers, *"The methodological practices of strategies and tactics are framed by broader systems of inquiry and schools of thought"* (Groat and Wang 2013, p. 10) (Figure 14). Before moving on to the account of the strategy and tactics employed in the present thesis, it is relevant to dwell on these broader underlying assumptions.

## SYSTEM OF INQUIRY AND SCHOOL OF THOUGHT

Systems of inquiry are also referred to as research paradigms or world views (Groat and Wang 2013). Architecture is a highly interdisciplinary field, placing itself in the midst of different traditions, e.g., the natural sciences and social sciences, drawing on different worldviews spanning from a post-positivist stance that assumes an objective reality to a constructivist stance that assumes multiple socially constructed realities (Groat and Wang 2013).

This is also the case for the research in this thesis. Both because of the interdisciplinary collaborations with other parties in the ReVALUE project – which represent different ontological and epistemological outsets – and because the subject itself, synergies between well-being and energy savings in renovation projects could be addressed from different stances.

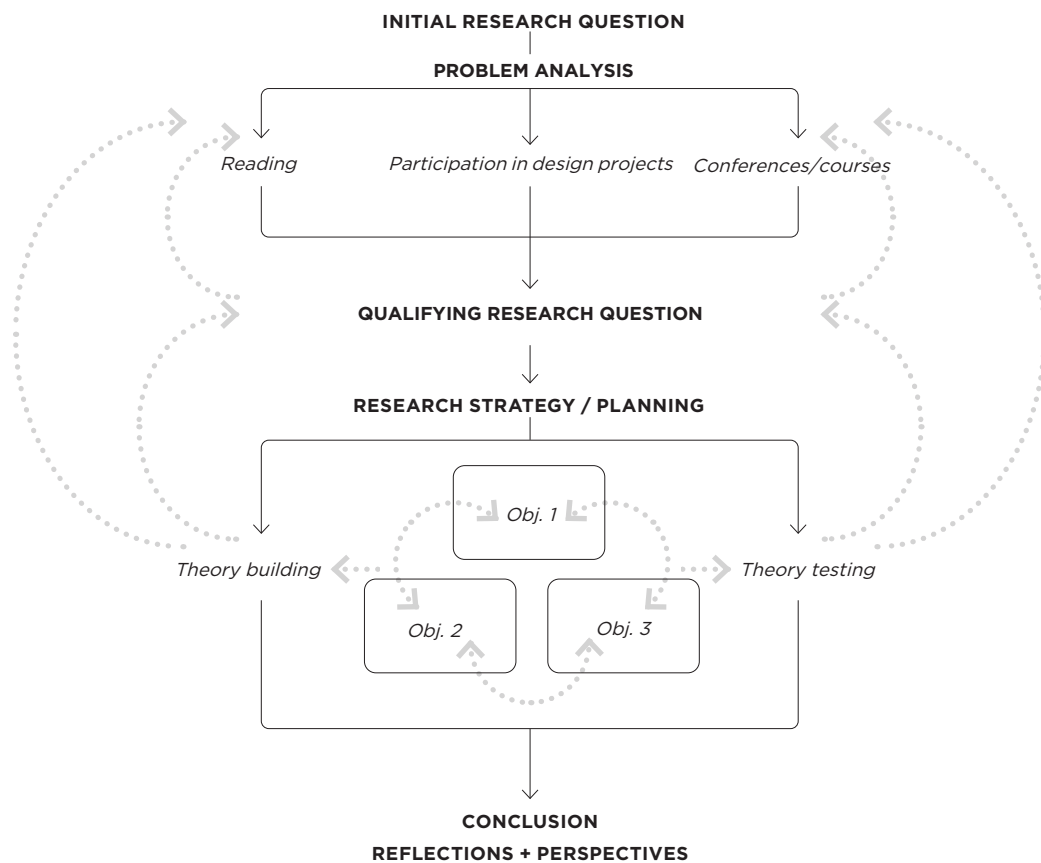
Groat and Wang present a continuum for describing epistemological and ontological positions, ranging from objective/quantitative to subjective/qualitative stances. The system of inquiry – or worldview – framing this thesis can be described using Groat and Wang's term 'Inter-subjective' (Groat and Wang 2013) in the middle of their proposed continuum (Figure 15). Groat and Wang explain that researchers taking this stance *"...recognize the significance of values and meaning in framing the goals of the research and/or interpreting the results [...] in contrast to the positivist paradigm, causality is assumed to be just one of many possible relations or interactions within the phenomena under study"* (Groat and Wang 2013, p. 78). Nevertheless, it is an underlying assumption in the thesis project that it can bring value to the architectural process to identify patterns (relations between alteration of the built environment and resident well-being), which – with careful attention to contextual factors – can be visualized to inform the creative design process.

'Part 6: Closing' in this thesis includes a discussion of the experiences from collaborating with stakeholders in the ReVALUE-project with a more post-positivist or constructivist stance, which has served to continuously challenge the approach.

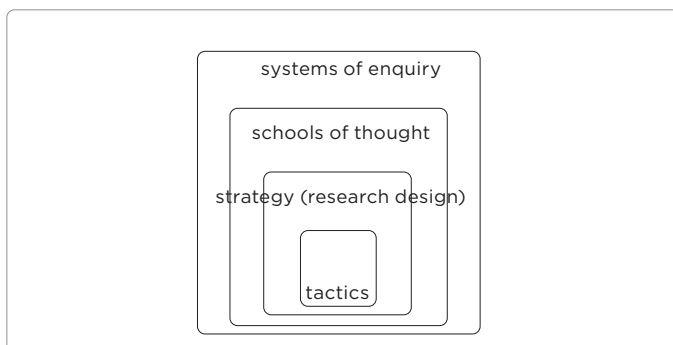
The project is based on a 'combined' or 'mixed methods' research strategy. The research strategy combines methods from diverse traditions, reflecting different schools of thought. Also, the included references represent a broad spectrum of schools of thought, e.g., ranging from deterministic studies aiming to isolate single measures, e.g., the impact of MVHR-systems on the perceived indoor climate (Abdul Hamid et al. 2019) to anthropological studies of reintegration of a housing area in the city fabric in the awareness of residents and public (Stender and Bech-Danielsen 2019).

## OVERALL RESEARCH STRATEGY

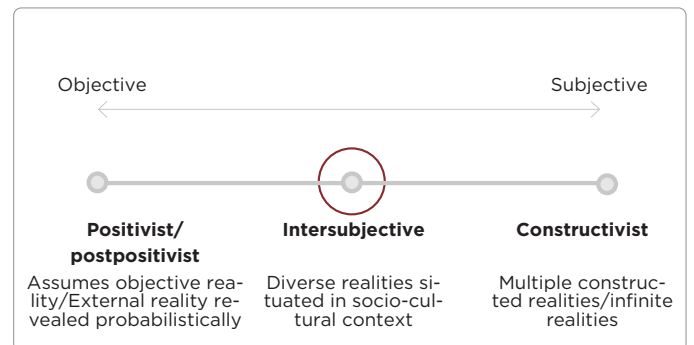
Figure 16 serves to describe the project development on an overall level. After formulating an initial research question, a problem analysis was carried out (Fisker and Keiding 2005), including gathering and reading existing research and frameworks, participating in design projects and conferences and courses to understand the problem field in more depth and to establish state-of-the-art for the project. After that, the research question was revisited and qualified, forming the basis for the research design.



**Figure 16** Overall development of the project.



**Figure 14** Different levels of methodological consideration in a research project (based on Groat and Wang 2013, p. 10).



**Figure 15** Continuum displaying different research paradigms (based on Groat and Wang 2013, p. 76). Red indicates the underlying paradigm framing this thesis.

The section includes an account of the applied methods and the distribution of roles in developing the paper "Towards a Holistic Approach to Retrofitting: A Critical Review of State-of-the-art Evaluation Methodologies for Architectural Transformation" (Jensen et al. 2017a).

Three objectives were formulated for investigating the research question. As mentioned, these objectives were investigated through a mixed-methods research strategy. Based on the studies in the thesis, a conclusion was formulated, followed by gathering and disseminating reflections on the research and perspectives for further development.

In reality, the process was less linear. As such, the dotted arrows in indicate the iterative character of the project. Due to collaboration with other stakeholders and the need for seizing opportunities to be involved in ongoing design projects – as well as learning from the individual studies – the project was characterized by going “back and forth” between the described stages.

#### MIXED METHODS RESEARCH STRATEGY

Figure 17 serves as a graphical overview of the research strategy which has formed the basis for the study. The strategy and the specific tactics employed in order to realize the strategy are explained in more detail in the following pages.

Overall, the project is based on a ‘combined’ or ‘mixed methods’ research design, combining methods from different traditions and including qualitative and quantitative approaches (Groat and Wang 2013; Johnson and Onwuegbuzie 2004; Schoonenboom and Johnson 2017). The complex character of the research question (and related objectives) makes it relevant to investigate the question from different angles. The combined research strategy is chosen based on the understanding that each research method brings with it particular strengths and weaknesses in meeting the relevant objective. Figure 17 shows the three objectives, each with their sub-strategy.

The conceptual framework, developed to answer Objective 1, has been applied as a starting point for the remaining studies (objectives 2-3). The original intention was to apply the methods “...in a sequence of distinct phases” (Groat and Wang 2013, p. 443), where the hermeneutic approach could help build theory to be tested through the empirical and action research studies (Groat and Wang 2013). However, it was quickly evident that “the ship sails!” when you are not doing isolated research but collaborate with others (the empirical approach) and work with real life ongoing building projects (the empirical and action research approach). As such, the research strategy can be described as a partially concurrent (pa-

rallel) and partially sequential mixed methods research strategy (Schoonenboom and Johnson 2017), meaning that the studies were carried out almost simultaneously – and essentially without informing the structure of each other. Nevertheless, there was some dependence between the studies; for instance, the conceptual framework was applied in addressing Objectives 2-3. Reversely, the gradual emphasis on articulating *documented* synergies between energy savings and resident well-being in the built environment as part of Objective 1 was a result of reflections from initial studies across all three objectives. Where studies have influenced each other, this is noted in Figure 18, Figure 19 and Figure 23 in the following pages.

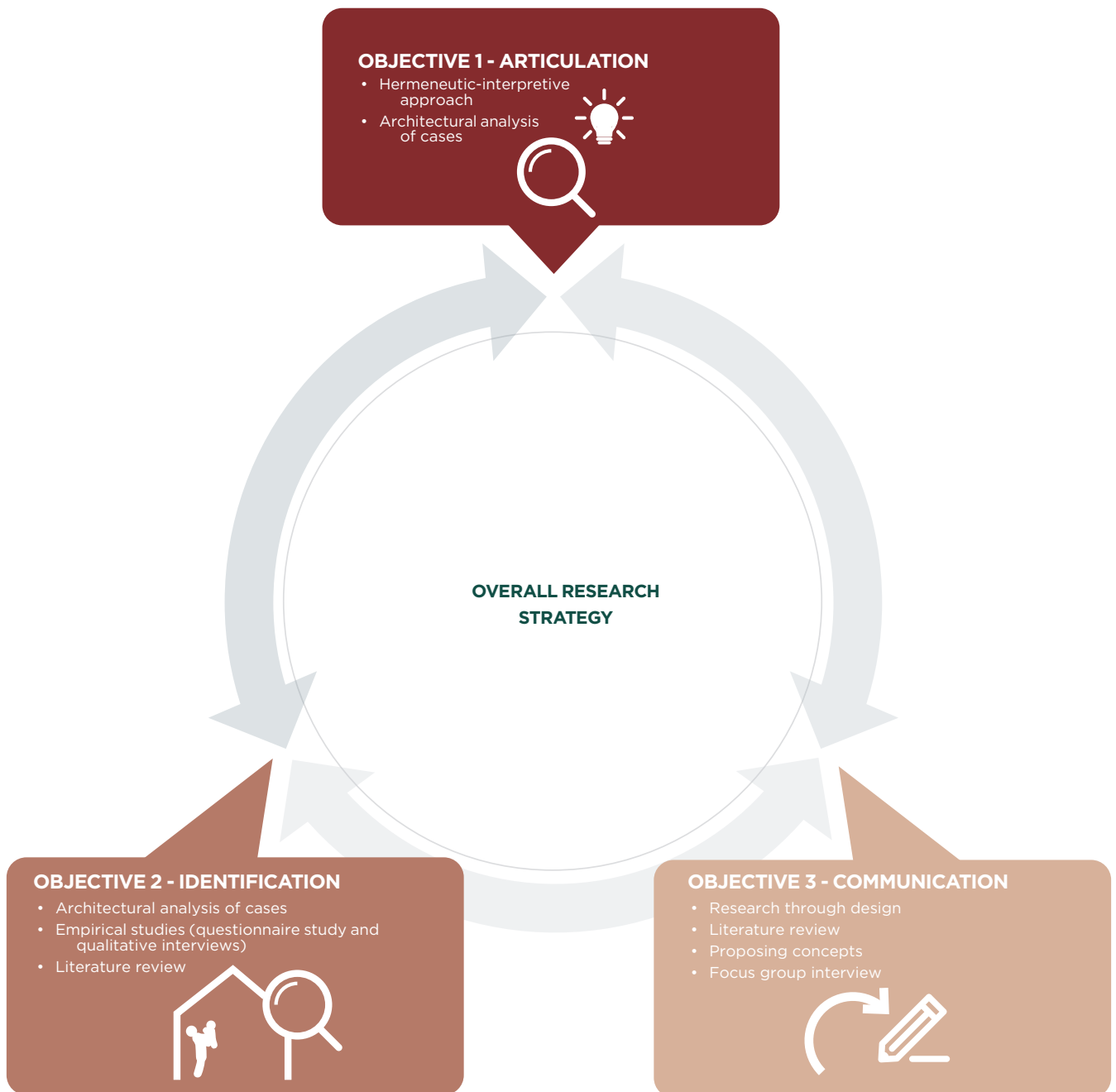
The following text accounts for the sub-strategies and tactics applied in addressing each of the three objectives. However, first, the text accounts for the tactics applied in the initial review of existing initiatives.

#### AN INTRODUCTORY REVIEW OF STATE-OF-THE-ART Literature review – meta-synthesis

A review of seven existing assessment methodologies was carried out at the beginning of the project period to address state-of-the-art for the problem field. The approach was to compare which sustainability indicators each methodology attach importance to and provide a meta-synthesis of the findings (Onwuegbuzie and Frels 2016; Cronin et al. 2008). The results were presented in the paper *Towards a holistic Approach to Retrofitting: A Critical Review of State-of-the-art Evaluation Methodologies for Architectural Transformation* at the World Sustainable Built Environment conference in Hong Kong in 2017 (Jensen et al. 2017a). The paper was developed in collaboration with Poul Henning Kirkegaard (PHK) and Aliakbar Kamari (AK). The author of this PhD thesis performed the analysis and wrote the paper with critical inputs from PHK and AK.

The review was updated for inclusion in this thesis, including the addition of more schemes and supplemented by a narrative literature review of relevant studies that address the subject area of the PhD project (Onwuegbuzie and Frels 2016; Cronin et al. 2008). The results are presented as part of the introduction. The reasoning for inclusion is described as part of the account in the introduction.





**Figure 17** Downstroke in Figure 16. Graphical representation of the overall research strategy for the project. The arrows serve to indicate the iterative character of the project.



# Objective 1 Articulation

## STRATEGY AND TACTICS RELATED TO OBJECTIVE 1

*To develop a conceptual framework for articulating synergies between energy savings and improved resident well-being in renovation from an architectural perspective.*

The aim was to gain a theoretical foothold for articulating synergies from an architectural perspective and to establish a foundation from where to engage in the two remaining objectives, focusing on identifying and visualizing synergies (Objectives 2 and 3).

Figure 18 provides a graphical overview of the research strategy applied to address Objective 1.

## PHASE A

### Hermeneutic-interpretive strategy

In order to gain a theoretical foothold for articulating synergies between well-being and energy efficiency in MSH, a strategy has been applied, focusing on interpreting and juxtaposing existing theory relevant to the current challenge of sustainable renovation of social housing. As such, the project leaned on a hermeneutic-interpretive research tradition related to the humanities and social science and widely used within architectural research to investigate the meaning of existing work and its significance to present-day challenges (Tvedebrink 2013; Eck 2004).

Phase A was based on a rereading of architectural theory, focusing on interpreting the theory through the lenses of the current challenge of renovation of MSH (Phase A in Figure 18). More specifically, Phase A was based on a rereading of tectonic architectural theory and renovation theory, with the former based on writings by Eduard F. Sekler and the latter based on writings by Fred Scott. The reason for looking into tectonic architectural theory was that it was considered a possible way forward for theoretically bridging technical and experiential aspects of the built environment. The reason for relating this to renovation theory was the recognition that renovation differs significantly from building new buildings.

Based on the rereading of architectural theory, a conceptual framework was proposed to articulate how alterations of the construction may contribute to both energy savings and improved well-being through the spatial gestures they preserve, accentuate, or add.

### Architectural analysis based on drawing material and literary references + Unstructured interviews

A comparative analysis of two completed cases was per-

The section includes an account of the applied methods and distribution of roles in developing the paper "Renovation of social housing: a tectonic dialogue between past and present?" (Jensen et al. 2019a)

formed using the conceptual framework as an analytical lens. In relation to Objective 1, this was done to test and further develop the conceptual framework.

The analysis was based on drawing material and available literary references. The comparative analysis of Park Hill and Rosenhøj was supplemented by inputs from representatives of the renovation teams through walk-and-talk-inspired unstructured interviews. Interviews included a physical "walk-and-talk"-session with Søren Nielsen from Viggo Madsen consulting engineers and a virtual meeting with Christoph Egret, where he went through images of the renovation whilst talking about it and answering questions.

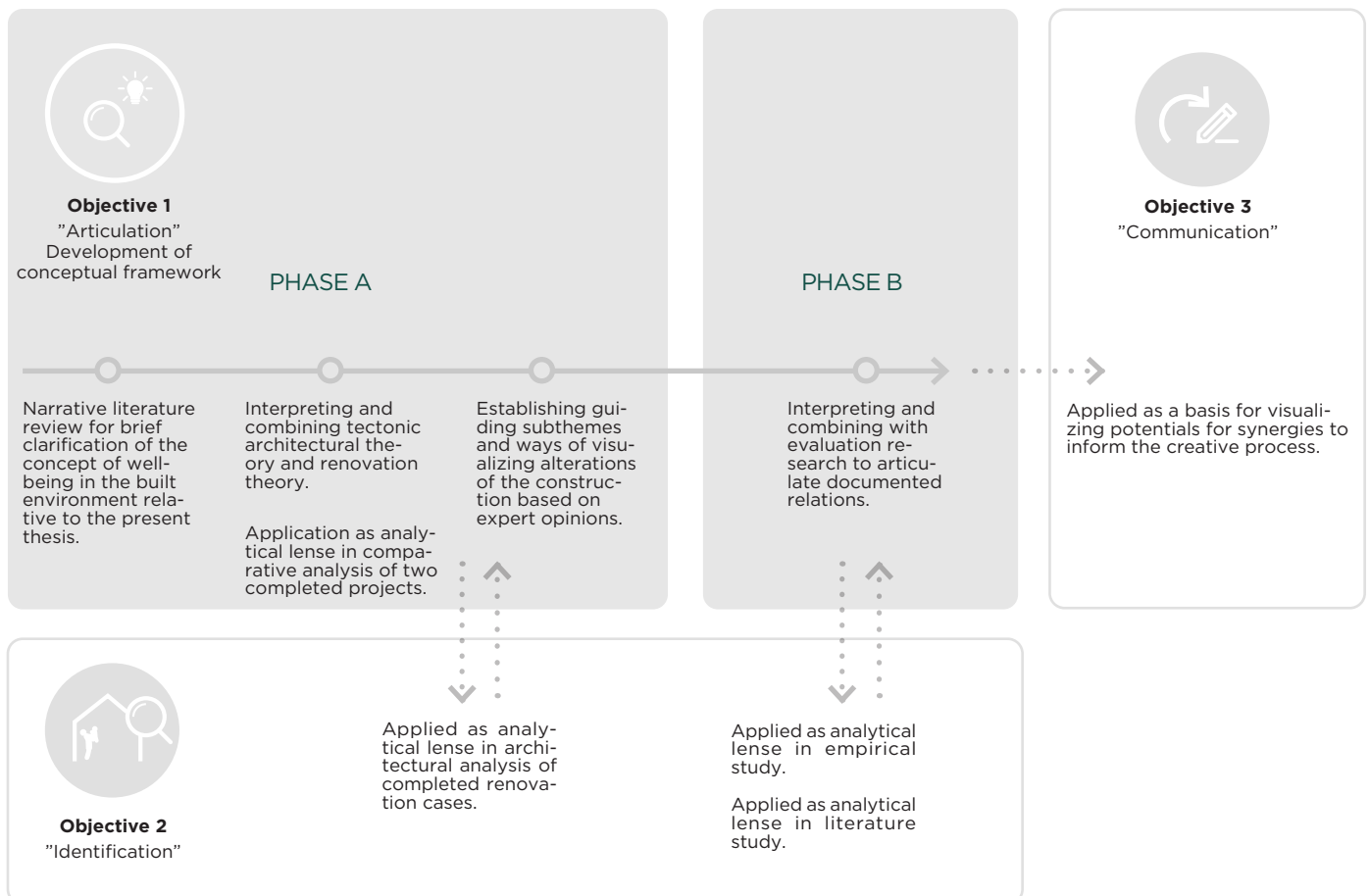
The interactions with Nielsen and Egret took place in connection with ongoing projects at AART architects (RtD study) and are characterized as unstructured interviews with reference to the following definition by Zhang and Wildemuth (2009): *"The researcher will keep in mind the study's purpose and the general scope of the issues that he or she would like to discuss [...] The researcher's control over the conversation is intended to be minimal, but nevertheless the researcher will try to encourage the interviewees to relate experiences and perspectives that are relevant to the problems of interest to the researcher..."* (Zhang and Wildemuth 2009, p. 240).

The PhD student took notes during the conversations.

The rereading of architectural theory and analysis of Park Hill and Rosenhøj was published in the paper "Renovation of social housing: a tectonic dialogue between past and present?" (Jensen et al. 2019a). The paper was developed in collaboration with Marie Frier Hvejsel (MFH), Poul Henning Kirkegaard (PHK), and Anders Strange (AS). The author of this thesis developed the preliminary framework with critical inputs from MFH and PHK. The author analyzed Park Hill and Rosenhøj and wrote the paper with continuous feedback from MFH, PHK, and AS. Revisions of the text and figures were performed by all authors.

### Adjustments based on expert opinions

The conceptual framework was discussed and further developed as part of a research stay at the Politecnico di Milano. During the research stay, the PhD student was involved in the preparatory work for a course on sustainable renovation of social housing. Through this work, the PhD student had the opportunity to discuss the conceptual framework with teachers involved in the course based on their previous experience - with the aim to use elements



**Figure 18** Graphical representation of the iterations of the development of the analytical model.

of the research in the course.

Through dialogue with especially professor Gennaro Postiglione, additional guiding themes and tactics for visualizing alterations of the construction have been proposed in order to guide the students further in their analysis of synergies. The proposed additional themes/tactics are based on the dialogue with the teachers – based on their “expert opinions” through weekly meetings over a two-month period (the term “expert opening” is used by e.g., Groat and Wang 2013). In future studies, it would be relevant to also analyze the learning outcome of the students from using the conceptual framework.

### PHASE B

As a reflection from ‘Phase A’ and the research through design study, it was found useful to expand the analytical framework by juxtaposing the hitherto findings with ‘evaluation research’ to be able to better articulate whether

the renovation initiatives have caused actual changes to the well-being of the residents (and not ‘only’ value creation identified by the architect as an interpreter). This development is accounted for in more depth in ‘Part 3: Articulation’. However, as Phase A, the underlying research strategy was that of interpreting the theory through the lenses of the current challenge of renovation of MSH and combining it with the findings from Phase A, focusing on architectural theory (Phase B in Figure 18). Phase B was described in the paper “Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation” (Jensen et al. 2020). The distribution of roles is described under Objective 2 (literature review).

As depicted in Figure 18 (with dotted arrows), the conceptual framework has formed the basis for Objective 2 (Identification) and Objective 3 (Communication).



# Objective 2 Identification

## STRATEGY AND TACTICS RELATED TO OBJECTIVE 2

*2a. To identify examples that renovation measures can impact resident well-being in a broad understanding.*

*2b. To identify examples for synergies between increased well-being and energy savings.*

The intention of Objective 2 has been to establish that there are indeed potentials for influencing the well-being of residents through specific renovation interventions. Further, to exemplify such potentials based on insights from completed or ongoing projects in order to inform the creative process (Objective 3).

Objective 2 has been addressed through three different lenses (Figure 19, Phase A):

- Architectural analysis of case studies of completed renovation cases.
- Empirical studies in three social housing departments in Aarhus, Denmark.
- Systematic literature review of existing impact studies. Subsequently, the findings were synthesized and discussed relative to a report on the Danish housing sector (Landsbyggefonden 2014).

The emphasis in the three mentioned studies has been on objective 2a. Objective 2b has been addressed as part of the individual studies and subsequent synthesis (Figure 19, Phase B).

## PHASE A

### Architectural analysis of cases

The thesis includes an architectural analysis of completed MSH renovation cases to identify examples of synergies between energy savings and spatial gestures which may influence the well-being of residents.

As such, the purpose for including the architectural analysis of cases differs from the “pilot analysis” of Park Hill and Rosenhøj, presented in relation to Objective 1, where the primary purpose was to test and further develop the conceptual framework.

The completed cases have been studied by the PhD student through the analytical framework developed as part of Objective 1 (based on Phase A, Figure 18). The analysis is based on existing literature and additional available documentation, including images and drawings from before and after renovation. In the case of Ellebo, the analysis was supplemented by inputs from a representative of the housing association KAB (Pernille Egelund Johansen), based on a walk-and-talk-inspired unstructured

interview during a site-visit at Ellebo (see description of unstructured interviews in relation to Park Hill and Rosenhøj under ‘Objective 1’).

The case studies include a background account and a brief introduction to the existing building. Thereafter follows a description of applied measures of alteration of the construction. On the basis of the description follows a discussion of synergies between energy savings and spatial gestures, supplemented by sketches which signal preserved, interpreted/accentuated, or added spatial gestures.

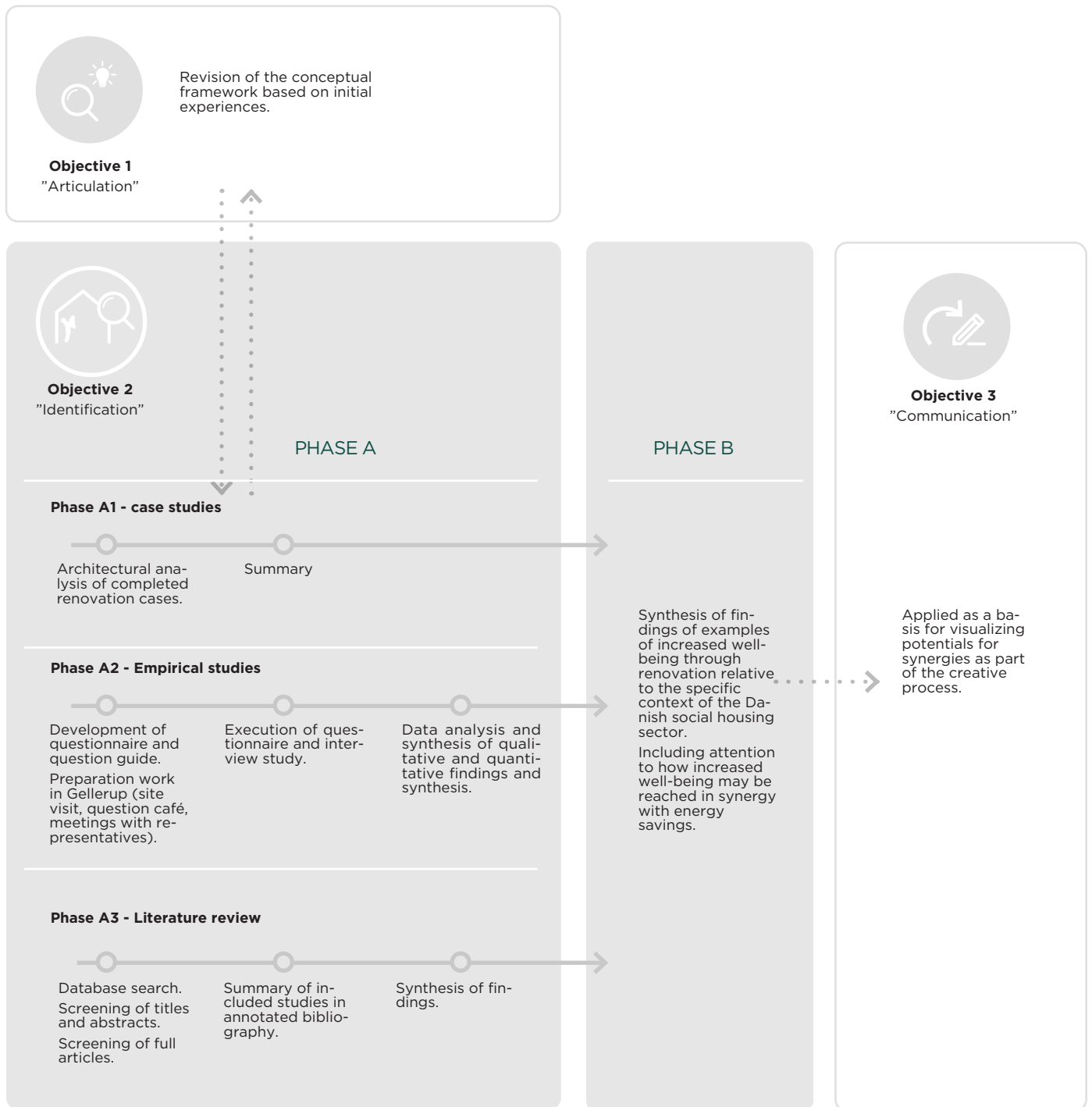
The study includes renovation cases, which have been completed within the last decade. It is possible to find cases in which the energy reductions are higher, yet the cases included in this study are chosen because they represent both attention to energy savings and spatial quality. The cases have all been published in architectural journals and/or received mentioning in the architectural milieu. This is used as an indicator that the works have been assessed to hold a certain level of architectural quality. Further, they have been included because they all include upgrading the thermal performance of the building envelope. This allows for a comparison of different alteration measures used to reach the same objective in terms of energy savings and how these alteration measures contribute to preserving, accentuating existing spatial gestures, or adding new gestures, which may influence the well-being of the residents.

The cases are:

- Fittja People’s Palace in Sweden
- Kleiburg in the Netherlands
- La Tour Bois le Prêtre in France
- Ellebo In Denmark

The findings from analyzing the projects Park Hill and Rosenhøj (Objective 1) are included as part of the summary of the case studies in relation to Objective 2.

The architectural analysis of Fittja People’s Palace, Kleiburg, and La Tour Bois le Prêtre was originally conducted by the author as part of the development of a “case atlas” for educational purposes at the Politecnico di Milano in fall 2018. An important point in the proposed conceptual framework is that alterations to the construction may influence spatial perception across scales. However, this thesis presents only a condensed version of the case studies, including one or two examples of identified spatial gestures in each project.



**Figure 19** Graphical representation of the process of identifying examples of synergies between increased resident well-being and energy savings in renovation of MSH.

The account of methods used in the empirical study was previously published in the paper “Potentials for increasing resident well-being in energy renovation of multi-family social housing” (Jensen et al. 2021). The section below includes an account of the distribution of roles in conducting the research and writing the paper.

Further, it is relevant to note that the original “case atlas” was supplemented with a red/yellow color-coding to illustrate which components have been demolished or added (Boesh et al. 2017). Due to limitations in access to detailed drawings and concerns related to image rights, the red/yellow color-coding is not included in this thesis. However, the color-coding (including color coding of detail drawings) is recommended in future use of the conceptual framework for analytical purposes to promote a tectonic understanding of the spatial implications of specific renovation measures.

### Empirical studies

The architectural analysis of completed cases is based on the assessment by a third-party interpreter, i.e., the architect. By including also quantitative and qualitative empirical studies, the chapter draws attention to the residents’ own accounts.

The empirical studies were carried out in Toveshøj, Gellerupparken, and Søvangen in Aarhus, Denmark, where extensive renovation is in progress.

The original aim of the study was to establish a baseline for evaluating the renovation interventions through post-occupancy evaluation (POE) to see if they have affected the residents’ perception of well-being relative to a number of factors (compare baseline and POE). To use the terminology developed as part of Objective 1, the aim was to identify if the renovation has resulted in increased well-being due to spatial gestures prompted by the renovation.

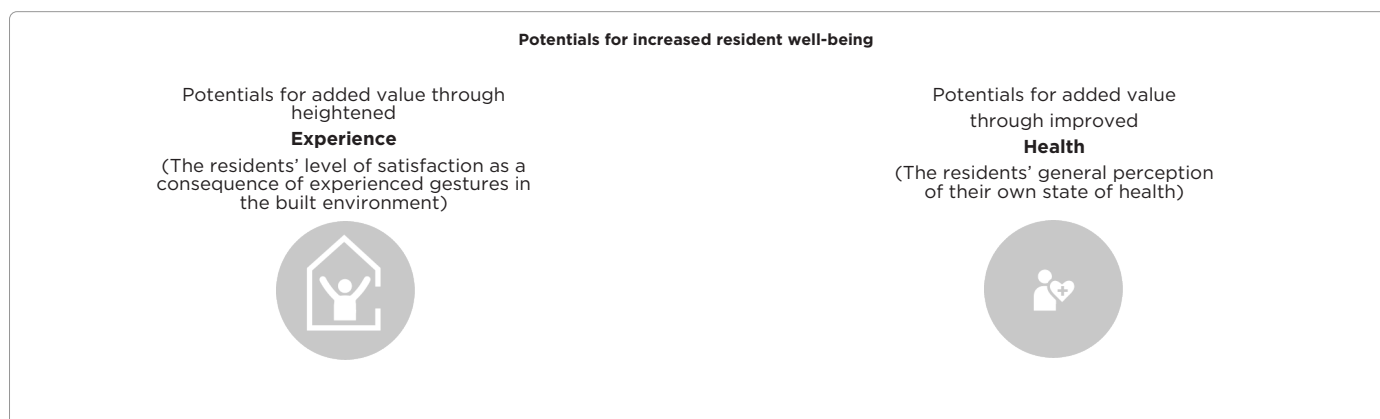
Due to political intervention in the renovation process, the remodeling in the three housing areas has been heavily delayed. After being postponed several times, the first POEs were finally scheduled to start in spring 2020, marking a year after the first residents moved back into

their renovated apartments (RIBA 2016). However, the COVID-19 Pandemic put the scheduled study on hold. The study is rescheduled for early 2022. Unfortunately, the results will not be ready for inclusion in this thesis.

Nevertheless, the baseline study in its own right points to important potentials for increased resident well-being and energy savings, which can help shed light on Objective 2a. Further, the approach may be valuable in gaining project-specific inputs on potentials for synergies between improved resident well-being and energy savings in larger renovation projects.

The empirical studies shed light on potentials for increased well-being based on an explorative, descriptive analysis of the residents’ *experience* of the existing built environment before renovation in three MSH areas in Denmark. This is done by asking about their satisfaction with elements in the built environment. The empirical studies further examine if the empirical data also provides a starting point for discussing potential related *health* effects. This is examined through descriptive analysis, exploring if the same groups of people who express dissatisfaction with the built environment also experience poor health (Figure 20).

The reason for addressing residents’ well-being through attention to experience and satisfaction is that the residents’ immediate appraisal of elements in the built environment is believed to be a valuable source of information about potentials for improvement. The approach was also used by, e.g., SBi (2000) and Knudsen and Jensen (2015). The reason for addressing resident well-being through attention to related health effects is to point attention to the possibility that renovation measures may not ‘only’ increase the satisfaction of the individual but also their



**Figure 20** The study focuses on identifying potentials for increased resident well-being by identifying trends in the residents’ experience and satisfaction with the built environment, and by providing a descriptive overview of experience and satisfaction with the built environment relative to residents’ subjective experience of their health.



health. This is important to the individual and may also hold economic potentials at a societal level (Volf et al. 2019; Ortiz et al. 2019).

#### *Mixed-methods research design*

The empirical studies were conducted by an interdisciplinary group of architects, anthropologists, engineers, and public health researchers. In relation to the aspects reported in this thesis, the PhD student collaborated with Charlotte Hansen Gabel from The Department of Public Health, Aarhus University.

The findings were based on a cross-sectional study carried out before renovation (Szklo and Nieto 2014; Levin 2006). The study applies a mixed-methods research approach. Quantitative questionnaires were used to identify overall trends, and qualitative interviews and observations through photography were used to gain a more in-depth understanding of identified trends (Johnson and Onwuegbuzie 2004; Groat and Wang 2013). The study was organized as a concurrent-independent research design (Schoonenboom and Johnson 2017), meaning that questionnaire data and interview data were collected without the studies defining each other. Rather, the quantitative and qualitative studies' findings have been synthesized in the interpretation phase to qualify and nuance the results (Figure 21) (Schoonenboom and Johnson 2017; Johnson and Onwuegbuzie 2004).

The study was based on the conceptual framework developed in relation to Objective 1 as a starting point for articulating how certain characteristics of the built environment (and alterations hereof) may contribute to the residents' sense of well-being in a deeper understanding. As mentioned above, this was done by investigating the residents' 'Experience' of their existing built environment

and 'Health' referring to their perception of their state of health (Figure 20).

#### *Description of MSH areas*

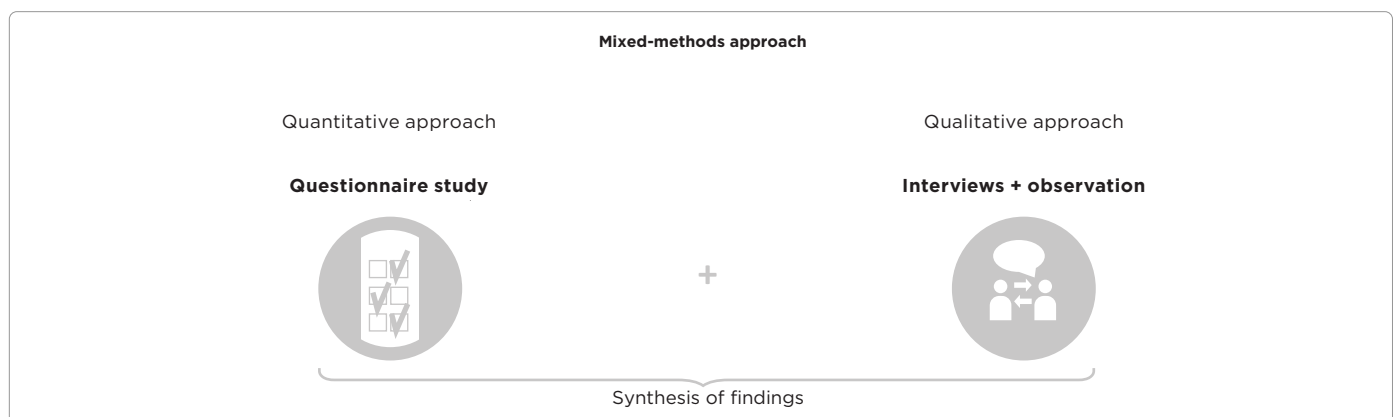
The study was based on empirical data collected in three MSH areas in the Western part of Aarhus, Denmark, named Toveshøj, Søvangen, and Gellerupparken. See Table 6 on page 115 (in "Part 4: Identification") for a description of selected physical characteristics and images of the built environment in these housing areas.

The housing areas are administered by the Housing Association "Brabrand Housing Association" (BBBO), a partner in the ReVALUE project. The housing areas were selected for the study because their built environments represent a widespread Danish postwar housing type built before the tightening of building code energy requirements due to the energy crisis in 1972. Further characteristics of the three housing areas are accounted for in "Part 4: Identification."

The following sections include a description of the methods applied in the mixed-methods study to identify potentials for increased resident well-being as part of future sustainable renovation of the MSH areas.

#### *Quantitative questionnaire study*

The questionnaire study was organized as a structured interview, where the interviewer read questions aloud to the participant from a tablet (computer-assisted interview (CAI)). The CAI format was chosen to avoid the exclusion of the illiterate, other language barriers, lack of access to technology, and to enable encrypted data collection to protect the residents' privacy. Some of the CAI's were carried out with the assistance of an interpreter. The questionnaire study and the qualitative interviews took place in the apartment of the participating resident.



**Figure 21** The aim of the paper is addressed through a mixed-methods approach.

The interviewers were instructed by the project manager or experienced interviewers and were equipped with a 'question guide' on the concept of each question.

The questionnaire has previously been applied in the research project BE-READY (Realdania n.d.). The original questionnaire included questions about the perception of indoor environmental quality (IEQ), practices, health symptoms, and diseases and background questions for gaining a demographic overview of the participants. It was inspired by the SF12 (12-item short-form health survey) (Ware et al. 1996) and ECRHS (European Community Respiratory Health Survey) (Burney and Jarvis n.d.). The questions were generally formulated as closed questions, with a five-point scale, and present tense questions were prioritized to avoid recall bias, with few exceptions. All questions were generated by an expert panel consisting of a professor and an assistant professor in environmental and occupational medicine and an associate professor in engineering and indoor climate.

The present study forms part of the research project ReVALUE (Petersen et al. 2019). Additional questions were added for the ReVALUE project to demonstrate a broader range of potential added values. The purpose was not to make an exhaustive study of potentials for increased well-being in sustainable renovation. Rather, the intention was to *exemplify* potentials for increased resident well-being in sustainable renovation across both physical and psychological well-being aspects. The original BE-READY questionnaire focused on physical themes related to IEQ. As such, the PhD student contributed with questions extending this approach to well-being. The added questions were based on Acre and Wyckmans (Acre and Wyckmans 2014) and KAB (KAB and Nørregård-Nielsen & Rosenmeier ApS - Rådgivende Sociologer 2008). They focused on private outdoor spaces, relation to neighbors, sense of privacy and safety, whether the layout of the apartment supports everyday practices, the resident's appraisal of the state of materials, and the expression of the building, as well as the level of influence on conditions in the built environment.

Further, the PhD student aimed to promote a broader understanding of already included domains, for instance, by talking about "sound" rather than "noise". This was done to address the potential to both limit negative stimuli and preserve and promote positive stimuli. The domains of the questionnaire relevant to this thesis are included in Appendix B, Table B.1. The revised questionnaire was tested with two test subjects in December 2016. Further, the total questionnaire was reviewed on two occasions based on focus group interviews with the employed interviewers in ReVALUE in May and August 2017.

The study has approval from the Danish Data Protection Agency (2016-051-000001, 1475), and all participants received participation information before entry.

#### *Qualitative interviews and observation through photography*

The study included eight semi-structured interviews (SSI) carried out during the non-heating season (Kvale 1996). The purpose of including the SSIs has been to supplement the quantitative approach, based on closed questions, with open-ended questions (Kvale 1996; Adams 2015). As with the questionnaires, an interview guide initially developed for the BE-READY-project was supplemented with additional questions to meet the broader scope of the ReVALUE project. A senior anthropologist carried out the interviews, and the PhD student participated in two of them.

Two interviews were carried out with the assistance of an interpreter. The interviews were documented through audio recording and field notes and supplemented by images taken in the apartments to 'capture' existing physical gestures or potentials for added gestures identified through the conversations with the participants. By using photography as a method of observation, the study leaned on the field of visual ethnography (Pink 2007). Images of the façades (Table 6 on page 115) were taken as part of an initial observational study carried out by the author. The study was based on Gordon Cullen's phenomenological "serial vision"-approach to analyzing the city (Cullen 1995), taking images along a predefined route. In this study, the predefined route reflected how residents are likely to approach the buildings from a distance.

#### *Inclusion and collection process*

All residents above the age of 18, speaking/understanding either Danish, English, Arabic, or Somali, were invited to participate in the study. The recruitment process (Appendix A) focused on recruiting one person per apartment to participate in the study. Though different household members may experience the built environment differently, this was believed to be the most realistic approach based on previous experience. If more than one person per apartment wished to participate, this was accepted. This was the case for a married couple and three residents living in a co-housing scheme. In these cases, the questionnaire study was carried out separately for the individual participants to ensure independent answers. The questionnaire study was carried out during both the non-heating and heating seasons. However, the results reported in this thesis are based on the quantitative findings from the heating season alone, as this represents the most extensive set of data. The participants for the qualitative interviews were recruited when carrying out the questi-

onnaire study, and the interviews were conducted during the non-heating season. Only participants in Toveshøj and Gellerupparken were invited to the qualitative interviews due to administrative circumstances. Data collection was carried out from February 2017 – September 2018 after an extensive information process from November 2016, including meetings with BBBO, the boards of the housing areas, information via digital platforms, and physical visits with hand-outs of information material (Appendix A). A timeline for the preliminary information process and data collection process is included in Appendix A, Table A.1.

### Study population

A total of 149 residents participated in the quantitative study in the heating or non-heating season or both seasons, representing 146 apartments. Out of 577 inhabited apartments, this amounts to a response rate of 25% in the quantitative study when considering the recruitment strategy of targeting one resident per apartment. As described previously, only data from the heating season was used in the context of this thesis, corresponding to 121 samples ( $n = 15$  in Toveshøj,  $n = 47$  in Søvangen, and  $n = 59$  in Gellerupparken).

Appendix C displays the sample's demographic characteristics relative to the given housing area population in the heating season. The comparison is based on data provided by BBBO (extracted from a database by The Danish National Building Foundation based on information by Statistics Denmark and The Danish National Buildings Foundation's 'rent register'), except for gender, for which comparative data has not been available. The empirical data did not include citizenship information, and, as such, this should be considered when comparing the number of immigrants (Appendix C). Table 5 displays an extract of Appendix C, Table C.1.

The study population in this study varies from the population of each MSH area. Still, it has a relatively broad distribution of participants in terms of age, gender, ethni-

city, educational background, and employment. Further, a mix of single residents, people living in partnerships with and without children, and people living in co-housing schemes took part in the study.

### Data assessment

Data assessment of the quantitative data was carried out using the software STATA 15 (STATA n.d.). The analysis of the residents' experience (focusing on their level of satisfaction) was based on both quantitative and qualitative findings. In contrast, analysis of indications of health potentials was based solely on quantitative results because the interviews did not include questions related to health. Both were based on an explorative, descriptive approach.

In terms of satisfaction, a potential for added value was assumed if more than 33% of the participants expressed dissatisfaction with the given theme. The threshold was introduced to ensure a certain volume behind the identified potentials and ensure a systematic and transparent approach. The specific threshold of 33% prevalence was established because it coincided with reporting >5 observations when dealing with the smallest sample size in Toveshøj ( $n = 15$ ), a threshold defined by the Danish Health Data Authority to protect personal data (Sundhedsdata-styrelsen 2018).

The 33% threshold was then adopted also in relation to the descriptive, explorative study of health indications as a common threshold for identifying potentials for added value. More specifically, the analysis explored if more than 33% of the residents who experience 'poor' or 'less good' health also express dissatisfaction with the built environment. Such tendencies were considered to indicate potential health effects worth examining more closely in future studies.

**Table 5** Extract from the demographic overview of the questionnaire sample (heating season) relative to the population of the given housing area. All values are presented as number (%) of the total population. For additional information, see Appendix C.

	Toveshøj		Søvangen		Gellerupparken	
	BBBO	ReVALUE	BBBO	ReVALUE	BBBO	ReVALUE
	<b>1.556(100%)</b>	<b>15(100%)</b>	<b>813(100%)</b>	<b>47 (100%)</b>	<b>4058 (100%)</b>	<b>59 (100)</b>
<b>Age</b>						
18-29 years	347 (22%)	<5	135 (17%)	<5	963 (24%)	11 (19%)
30-64 years	565 (36%)	7 (47%)	354 (44%)	30 (64%)	1582 (39%)	43 (73%)
65 years or older	109 (7%)	5 (33%)	167 (21%)	13 (28%)	205 (5%)	5 (8%)
<b>Gender</b>						
Male		6 (40%)		23 (49%)		21 (36%)*
Female		9 (60%)		24 (51%)		36 (61%)*

\* Two missing responses, corresponding to 3%.

The account of methods applied in the literature review was previously published as part of the paper "Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation" (Jensen et al. 2020). The section below is elaborated and edited to form a coherent part of the thesis and includes an account of the distribution of roles in conducting the developing the paper.

The data from the qualitative interviews were anonymized and summarised in writing based on notes and audio recordings (by anthropologist Mia Kruse Rasmussen). After that, the PhD student initiated a coding process using the qualitative data management program NVivo 12 (QSR n.d.). Firstly, each interview was coded individually using emic terms (terms identified from the subject's language use) (Fetterman 2015). After that, a process was carried out to identify transverse themes and organizing domains (Spradley 1980). Lastly, the data was compared to the quantitative findings.

#### *Distribution of roles*

As mentioned, the PhD student collaborated with other researchers to conduct the empirical study, in particular Charlotte Hansen Gabel (CG), Steffen Petersen (SP), and Poul Henning Kirkegaard (PHK). The paper (in which the empirical study was originally published) was written by the author of this thesis with critical inputs from CG. Data collection was performed by SRJ and CG and external anthropologist Mia Kruse Rasmussen with assistance from student workers. Data analysis was performed by SRJ and CG in continuous dialogue with PHK, SP, and anthropologist, head of AART architects' Impact team, Johanne Mose Entwistle. Revisions of the text and figures were performed by all authors.

#### *Summary*

In summary, the empirical study applied a mixed-methods research approach to identifying potentials for increased resident well-being, focusing on 'experience' and 'health.' The empirical data for the study was collected in three Danish MSH areas which will undergo extensive renovation. Quantitative questionnaires were used to identify overall trends, and qualitative interviews and observations were used to gain a more in-depth understanding of identified trends. The quantitative and qualitative findings were synthesized in the interpretation phase by the interdisciplinary group of researchers to qualify the results and

#### **Systematic literature review**

A systematic literature review was conducted to supplement the findings of the architectural analysis and the empirical studies with examples of documented "lived gestures". That is, documented accounts that certain ways of altering the construction have induced spatial gestures which have influenced the well-being of the residents. As such, the review aimed to gather examples of already established relations between renovation measures and the well-being of residents. The review has been structured relative to the conceptual framework developed as part of Objective 1 (Phase B). The framework is described in depth in "Part 3: Articulation."

In the efforts to gather examples of the documented impact of alteration measures, it is relevant to reflect on available sources of knowledge. According to Groat and Wang (2013) available sources in the architectural field range from what they refer to as 'Design-Polemical Theory,' over 'Normative theory' to 'Explanatory theory' (Figure 22).

Starting in the middle of the continuum, Groat and Wang describe "normative theory" as theory which "...describes and explains practices that are so normally accepted that they have become conventional" (Groat and Wang 2013, p. 115). The term "Design-polemical theory" is used to explain that "...designers are guided in their actions by "value-full" convictions of how a design problem should be (or ought to be) addressed or solved. These value-full convictions stem from a range of cultural variables, including the designers' attitudes towards society, people, the natural environment, technology, and also the design professionals themselves" (Groat and Wang 2013, p. 116). In contrast, "Explanatory theory" is defined as "Plausible or scientifically acceptable general principles or body of principles offered to explain phenomena" (Groat and Wang 2013, p. 111). Groat and Wang use the term 'explanatory' to "...broaden the term beyond positivism and/or post positivism" (Groat and Wang 2013, p. 112). Figure 22 provides examples of such explanatory theory that address the relationship between the built environment and the well-being of people inhabiting the spaces. In later years, especially the influence on patients' healing process has been examined through different research perspectives.

The literature review in this thesis focuses on what Groat and Wang (2013) refer to as 'explanatory theory' from diverse research disciplines. As such, the review excludes accounts of 'intended gestures,' referring to the intended/assumed impacts of architectural interventions on the well-being of the residents, and only includes studies that document an actual impact on residents' experience and/or behavior ('lived gestures'). Due to the interdisciplinary problem field, references from a broad spectrum of disciplines were examined and included. Peer review in an academic journal was used as an indicator that the reported study meets the academic standards of its field.

The study has been performed as a database search in Science Direct. The following search words were used: *(renovation OR retrofitting) AND (resident OR tenant) AND (well-being OR health OR comfort) AND (multifamily OR apartment building) AND (effects OR impact OR influence OR outcome)*

The search resulted in 645 hits, which were subsequently examined for relevance to the present study. The first



screening was performed on a title or abstract level, followed by a screening of full articles. The main inclusion criteria were: peer-reviewed, original research articles published within the last five years. The time frame was introduced to delimit the search and focus the study on state-of-the-art within recent years. The review focused on studies on apartment and building scale; however, it also included studies on interventions to exterior spaces in residential areas. To ensure climatic and cultural similarities, a geographical delimitation was set up for the review, including Northern Europe/Western Europe. All of the mentioned delimitations were introduced to ensure the best possible macro-contextual similarities from study to study. Priority was given to studies, including empirical data collection related to the experienced influence of alteration measures 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 (Appendix D) and synthesized in Table 11 on page 128, inspired by Almeida & Ferreira (Almeida and Ferreira 2017) and with special attention to applied ‘alteration of the construction’ and the related ‘well-being outcome’.

The literature review was published in the paper “Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation” (Jensen et al. 2020). The paper was developed in collaboration with Johanne Mose Entwistle (JME), Hanne Tine Ring Hansen (HTRH), Anders Strange (AS), and Poul Henning Kirkegaard (PHK). The author of this thesis developed the structuring framework with critical inputs from JME and HTRH. The author performed the database search, screening of references, and analysis and wrote the paper with continuous inputs from JME, HTRH, PHK, and AS.

#### *Development of the study*

The impact studies identified through the literature review had an ‘overweight’ of focus on physical well-being, related to the perception of the indoor environmental

quality (see “Part 4: Identification”). In order to nuance the findings, two examples of references that have a more “soft”/“ qualitative” foundation have been added in Table 11 (these two references were not included in the published version of the literature review).

The added references both include follow-up studies after renovation. They are, thus, assessed to respect the search criteria related to establishing actual “lived” gestures following alteration measures having been implemented. Nevertheless, they fell outside the original search criteria of the initial structured study. The added references are included in Table 11 in orange writing.

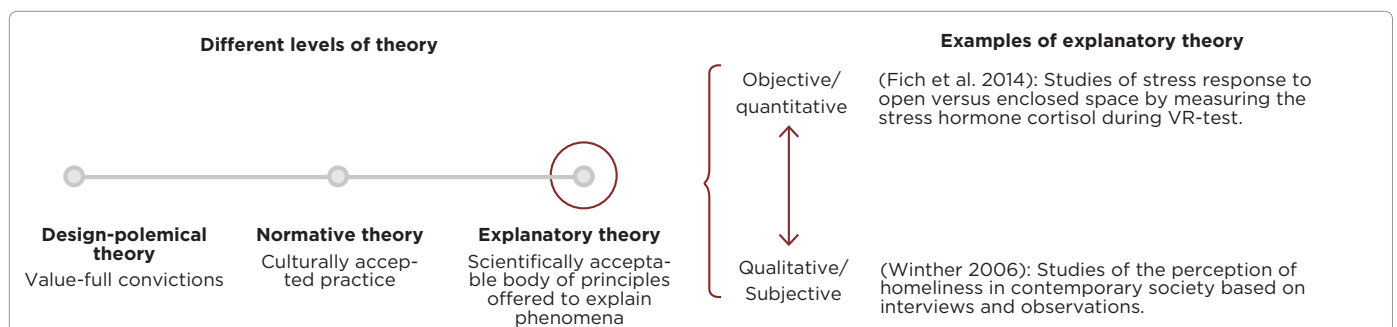
The added references are:

- Stender and Bech-Danielsen (2019): A peer-reviewed article, which was not detected when using the established search words.
- Nørgaard and Rudå (2021): A report from the Danish research institution BUILD (formerly known as the Danish Building Research Institute). As the research is not published in a peer-reviewed article, it does not adhere to the established search criteria. Nevertheless, BUILD represents a well-established knowledge institution. For this reason, the report is included in this “added layer” of the review to exemplify “softer” aspects of resident well-being.

The two references were identified in connection with the narrative literature review as part of establishing a state-of-the-art of the project (Onwuegbuzie and Frels 2016; Cronin et al. 2008).

#### **PHASE B**

Following the three individual studies described above, Phase B (Figure 19 on page 51) included a synthesis of the findings. The approach was to establish “well-being themes” based on the findings of the literature review, and further, to nuance the findings using the results from the architectural analysis and empirical studies. The choice to establish well-being themes was inspired by Gehl (Gehl 1973). As part of the synthesis, the well-being themes were related to the context of Danish social housing. Further, the themes were related to typical energy renovation measures to answer Objective 2b.



**Figure 22** Examples of different levels of research related to well-being in the built environment. The literature review focuses on ‘explanatory theory’ from different disciplines (the illustration to the left is inspired by Groat and Wang 2013, p. 111).



# Objective 3 Communication

Objective 3 consists of the following sub-objectives:

*3a. To describe typical characteristics of the early stages of renovation of multi-family social housing.*

*3b. To exemplify how a framework could be developed to visualize potentials for synergies between energy savings and improved resident well-being, in a manner where traditionally “soft,” qualitative aspects are treated on equal terms as “hard,” quantitative aspects (to be used by architects when engaging in dialogue with other stakeholders in the early design process).*

Whereas Objective 2 was devoted to identifying examples of synergies between energy savings and resident well-being, Objective 3 focuses on how to bring the identified insights “into play” in future renovation projects.

Objective 3a was addressed in part in the introduction to this thesis, by including a brief overview of the typical renovation process and the typical stakeholders involved when performing renovation of MSH in a Danish context. The findings of a research through design study (RtD study) were used as a point of departure for exemplifying the general process. Subsequently, the RtD-case was used to explore the creative interdisciplinary process in more depth, first by pointing to key learning points related to the decision process, and after that by zooming in on three downstrokes into the decision process and discussing how insights into potential synergies between energy savings and increased resident well-being might have supported the process in these specific situations (shown as Phase A in Figure 23).

Objective 3b was addressed by pointing to different approaches within the architectural field for informing the early design stages (shown as Phase B in Figure 23). After that, three different concepts for informing the process were proposed (Phase C in Figure 23). First, a concept was proposed based on metrics for computer simulation. The concept was evaluated relative to the key findings of Phase A and – in a developed form – through a focus group interview. The findings of the preliminary evaluation formed the basis for proposing two additional concepts for informing the process: the first being an example catalog and the second being an addition to the example catalog focusing on supplying examples of monetary valuation of the identified examples of value creation. These two additional concepts were also evaluated relative to key

findings of Phase A, and lastly, the chapter’s findings were summarized in Figure 23.

## PHASE A Research through design

As part of the PhD project, the author has been involved in four renovation design projects in the studio of AART architects in Aarhus. On a general level, this has helped the PhD student to gain valuable background knowledge about the field.

One of the projects, B4, in Gellerup, Aarhus, has been used as the point of departure for a more thorough study. The study took place from December 2016 to April 2017. The author took an active part in the design process in the competition phase of the renovation of a MSH block in Gellerup, Aarhus. The study was based on the relatively open research question: *“How do practicing architects work to articulate, implement and assess values related to the well-being of residents and energy savings in the design phase?”*

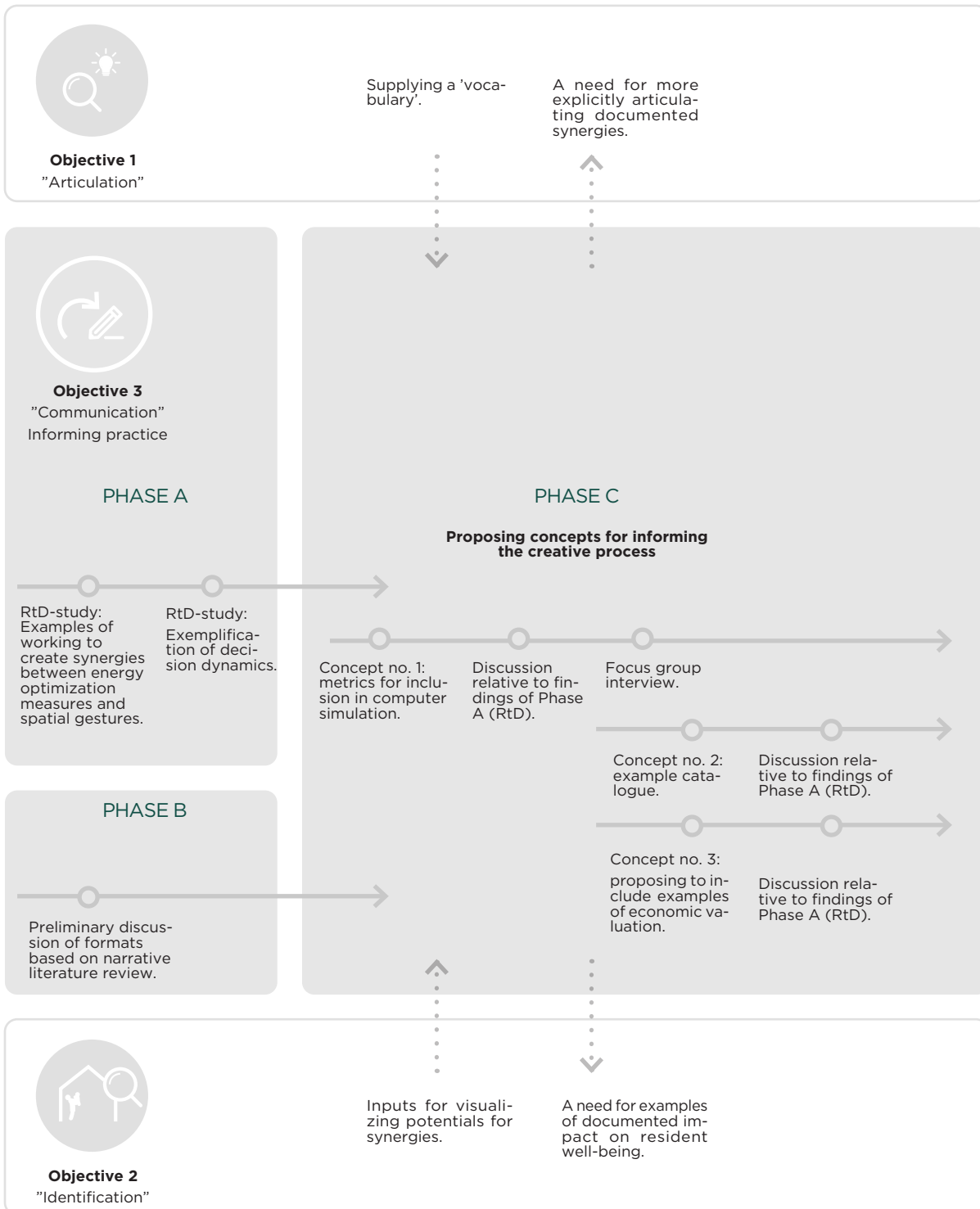
The study can be described as a ‘research through design’ study (RtD study), focusing on deriving knowledge by engaging in an architectural project team (as part of an interdisciplinary team of architects, engineers, and contractors). The reason for choosing the RtD approach was that it allows insights into “the belly of the beast” of the complex creative process, rather than observing from the outside.

Christopher Frayling in 1993 introduced the idea of doing research for, into, and through design (Frayling 1993). The research approach is closely related to action research (Frayling 1993). According to McKay and Marshall, action research can be understood in the following way:

*“One distinguishing feature of AR [action research] is, therefore, the active and deliberate self-involvement of the researcher in the context of his/her investigation. Unlike the methods of objectivist science where the researcher is argued to be an impartial spectator on the research context (Chalmers, 1982), the action researcher is viewed as a key participant in the research process, working collaboratively with other concerned and/or affected actors to bring about change in the problem context”* (McKay and Marshall 2001, p. 47).

Whereas action research may be applied in different fields (generally, fields within social sciences), this thesis leans





**Figure 23** Graphical representation of approach to investigating objective 3.

A retrospective architectural analysis of examples of gestures in the B4 project was published in the paper "A tectonic approach to energy renovation of dwellings – The case of Gellerup" (Jensen et al. 2019b). The distribution of roles in developing the paper is accounted for in this section.

on descriptions of 'research through design' to target the action research approach to the context of design. In doing so, the thesis leans on the following definition of Research through Design by Zimmerman and Forlizzi: "Research through Design (RtD) is an approach to conducting scholarly research that employs the methods, practices, and processes of design practice with the intention of generating new knowledge." [...] "On the surface, RtD can look suspiciously like design practice. However, it is generally more systematic and more explicitly reflective in its process of interpretation and reinterpreting a conventional understanding of the world, and it generally requires more detailed documentation of the actions and rationale for actions taken during the design process" (Zimmerman and Forlizzi 2014, pp. 167-168).

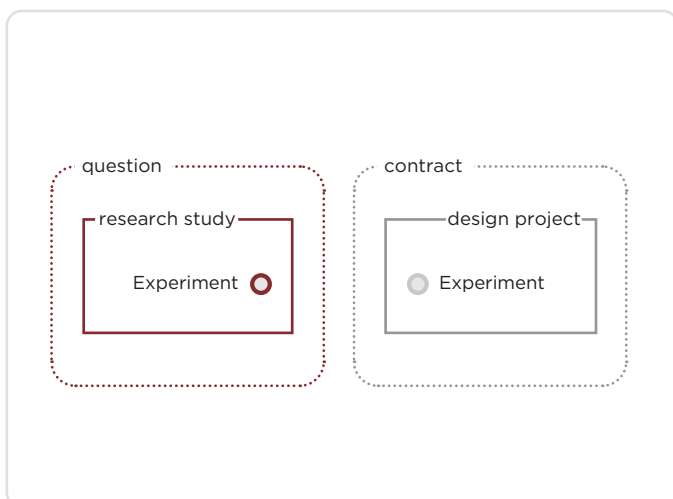
Zimmerman and Forlizzi target the field of interaction research. However, applying their line of thinking to the present thesis is found relevant, as their work represents a more detailed account of what characterizes a RtD study.

In order to navigate in a territory that "...can look suspiciously like practice" (Zimmerman and Forlizzi 2014, p. 168), it is crucial to keep the focus on the dual purposes of the design project and a RtD study. In this regard, the thesis leans on the research by Dalsgaard (2009). Dalsgaard distinguishes between a research program, which is framed by a research question, and a design program, which is framed by contractual obligations (Figure 24). Figure 24 graphically displays this distinction (using the terms research study and design project instead). The research study and the design project then have an overlap in their shared "experiment" (Figure 25).

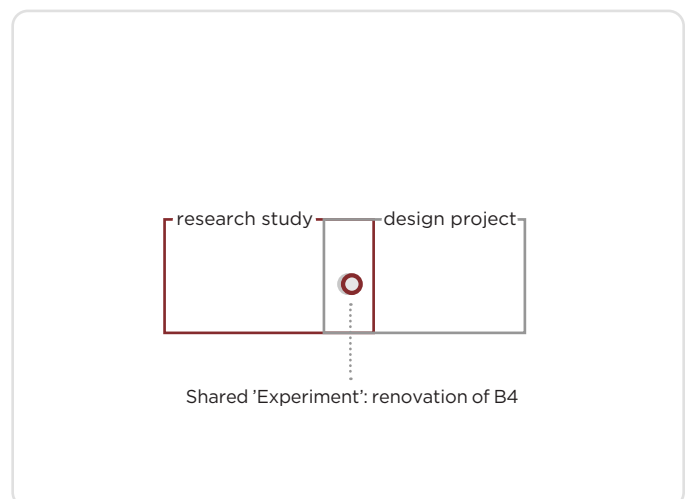
Though developed for interaction research, it is found

relevant to apply Dalsgaard's line of thinking to describe the RtD study in this thesis. In the case of the B4 project, the competition entry can be seen as the shared "experiment." The research program was framed by the open research question stated above, and the design program was framed by the competition brief (Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a).

In order to describe the "...more systematic and explicitly reflective" (Zimmerman and Forlizzi 2014, p. 168) character of the RtD-process in this project, the thesis leans on Basballe and Halskov's (2012) account of 'coupling', 'interweaving' and 'decoupling'. Basballe and Halskov describe "Coupling [as] a dynamic that unites design and research interests, and thereby establishes a framework for, as well as a set of constraints on the further steps in the process. Interweaving is a dynamic wherein one activity or material informs both design and research interests. Decoupling is a dynamic that modifies the focus, by turning either design or research interests into the salient focus of the process" (Basballe and Halskov 2012, p. 8). In the case of B4, the underlying research question formed the motivation for the PhD student to form part of the project (coupling). The full project period of designing the competition entry can be seen as interweaving research and design interest. While documentation was collected continuously throughout the period, decoupling happened after the hand-in of the competition proposal. As such, reflections on the process took place retrospectively after the design project was completed. This approach reflects that the RtD study was carried out early in the PhD project, focusing on gathering insights rather than, e.g., testing theory.



**Figure 24** "The design program [...] is framed by contractual obligations, whereas the research program [...] is framed by research questions" (Dalsgaard 2009, p. 41). This thesis uses the terms 'research study' and 'design project'.



**Figure 25** The research-project and design-project share "experiment"; however they use the experiment for different purposes (diagram based on Dalsgaard 2009, p. 41).

### Documentation

Zimmerman and Forlizzi stress that a RtD study should include “...more detailed documentation of the actions” (Zimmerman and Forlizzi 2014, p. 168) than in a ‘regular’ design project. This emphasis on documentation is also evident in Christopher Frayling’s first definition of research through design as “*materials research, development work or actions research, where a research diary tells, in a step-by-step way of the practical experiment in a studio and where the results are communicated in a research report*” (Frayling 1993, p. 5).

In the present RtD study, the process steps have been documented through a calendar of internal and external meetings, including brief notes about key decisions and where to find related collected material. The related collected material would include images from site visits and presentations from weekly/bi-weekly meetings within the interdisciplinary group of architects, engineers, and contractors. Additional material counts the tender documents, the two phases of the competition proposal, and jury report.

### Decoupling - reflection

The findings of the RtD study were synthesized in what is referred to as Key learning points. In this decoupling/reflection process, drawing material from the B4 project was used as a basis for pointing to patterns in the decision dynamics identified by the PhD student.

In addition, the RtD study was used as a basis for pointing to examples of situations where the stakeholders may have benefitted from insights on potential synergies for increased well-being and energy efficiency. These

examples are a further development of the paper “A tectonic approach to energy renovation of dwellings – The case of Gellerup” developed in collaboration with Genaro Postiglione (GP), Poul Henning Kirkegaard (PHK), and Anders Strange (AS) (Jensen et al. 2019). The PhD student performed the analysis based on discussions of the conceptual framework with GP and wrote the paper with inputs from GP, PHK, and AS.

The key learning points and examples are used as a point of reference in the later discussion of the proposed concepts for informing the process (Objective 3b – Shown in Figure 23 on page 59 as Phase C).

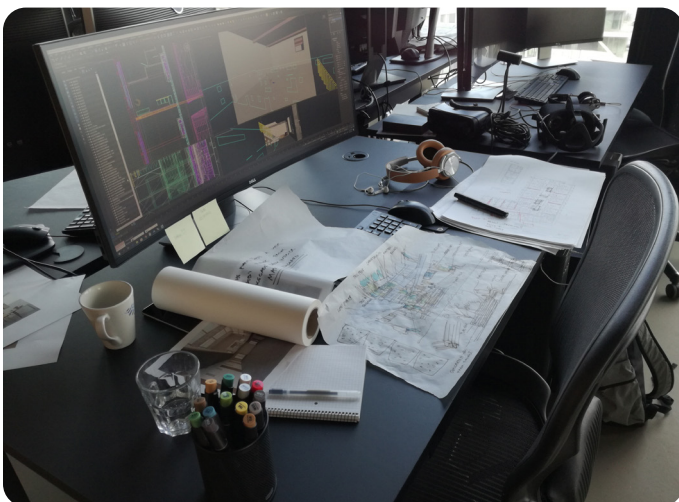
### PHASE B

#### Narrative literature review

In order to address research objective 3b, a brief literature review has been carried out to exemplify how theorists within the architectural field have previously worked to inform the creative process on “softer” themes related to resident well-being (shown as Phase B in Figure 23 on page 59).

The study was performed as a narrative literature review (Cronin et al. 2008; Onwuegbuzie and Frels 2016). The narrative approach has been selected because the purpose is to exemplify different approaches within the architectural field rather than making a systematic report on the subject at hand.

The selection process for including architectural theoreticians has been to include a span of different approaches. In order to structure the literature review, the study focused on how each of the theorists communicates findings



**Figure 26** Using research through design as a method to gain insights into the dynamics of the interdisciplinary, creative process. To the left: image from the architectural studio. To the right: image from site-visit in B4 Gellerupparken.

The section "Phase C" includes an account of the distribution of roles in relation to the papers "Towards a Holistic approach to Low Energy-Building Design: Introducing Metrics for Evaluation of Spatial Quality" (Jensen et al. 2017b) and "Towards a Holistic approach to Low Energy-Building Design: Consequences of Metrics for Evaluation of Spatial Quality on Design" (Purup et al. 2017).

The section further accounts for the distribution of roles in relation to the paper "Sustainability Key Performance Indicators' (KPIs) assessment and visualization aimed at architects in (early) renovation design processes" (Kamari et al. 2021a).

related to 'views' and 'privacy'. The themes – views and privacy – were identified as part of Objective 2 as examples of values that may be compromised or improved through renovation.

The study only included literature with relevance for the dwelling scale and its immediate surroundings. The different approaches are presented in a table, including an arrow representing the theorist's position on a continuum ranging from more loosely defined spatial themes to research focusing on establishing more generally applicable and quantifiable "rules."

### **PHASE C: Proposing concepts**

Following the literature review, three concepts for informing the early design phases have been developed; firstly, a proposal for metrics for computer simulation. After evaluation relative to findings of the RtD study and a focus group interview, two additional concepts were proposed: an example catalog and economic valuation of the social value creation.

The three concepts represent different parts of the described continuum identified in the narrative literature review (Phase B in Figure 23).

The intention was to exemplify how a framework could be developed to visualize potentials for synergies between energy savings and improved resident well-being in order to inform decision-making in the early stages of interdisciplinary renovation processes (to be used by the architect when engaging in dialogue with fellow architects and other stakeholders).

The three concepts build on the theoretical foundation established to answer Objective 1. The insights communicated in the concepts were identified as part of Objective 2. As described on page 46, the efforts to address Objective 3 made it necessary to continuously "revisit" Objectives 1 and 2. For instance, establishing an impact catalog (Concept no. 2) as part of objective 3 made it relevant to combine the conceptual framework with evaluation research to account for the documented impact of alteration measures on well-being and energy consumption (Objective 1) and to identify examples of such documented impacts in the completed renovation of MSH (Objective 2).

The proposed concepts were developed at a conceptual level and with a graphic expression at sketch level.

All three concepts were evaluated by the PhD student relative to the key findings of the RtD study. A developed version of Concept no. 1 was further evaluated through a workshop (focus group interview).

### *Establishing metrics*

Concerning Concept no. 1, the PhD student collaborated with PhD student Pil Brix Purup (PBP) to propose metrics. The author of this thesis carried out the underlying research related to the motivation for introducing the metrics and discussing alternative approaches. The metrics were developed in collaboration with PBP, who was responsible for programming the metrics as an integral part of the software IceBear for Rhino. The case study and subsequent discussions were conducted in collaboration between PBP and the author. Steffen Petersen and Poul Henning Kirkegaard contributed with insights and guidance as supervisors. Anders Strange contributed with inputs on the potential application of the metrics in architectural practice.

### **Focus group interview**

The idea of turning traditionally "softer" values into metrics – Concept no. 1 – was integrated into a study of a proposed decision-support tool developed as part of the ReVALUE project. The decision support-tool PARADIS was developed as part of ReVALUE-project to rapidly evaluate several alternative renovation scenarios in terms of a number of criteria (Kamari et al. 2021). The development of the tool itself was managed by professor Poul Henning Kirkegaard and post-doc Aliakbar Kamari. The PhD student became engaged in discussing the potential inclusion of new metrics.

Three different sketches for user interfaces (paper prototypes) were discussed with potential users in a focus group interview in May 2019. The aim of the study in its entirety was to investigate how to visualize data to best inform the early renovation design stages with decision support. The study is described in Kamari et al. (2021a), developed by the author of this thesis in collaboration with Aliakbar Kamari (AK), Poul Henning Kirkegaard (PHK), and Steffen Petersen (SP).

The PhD student organized the study with inputs from AK, SP, and PHK. The author further functioned as a facilitator of the plenum sessions and as an observer during the exercises/group discussion with the "hidden agenda" (purposefully not disclosed to the participant before the discussions) to test the participants' reaction to the inclusion of traditionally more qualitative metrics related to resident well-being alongside "traditional" metrics such as energy consumption. The idea was to make a preliminary evaluation of the idea based on these reactions. AK was the lead author on the paper, for which the PhD student provided sections and figures.

The focus group interview was conducted in Aarhus, Denmark, on 13 May 2019. It included eight practitioners: four architects, two constructing architects, and two anthropologists. The participants represented three larger architectural companies in Denmark: AART architects, Friis & Moltke, and CEBRA. The focus group interview was initiated by the PhD student giving a brief introduction. This included “setting the scene” for the subsequent discussion about (A) the use of – and level of importance assigned to – certain key performance indicators and (B) feedback on three paper prototypes. The findings reported in this thesis are based on (B) feedback on paper prototypes, focusing in particular on the “hidden agenda” of testing the participants’ reaction to the inclusion of traditionally more qualitative metrics related to resident well-being.

#### *Paper prototypes*

As mentioned, three different sketches for user interfaces (paper prototypes) were discussed with the participants. The thesis leans on the following definition of the term “paper prototype” put forward by the Interaction Design Foundation:

*“Paper prototyping is a process where design teams create paper representations of digital products to help them realize concepts and test designs. They draw sketches or adapt printed materials and use these low-fidelity screenshot samples to cheaply guide their designs and study users’ reactions from early in projects”* (Interaction Design Foundation n.d.).

The approach is often used within the field of user experience design (UX design). Since Concept no. 1 proposes metrics for computer simulation, it was found relevant to look to this field for methodological inspiration.

Paper-prototypes are often used in two-on-one interviews (Holtzblatt et al. 2005) and as part of usability tests (Snyder 2004). Since this thesis (and the studies related to the PARADIS-tool) ‘operates’ at a very early conceptual stage, it was found valuable to get more overall feedback

on the suggested approaches rather than the specifics of the tool. As such, the focus group format was chosen to allow for open-ended questions and discussions about the presented prototypes amongst a group of participants (Groat and Wang 2013).

#### *Feedback capture grid*

To organize the feedback from the participants, a so-called “Feedback Capture Grid” was introduced to the participants, inspired by Interaction Design Foundation (n.d.-b) (Figure 27). During the focus group interview, the participants were divided into two groups of four people each. They were asked to fill out the grid. At the same time, the author observed and listened to the conversations in collaboration with post-doc Aliakbar Kamari, associate professor Steffen Petersen, and professor Poul Henning Kirkegaard. Using the feedback capture grid, the participants were encouraged to express their likes, criticisms, questions, and ideas regarding the prototypes. A plenum discussion about the feedback followed the exercise.

#### *Audio and image documentation*

The filled-out feedback grids were collected and supplemented by notes taken by the author. Further, the focus group interview was audio recorded. The recordings were not transcribed but served as raw data that allowed the author to “revisit” certain discussions during the subsequent analysis phase. “Mood pictures” were taken during the session. Written consent to the documentation thorough audio recordings and images were collected from all participants.

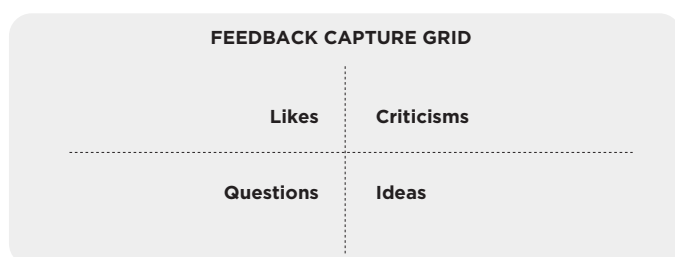
#### *Analysis and reflection*

The analysis of the data was carried out by synthesizing the findings of the feedback grid exercise. The feedback was implemented in an iteration of the PARADIS-tool (independently of the author of this thesis).

Concerning this thesis, the feedback was used to reflect on Concept no. 1. Quotations from the focus group study are included in “Part 5: Communication” for this purpose. Further, the feedback and the evaluation relative to the key learning points from the RtD study served as a point of departure for suggesting two additional concepts.

#### **Summary**

Following the proposal of the three concepts for informing the process, the findings were summarized.



**Figure 27** Feedback Capture Grid used to “capture” feedback from potential future users during the workshop (based on Interaction Design Foundation 2019).

# Part 3 : Articulation







# Towards an architectural conceptual framework

The previous chapter accounted for the methodology of the thesis. This chapter is devoted to objective 1:

*To develop a conceptual framework for articulating synergies between energy savings and improved resident well-being in renovation from an architectural perspective.*

The thesis focuses on supporting the architect's role as a promoter of energy savings and resident well-being within the highly interdisciplinary and complex field of renovation of MSH. Objective 1 should help gain a stronger theoretical foothold for articulating synergies from an architectural perspective. This is considered essential in order to establish a foundation from where to engage in the two remaining objectives, focusing on *identifying* and *visualizing* synergies (Objectives 2 and 3) (Figure 28).

## TOWARDS A CONCEPTUAL FRAMEWORK

The chapter is divided into three sections; first, an introduction to different approaches to the term 'well-being' in the built environment. After that follows an account of Phase A and Phase B in developing the conceptual framework.

### Resident well-being in the built environment

Before discussing how to articulate synergies between well-being and energy-saving initiatives in the renovation of MSH, it is relevant to first reflect on the concept of well-being in the built environment. The section provides an introduction to different perspectives on the concept and positioning of the research of the present thesis relative to these perspectives.

### Phase A

Following the reflection on the use of the term 'well-being', the chapter proposes a combination of tectonic architectural theory and renovation theory as a point of departure for articulating how renovation measures may influence energy performance and resident well-being through the spatial gestures they trigger.

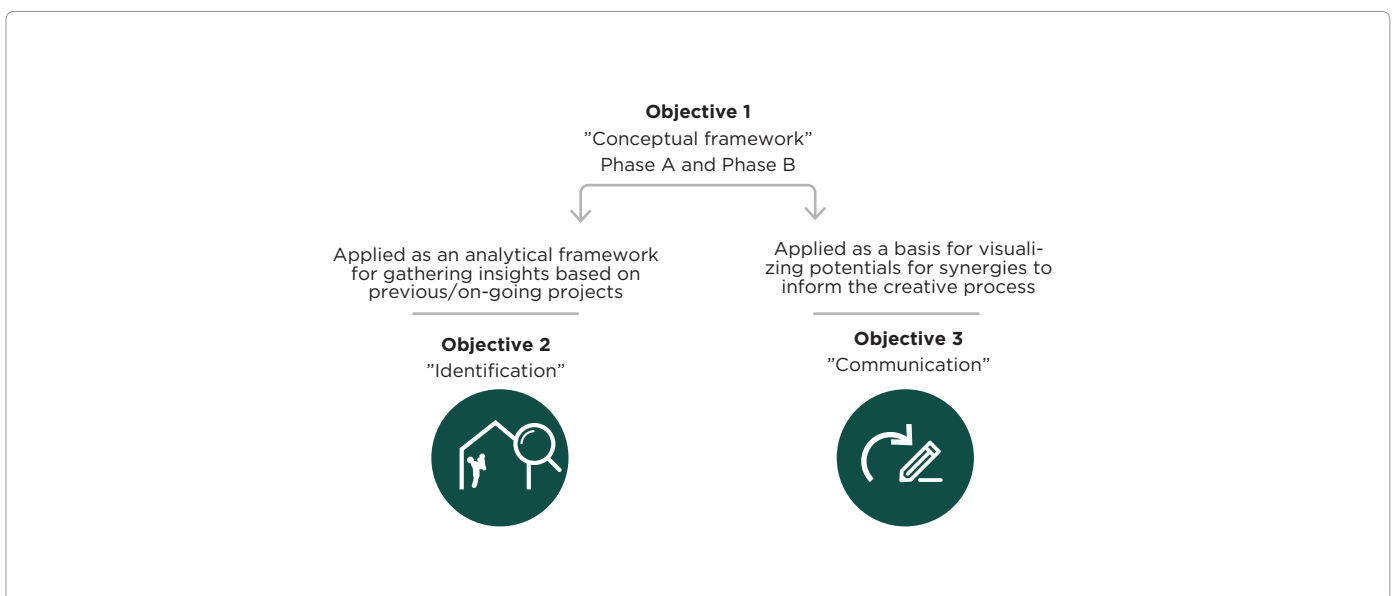
Subsequently, the section includes the findings and reflections from applying the conceptual framework as an analytical lens in a comparative analysis of two completed renovation projects and from discussions with academics engaged in teaching on related subjects.

Phase A reflects the main efforts to answer Objective 1. However, it also forms "a step on the way" in developing an elaborated version of the framework in Phase B.

### Phase B

Based on the experiences from Phase A, it is found relevant to distinguish between *intentions/potentials* for value creation and *documented* value creation. This calls for further development of the conceptual framework to articulate if the alteration of the construction has indeed contributed to an increased sense of well-being for the residents. In Phase B, this is addressed by proposing combining the conceptual framework from Phase A with terminology adopted from evaluation research.

Lastly, the findings from the two phases are summarized, and it is outlined how the findings are used to address Objectives 2 and 3 respectively in the remaining parts of the thesis.



**Figure 28** The perspective is to further develop and apply the conceptual framework in fulfilling Objectives 2 and 3, which focus on identifying and visualising potentials for synergies between energy savings and resident well-being.

# Well-being in the built environment

## THE IMPACT OF THE BUILT ENVIRONMENT

The thesis is based on the ontological assumption that the built environment (and energy motivated alterations hereof) influence residents' sense of well-being. The idea of considering the built environment and the well-being of people inhabiting this environment is not a novelty. On the contrary, it has been a subject of concern throughout history, dating back to Vitruvius, who claimed that architecture should be rooted in 'firmitas' (durability), 'utilitas' (convenience), and 'venustas' (beauty) (Vitruvius (transl. by Morgan) 1914).

Nevertheless, researchers have pointed to a somewhat limited understanding of the notion of architecture amongst stakeholders in the building sector, e.g., Erik Nygaard (2002): "...In several of these groups, there was a tendency to see architecture as some kind of supplement to the more measurable forms of quality. Architecture was seen as something exterior, which could be added in larger or smaller doses, once the concrete concerns were settled" (Nygaard 2002, p. 91, translation by author).

In order to articulate the impact of renovation measures on the well-being of residents, it is crucial to first break with this delimited understanding. To shift focus from architecture as an artistic "supplement" to architecture as a catalyst for value creation; from a focus on the building itself (what it *is* and how it *looks*) to a focus on how the built environment influences the everyday lives of the residents (what it *does*).

In this regard, the following statement from the foreword of Harry F. Mallgrave's "Architecture and Embodiment" has served as a great inspiration:

*"...we should turn our focus away from the objectification of architecture (treating design as the creation of objects) and redirect it back to those for whom we design: the people inhabiting our built environments"* (Mallgrave 2013, foreword).

## DIFFERENT PERSPECTIVES ON WELL-BEING IN THE BUILT ENVIRONMENT

Well-being in sustainable renovation represents a highly interdisciplinary field. In order to position the research of the present thesis, the following text provides a brief introduction to different research perspectives on well-being in the built environment at a more general level.

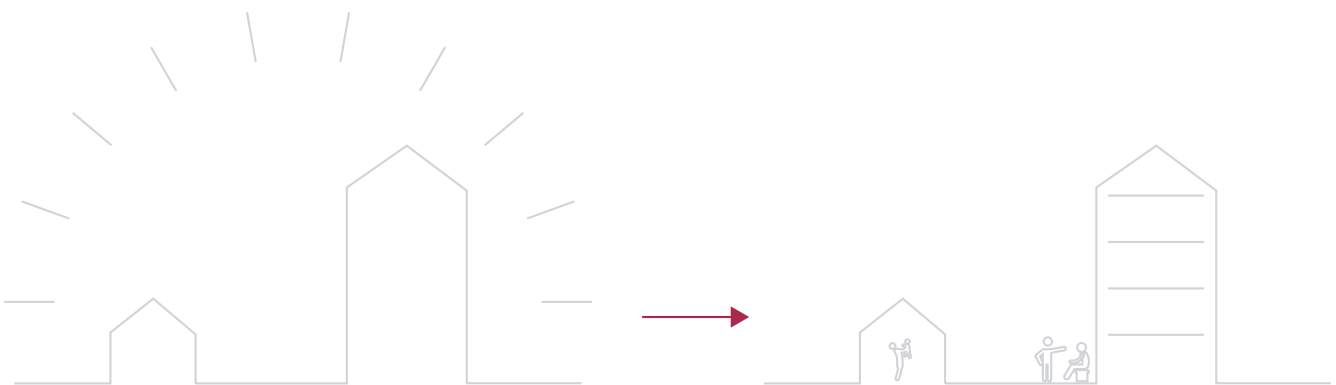
Within the field of energy research, the synonym 'comfort' is often applied when characterizing a given physical environment (Madsen 2017).

According to Line Valdorff Madsen, "*The concept of comfort is often taken for granted*" (Madsen 2017, p. 3). To continue, "*...comfort is most often inscribed as thermal comfort. As such, the meaning of the word comfort is implicit in energy research...*" (Madsen 2017, p. 3). This understanding may be traced back to Fanger's seminal work on thermal comfort in the 1970s (Fanger 1970; Madsen 2017). Also, the study of existing initiatives in the introduction to this thesis revealed that most frameworks that include attention to both energy savings and resident well-being tend to emphasize physiological, quantifiable well-being themes, such as thermal comfort.

To counterbalance this tendency, this thesis pursues a broad understanding of resident comfort, going beyond physiological comfort. There are several examples of the term 'comfort' being used more broadly. For instance, Chappells & Shove stated that "*The term 'comfort' might be used to describe a feeling of contentment, a sense of cosiness, or a state of physical and mental well-being*" (Chappells and Shove 2004, p. 3). Nevertheless, in the context of this thesis, the term 'well-being' will be used to differentiate the work from the prevailing delimited understanding of comfort within the field of energy research.

Lars Fich et al. (2014) and Ida Wentzel Winther (2006) represent two examples of addressing 'well-being' from distinctly different perspectives. Fich et al. (2014) studied the level of the stress hormone cortisol in response to open versus enclosed space. At the other end of the methodological scale, pedagogic anthropologist Ida Wentzel Winther unfolded perceptions of the home from a cultural-phenomenological perspective. Winther was concerned with what makes people 'feel at home.' As such, she focused on emotional aspects of dwelling, using qualitative interviews and observations (Winther 2006).

*“...we should turn our focus away from the objectification of architecture (treating design as the creation of objects) and redirect it back to those for whom we design: the people inhabiting our built environments”*  
(Mallgrave 2013, foreword).



**Figure 29** From viewing architecture as an art form (“what it is”) to viewing architecture as catalyst for social and environmental value creation (“what it does”).

If looking up the term 'well-being' in the Oxford English Dictionary, the following definition of the noun can be found:

*"Well-being, n.:*

*With reference to a person or community: the state of being healthy, happy, or prosperous; physical, psychological, or moral welfare"*

(The Oxford English Dictionaries n.d., "well-being" entry).

Applying the above quotation to this thesis's specific context, the thesis is thus concerned with the *"physical, psychological, or moral welfare"* (The Oxford English Dictionaries n.d.) of the residents in a social housing dwelling undergoing renovation. Acknowledging the limitations of physical initiatives, the focus will be on promoting physical and psychological well-being and leaving morality for others to address.

Considering *both* the physical and psychological well-being of people inhabiting this environment is not new. Theorists accounting for the development of the dwelling through history (e.g., Schoenauer 2000; Frampton 1995; Winther 2006) have pointed to multiple interrelated purposes of the dwelling, e.g., to provide physical shelter and the physical framework for people to "dwell" in an existential understanding of the word. The latter perspective was promoted in the phenomenological, philosophical writings of, e.g., Bachelard and Heidegger (Bachelard (transl. by Jolas) 1994; Heidegger (transl. by Hofstadter) 2013) and made topical by, e.g., Winther (Winther 2006), who argued that the physical frame of the home is still central in supporting a sense of dwelling in today's society.

Different theorists have proposed a broader set of indicators for ensuring residents' physical and psychological well-being in the built environment. Within the context of the Danish housing sector, environmental psychiatrist Ingrid Gehl already in 1971 published a guideline as part of the Statens Byggeforskningsinstitut, SBI (Danish Building Research Institute) series of publications. In this guideline, she stated that the living environment [bo-miljø] influences human well-being by prompting experiences, influencing behavioral patterns and feelings (Gehl 1973). Building on the work of Abraham Maslow, and based on a combination of literary references and explanatory photo documentation, she pointed the attention of the reader to physical and psychological "bo-behov" [living needs] that

should be met to accommodate human well-being. More precisely, she proposed six physiological needs: Sleep and rest, Food and drink, Urination and defecation, Hygiene, Sex, Air, and Light and sun; and eight psychological needs: the need for Contact, for Isolation, for Experience, Activity, Play, Structuring, Identification, and Aesthetics (Gehl 1973, the listing is based on Gehl's English summary, p. 166f.). In addition, she proposed needs related to safety.\*

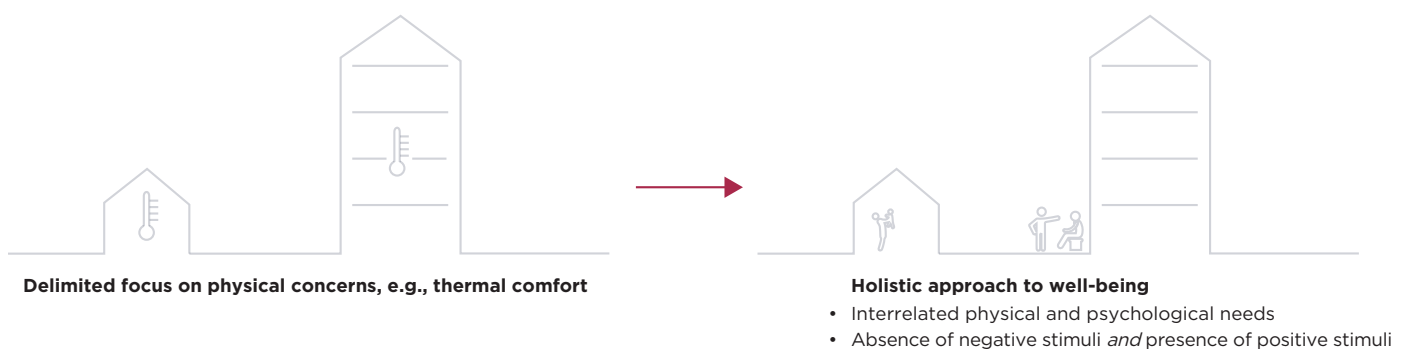
Architectural theorist Terry Peters in 2016 advocated for the relevance of 'rediscovering' Gehl's work as a basis for contemporary discussions on sustainability in the built environment (Peters 2016). However, at the same time, she stated that it is necessary to revisit the themes proposed by Gehl and substantiate her claims through *"more specific scientific, peer-reviewed studies of psychology to underline each of the main points, driving home the impact of design on human behavior and wellness"* (Peters 2016, p. 374). Peters herself has proposed such substantiation with references to contemporary research (Peters 2016). Peter's updating of Gehl's 'living needs' directs attention to a broader range of physical and psychological well-being themes that may be influenced by (renovation of) the built environment. The work is in line with other voices in current research, who question the apparent focus on single, quantitative well-being parameters in the building industry, such as temperature and humidity, and stress a need to acknowledge the interwoven character of physiological and psychological human needs (for example, Rohde et al. 2020; Brunsgaard and Fich 2016; Steemers 2015).

The present thesis endeavors to promote such a broad understanding of resident well-being in the context of sustainable renovation of MSH.

Further, it is found necessary to stress that promoting resident well-being in sustainable renovation of MSH is not only about securing the absence of negative stimuli. It is also about ensuring the presence of positive stimuli. This was addressed by, e.g., Koen Steemers (2015) and Rohde et al. (2019), the latter with a specific focus on indoor environmental quality. Accordingly, this thesis is not (only) focusing on potentials to limit poor health, but on potentials for promoting *"complete physical, mental and social well-being"* (WHO n.d., para. 1). In the words of Steemers, *"The notion of well-being consists of two key elements: feeling good and functioning well"* (Steemers 2015, Defining health and well-being, para. 7).

\* Gehl mentions Basic physical safety, Avoiding harmful sensory stimuli, Safety from accidents, and Traffic safety.





**Figure 30** From a delimited understanding of (thermal) comfort to a more holistic understanding of well-being. The thesis promotes an understanding of well-being, spanning both physical and psychological concerns, and focusing on limiting negative stimuli as well as promoting positive stimuli.

## SUMMARY

Summing up, this section has stressed the importance of breaking with existing delimited understandings of architecture as an artistic supplement and focusing on how the built environment influences the everyday lives of residents (what it does) (Figure 29 on page 69).

The section provided a brief introduction to different perspectives on the concept of well-being in the built

environment and an account of the understanding of the term promoted in this thesis.

The thesis promotes a broad understanding of the well-being term, spanning physical and psychological well-being aspects, and focusing on limiting negative stimuli as well as promoting positive stimuli. This understanding forms the basis for engaging in the established research objectives (Figure 30).

The section includes a development of the paper “Renovation of social housing: a tectonic dialogue between past and present?” (Jensen et al. 2019a). The text has been edited to form a coherent part of the thesis.

Further, the first paragraph under “Towards a conceptual framework...” was previously published as part of the paper “Potentials for increased resident well-being in renovation of multi-family social housing” (Jensen et al. 2021).

# Towards a conceptual framework phase A

The interrelated nature of the material world and human perception has been studied from various perspectives, e.g., through the lenses of change theory, material cultures, actor-network theories, and socio-technical theories. As an architect, it has been natural to look into our own theoretical “backpack” to establish a standpoint from which to act in the highly interdisciplinary field of MSH renovation. As such, Phase A is based on a rereading of architectural theory.

In this section, a combination of tectonic architectural theory and renovation theory is proposed as a lens to articulate how specific ways of constructing the built environment (or altering the built environment in the case of renovation) may influence the energy performance and influence resident well-being through the spatial gestures they prompt or inhibit – for instance, inviting for social interaction or allowing for privacy.

The section is based on the paper “Renovation of social housing – a tectonic dialogue between past and present?” presented at the Nordic Association of Architectural Research symposium 2017 (Jensen et al. 2019a). The text and figures have been edited to form a coherent part of the thesis. Further, the sub-section ‘A Tectonic Approach to Sustainable Renovation?’ has been elaborated with additional references from architectural theory.

The first part of the section is devoted to developing a conceptual framework based on a rereading of Eduard Sekler’s tectonic architectural theories combined with writings by Fred Scott on alterations in architecture. In this matter, Sekler’s tectonic theory provides a vocabulary for articulating the relation between technical initiatives and the implication on perceived spatial quality. By combining this approach with Fred Scott’s writings on renovation theory, the aim is to relate tectonic theory to the renovation domain, which is by definition centered on alterations to an existing building and an understanding of our initiatives not as something final but as a downstroke in a continuum.

In the second part of the section, the developed framework is applied in a comparative analysis of two MSH renovation cases: Park Hill in Sheffield, UK and Rosenhøj in Aarhus, Denmark. They were selected as two complementary cases related to Scott’s alteration spectrum on how to approach (sustainable) renovation (Scott 2008). One represents a listed project, focusing on a combination of

preservation and reinterpretation, and the other represents an approach focused on renewal. Hereby, a comparative study of the two opens up a potential to study whether introducing a tectonic lens in the context of sustainable renovation can help articulate the consequences and potentials of technical initiatives on the perceived spatial quality across Scott’s alteration spectrum.

The housing estates were both built in the 1960s and have been renovated within the last decade (Levitt 2010; Aarhus Omegn n.d.). Despite differences in scale and layout, for example, they represent comparable cases in terms of typology and age. This allows for the focus on the applied renovation initiatives and how they have affected the perceived spatial quality. The analysis is based on drawing material, literary references, and interviews with representatives of the renovation teams.

Lastly, the section discusses perspectives and potentials for developing and implementing the architectural conceptual framework as a way to position the question of spatial quality and well-being in the early stages of renovation projects alongside attention to energy savings.

## A Tectonic Approach to Sustainable Renovation?

Throughout the history of architecture, the notion of tectonics has been applied as a critical means to discuss the task, role, and responsibility of the architect in bringing together technique and aesthetics. In this section, tectonic theory is reintroduced as a starting point for addressing energy renovations and establishing a link between environmentally motivated alterations and the spatial experience of the building.

The term ‘tectonic’ derives from the Greek word *tekton*, signifying a carpenter or a builder. Throughout history, the term has developed to signify what Kenneth Frampton refers to as ‘poetics of construction,’ a linkage between a given construction of a space and the way people experience that space (Frampton 1995). According to Frampton, the first poetic connotation of the term appeared in the poems of the Greek poet Sappho in the 6<sup>th</sup> century BC (Frampton 1995). This suggests an early understanding of the act of construction as not only a pragmatic concern but as something which influences human perception at a deeper level.

The notion of tectonics reappeared in German architectural theory around 1850 as a response to the eclectic formal development of architecture and its relation to a

possible meaningful exploitation of emerging industrial technology (Semper (transl. by Mallgrave & Herrmann) 1989; Bötticher 1852). In the wake of postmodernism, the application of tectonics reappeared as a lens through which to discuss a meaningful development of architecture rooted in primordial aspects of dwelling, on the one hand, and in exploiting technological inventions, on the other. This was, for instance, evident in the seminal writings of Kenneth Frampton (Frampton 1995).

In contemporary research, this interest in tectonics seems to be increasing, lately being associated with the question of ecology and sustainability as well (Beim and Madsen 2014; Ejstrup 2019; Beim et al. 2019; Hvejsel et al. 2015). This section builds upon this foundation with the aforementioned attempt at applying tectonics as a critical lens for articulating the spatial potential of technical energy-saving initiatives.

This thesis leans in particular on Eduard Sekler's etymological study of tectonics. The reasoning for doing so is that his studies represent a relatively clear theoretical framework for addressing the interrelation between technique and spatial quality. In his essay 'Structure, Construction, Tectonics,' Sekler defined 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 1965, p. 93). He thus established a link between what he referred to as the structural concept and the way it ultimately affects the experiencing subject through spatial 'gestures' once the structural principle is manifested, or realized, in concrete' construction' (Sekler 1965).

In the paper 'Towards a Tectonic Approach: Energy Renovation in a Danish Context,' Marie Frier Hvejsel, Poul Henning Kirkegaard, and Sophie Bondgaard Mortensen proposed that Sekler's terms be used as a vocabulary to articulate not only the "visible play of forces" (Sekler 1965, p. 93), but also the implications of technical interventions on the perceived spatial quality in a broader sense (Hvejsel et al. 2015). Building on this reading of Sekler's theory, this thesis proposes that the notion of structure, construction, and gestures can be used to describe how the technical concepts are realized through specific measures of alterations to the construction and to what degree these alteration measures contribute to well-being for the residents through improved spatial gestures.

The term spatial gesture is used to denote the resulting spatial capabilities of, e.g., the building envelope in the exterior and interior, spanning from how it is experienced from a distance, for example, when viewing the building as part of the urban fabric, to the experience through tactile encounters on the smallest scale.

The importance of articulating spatial gestures as a matter of entirety as well as detail was mentioned by, e.g., Stylsvig Madsen and Beim (2012), who stated that "*Details play a central role to our immediate experience of architecture. We usually get in direct physical contact with this small scale part of the building*" (Stylsvig Madsen and Beim 2012, Section 1.1). Frascari referred to details as "...minimal units of signification in the architectural production of meanings" (Frascari 1996, p. 500). Relating the statements to the context of sustainable renovation, it is thus crucial to consider how specific alterations to the construction, e.g., the addition of exterior re-insulation, influence the well-being of residents not 'only' through changes to the exterior expression but through gestures at the smallest scale. Pallasmaa, from his end, emphasized the importance of reaching beyond a visual understanding of (alterations of) architecture: "*The authenticity of architectural experience is grounded in the tectonic language of building and the comprehensibility of the act of construction to the senses. We behold, touch, listen and measure the world with our entire bodily existence...*" (Pallasmaa 2012, p. 69). His statement directs attention to how alterations to the existing construction not 'only' influence human perception through visual gestures. Rather, alterations should promote sensuous encounters in a scale close to the body.

These additional examples from tectonic theory serve to supplement the rereading of Sekler by pointing to the importance of addressing the implications of alteration measures on spatial gestures across scales.

### Tectonic thinking in renovation

The task of renovating a building differs significantly from building 'from scratch,' as it involves an evaluation of the state or value of the existing construction and how to manage this in the renovation process. In order to relate the rereading of Sekler's tectonic architectural theory to the field of (sustainable) renovation, it is suggested to combine the tectonic framework with perspectives from renovation theory. Historically, changing – and even conflicting – attitudes to managing the existing built

environment have been advanced. For example, the 19<sup>th</sup> century French architect and author Eugène Emmanuel Viollet-le-Duc advocated an approach to renovation based on restoring the grandeur of the original building, maybe even a grandeur that has never existed (Viollet-Le-Duc 1854–68 cited in Scott 2008, pp. 45, 59). By contrast, his contemporary, the author John Ruskin, considered such a restorative approach to be altogether deceiving and advocated an approach based on preservation and preventing interference (Ruskin 1866). The purpose of including these examples is not to initiate a thorough account of the theoretical development of the renovation field. Rather, the intention is to exemplify different views on the matter.

This section leans on writings on alteration by the architect and design theoretician Fred Scott. Based on a critical review of existing theories (the theories formulated by Viollet-le-Duc and Ruskin, among others), Scott stressed that if buildings are to stay inhabitable, they must be understood as part of a spatial continuum in constant alteration. When faced with the task of renovation, the architect inevitably enters into a dialogue with this continuum.

Where Sekler's tectonic theory offered a vocabulary for articulating the spatial implications of technical initiatives, Scott's writings provided a theory for understanding the initiatives not as something static or final but as one of many alterations that the building will undergo throughout its lifespan (Scott 2008). His understanding of renovation as a downstroke in a constructed spatial continuum is crucial when seeking to add lasting value for the users. Scott pointed out that the changes to a building alter our perception of it:

*"If electricity is introduced into a pre-electric building, it alters it. If central heating is put in to replace local heating via foci of heat, such as stoves and fireplaces, the building is altered spatially. Most markedly, if extensive electric lighting is introduced, the building is altered. The alteration is in the way the building is perceived: to see the spaces fully illuminated by an internal light source during the hours of darkness causes the building to be seen differently from at its inception"* (Scott 2008, p. 92).

This supports the tectonic understanding that (technically motivated) interventions ultimately affect how a building is perceived and therefore constitute a spatial challenge. There are, of course, multiple degrees of alteration. Scott

referred to wiring as an example of an alteration that can be easily concealed. In contrast, comprehensive changes to the spatial arrangements may cause a greater 'stir.' In the case of sustainable renovation of social housing from the 1960s, the intention is not to introduce electricity or central heating. Rather, the focus is on the energy performance of the building. In the specific case of energy renovation, research shows that one of the biggest potentials for energy savings lies in the re-insulation of the building envelope (Jensen 2009). Furthermore, this is a commonly applied strategy in a Danish context. In order to ensure relevance for contemporary practice, the focus of this section is, therefore, placed on this particular part of the building, investigating the spatial implications of altering the building envelope to be more energy-efficient.

Scott stated that "[w]ork to existing buildings is of two types: either restorative or interventional" (Scott 2008, p. 64) and that a building can be altered "...in the style of the original or in contrast to it" (Scott 2008, p. 95). As an interpretation of these statements, three concepts for articulating the degree of alteration to the building envelope are introduced: preservation, reinterpretation/ accentuation, and addition/renewal. These concepts represent extremes, and, as such, a building renovation could often represent an approach somewhere 'in-between' or even include different approaches in relation to different building components. Further, other theoreticians have suggested alternative, more detailed categorizations (e.g., Feilden and Jokilehto 1998). Nevertheless, Scott's statement serves as a reminder that different views on this matter exist. It is relevant to articulate the implications for spatial quality in one approach over another depending on the level of existing quality in the particular project. The three concepts serve as a starting point for this articulation.

Relating back to the tectonic notion of 'spatial gestures' inspired by Sekler, one can say that the specific alterations to the construction can serve to 'preserve' or 'reinterpret' / 'accentuate' existing spatial gestures or 'add' new spatial gestures.

In summarizing the content of this section, it can be seen that the works of Sekler and Scott overlap in the sense that they both stressed the implications of technical initiatives on the perceived spatial quality in buildings. Based on the above rereading, the following interpretation of the two theories is introduced as a point of departure for

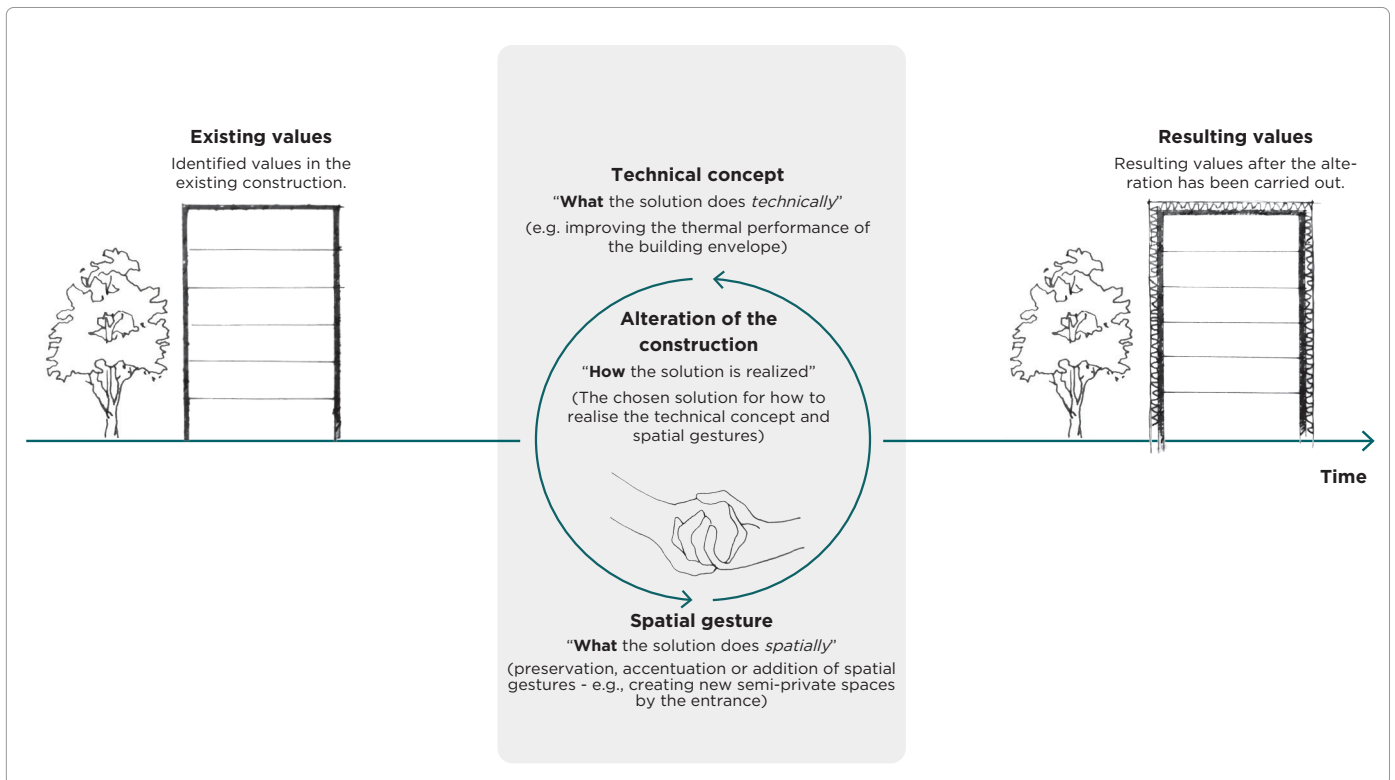


Figure 31 Proposed conceptual framework.

articulating the consequences and potentials of alterations on the perceived spatial quality in the particular context of contemporary sustainable renovation:

*Eduard Sekler:*

Introducing a vocabulary to describe how **technical** concepts (such as reduction of energy losses through the building envelope) are realized through **alterations to the existing construction** and to what degree these alteration measures contribute with **spatial gestures** which may influence the **well-being** of residents.

*Fred Scott:*

Establishing (sustainable) renovation as a dialogue between the past, present, and future, in which the existing construction is altered to ensure the value of the building to the inhabitants over time by **preserving** or **reinterpreting/ accentuating** existing values or **adding** new values.

## INTRODUCING AN ARCHITECTURAL CONCEPTUAL FRAMEWORK

The ideas presented above are summarized graphically in Figure 31, which will serve as a framework for analysis in the following.

The figure visualizes the process of identifying existing spatial qualities in the building as it appears before renovation and laying down a strategy for the alteration of the construction, that is, how to realize a technical concept (such as improving the thermal performance of the envelope) through alterations to the existing construction. Depending on the chosen strategy, the alterations to the construction can serve to 'preserve' or 'reinterpret' / 'accentuate' existing spatial qualities or to 'add' new qualities through the spatial gestures they induce.



## COMPARATIVE ANALYSIS OF TWO CONTEMPORARY RENOVATION CASES

The previous section proposed an architectural conceptual framework for articulating spatial quality as part of sustainable renovation projects through an improved mutually technical and spatial dialogue between the past and the present.

This section presents an analysis of two cases based on the proposed framework. The cases are the social housing complexes Park Hill in Sheffield, UK and Rosenhøj in Aarhus, Denmark. Both projects have been the subject of extensive renovation as part of the urban regeneration of the areas in which they are located. Yet, they represent different approaches. The renovation of Park Hill, on the one hand, was performed in line with English Heritage's requirements for a Grade 2 listed building (Levitt 2010) with an emphasis on maintaining distinctive modernist and brutalist characteristics and reinterpreting others. In the renovation of Rosenhøj, on the other hand, which is not a listed area, the original intentions are more hidden. The cases have been included as examples of how similar technical concepts, like energy optimization of the building envelope, can be realized through different degrees of alteration to the existing construction, ultimately affecting the perceived spatial quality in distinctly different ways. The purpose of the analysis is to examine if the developed conceptual framework might help to articulate, at a deeper level, the implications of technical energy-saving initiatives on the perceived spatial quality in each of these approaches. The analysis of each case includes introductory facts about the building. After that, the study will focus on addressing the building envelope through a brief account of the main characteristics of the existing constructions, followed by the analysis of the completed renovation based on the proposed tectonic conceptual framework.

### PARK HILL, SHEFFIELD, UK

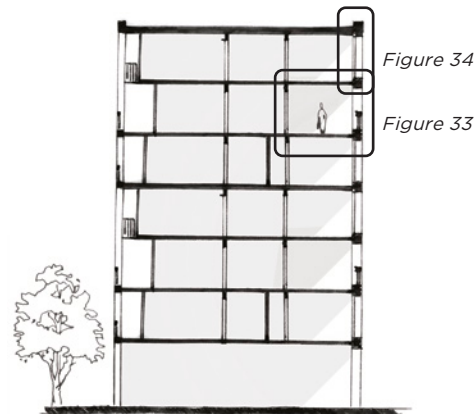
The residential area Park Hill was completed in 1961 with the help of architects Ivor Smith and Jack Lynn. Park Hill consisted of 985 flats for rent and accompanying shared services (Jones 2011; Levitt 2010). The 10-meter-wide slab blocks were built in up to fourteen stories, distributed in one continuous structure across the sloping hillside. The apartments were accessed through an entrance gallery on every third floor. This was made possible by introducing a mix of one-level apartments and maisonettes with internal staircases (Jones 2011). The typology of the Park

Hill complex differed greatly from that of the existing city. It sought to break with "*...the existing living-pattern of the area, which had become a notoriously blighted slum*" (Banham 1966, p. 132). At the time of its completion, Park Hill was considered an ambitious state-of-the-art project which met an urgent need for affordable housing. After approximately twenty years, the perception began to differ, and the once positive attitude towards the housing complex started to fade. Characteristics, such as the large scale, the extensive use of exposed concrete, and the mono-tenure principle, have been mentioned as contributing factors to the negative development. Park Hill was facing demolition when English Heritage decided to list the building complex in 1998 (Egret 2017; Levitt 2010). In 2004, the developer Urban Splash, in collaboration with the architects Hawkins/Brown and Studio Egret West, won a competition to renovate the housing complex. The renovation was carried out in three phases from 2004 onward, and the master plan involved changing the residential form from rental to mixed-tenure housing and including office spaces and a kindergarten, among other things (Egret 2017).

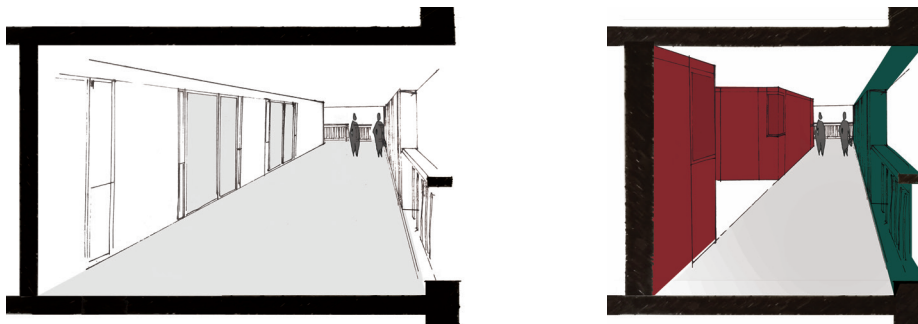
### Existing Construction (Building Envelope)

The Park Hill complex is an example of British brutalist architecture (Banham 1966). The structural concept is defining for the exterior expression, as is the repetitive composition of apartments (Banham 1961). As such, the concrete frame is a dominant characteristic in the facade. However, the rhythm of the facade is a result of the relationship between the in-situ concrete frame and its infill of precast balustrades, brickwork, windows, and balconies, all contributing to an experience of tactility and depth (Jones 2011; Banham 1966). The main materials of the construction are exposed concrete and brickwork in two colors, both materials typical for the brutalist era. The contrast of textures in these materials and the changing depths of the infill relative to the frame serve to emphasize the latter. Another characteristic of the facade is that of the galleries on every third floor. As opposed to central corridors, these entrance decks provide air, views, and a potential for social concentration. The decks further function as pedestrian bridges, so-called 'streets in the sky,' which bind together the slab blocks and connect the streets to the ground level at one end of the sloping site (Jones 2011). When the renovation project began, Park Hill was in a poor state, suffering from physical decay and social problems (Egret 2017). As such, the aim of the

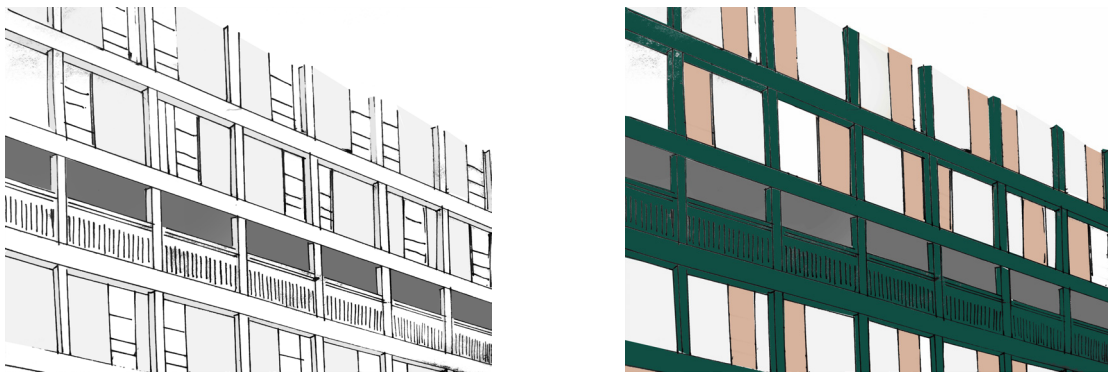




**Figure 32** Section through the Park Hill complex, illustrating the two areas of analysis (prior to renovation).



**Figure 33** Sketch of the 'street in the sky' before and after renovation (left and right respectively), ● preservation (repairs of concrete and restoration of balustrades), and ● addition of new elements.



**Figure 34** Spatial sketch of the facade above the entrance deck before and after renovation (left and right respectively), ● preservation (repairs and restoration of grid and balustrades), and ● accentuation (windows and aluminium panels).

renovation of the building envelope was to contribute to the revitalization of the complex and to update the construction to modern-day standards while at the same time respecting English Heritage's requirements for Grade 2 listed buildings (Egret 2017; Levitt 2010).

### Analysis of Renovation Initiatives (Building Envelope)

Figure 32 on page 77 illustrates a section through the building complex before renovation. Two subsections through the building envelope are highlighted for further analysis in the following text. The objective is to analyze the tectonic interrelation between the technical concepts and resulting spatial gestures in these areas of the building. To do so, the developed architectural conceptual framework has been applied as an analytical lens through which to address the alterations to the construction.

#### Street in the Sky / Covered Entrance Deck (Figure 33)

*Technical concept:* The main technical concept for the renovation of the entrance facade was to update the building envelope to a thermally efficient skin at the same time as protecting the existing concrete frame (Levitt 2010). At the eastern facade, there has also been a focus on improving the thermal and acoustical performance of the deck between the 'street in the sky' and the bedrooms in the underlying flats (Egret 2017).

*Alteration of the construction:* The technical concepts have been realized through a hierarchical approach. Everything but the concrete slabs, walls, and columns was demolished when the process began. The original concrete elements of the grid were repaired (green, Figure 33). New concrete balustrades were mounted following the original scheme, though in a slightly lighter version (green, Figure 33). The facade between the 'street in the sky' and the dwellings was rebuilt with a new facade line, including a part of the old 'street in the sky' and with only a few of the original concrete facade elements preserved. The new wall was erected as a thermally well-insulated envelope with new doors and windows (red, Figure 33) (Egret 2017).

*Spatial gestures:* The outer facade level with balustrades was altered as a continuation of the original style, both in terms of surface and spatial configuration. However, the actual building envelope (red) underwent considerable alterations, including demolishing the old wall and replacing it with new elements. The alterations allowed for new spatial gestures as the new building envelope

was alternately pushed forward or drawn back to create spaces in the interior, where it added a storage room (Jones 2011), and in the exterior, where it added a shared semi-private entrance for four dwellings. The consequence of doing this was that the 'street in the sky' was narrowed from three to two meters. The original width was defined by the milk cart being able to pass, which today is no longer a functional requirement (Egret 2017). The new layout allowed for a transition zone between the public and private realm, which has been described by a number of theoreticians as a general shortcoming in modernist housing schemes (e.g., Bjørn et al. 2015; Gehl 2003). The surface cladding material chosen for the building envelope was wooden panels. Normally, these panels would not be able to withstand the wear and tear of the climate, but in this case, the overhang allowed for protection. The finish of the joining of materials is open to interpretation, but the overall spatial gesture is that of warmth, which contrasts and accentuates the rough concrete. As part of the renovation process, windows were added in the building envelope, which allows for a little extra daylight in the interior space, but most importantly, may induce a sense of security for the entrance situation.

#### The facade above the Entrance Deck / Living Room Facade (Figure 34)

In this section, the alterations to the facade above the entrance floor, where the living rooms are located (Figure 34 on page 77), will be analyzed.

*Technical concept:* As with the facade on the entrance level, the main ambition from a technical perspective was to update the building envelope to a thermally efficient skin at the same time as protecting the existing concrete frame (Levitt 2010).

*Alteration of the construction:* In the realization, this led to a hierarchical approach to handling construction elements. Everything but the concrete slabs, walls, and columns was demolished. Starting from the stripped grid, the original concrete elements of the grid were repaired (green, Figure 34). New energy-efficient aluminum windows and sliding doors were added, filling two-thirds of the infill area as opposed to one-third in the original scheme. Squares of anodized aluminum were introduced next to the windows instead of the original brick elements (sand coloured, Figure 34) (Egret 2017; Jones 2011).

*Spatial gestures:* The treatment of the original grid can be described as preservation and continuation of the style of the original to an almost surgical degree. In this connection, it can be mentioned that the issue of thermal bridges in the concrete structure was de-emphasized to preserve the original expression of the grid (Egret 2017). By contrast, the team of consultants altered the facade elements within the grid in a more interpretive manner: the original brick elements were substituted with brightly colored aluminum as a contemporary interpretation of the graduating colors of the original brickwork. Together, the windows and the colored elements constitute a reflecting surface that contrasts the matte surface of the concrete grid. This serves to accentuate the hierarchy of the frame and infill and indicates a step change. However, it can be discussed if this happened at the expense of the tactility of the original brutalist brickwork.

In the interior, the alterations of the 'infill' provide increased access to daylight, which, together with partial demolition of inner walls, contributes to a spacious and light atmosphere. Furthermore, draught sealing the facades and the introduction of new sliding doors may improve the opportunity for utilizing the adjoining spaces.

#### **Summary: Tectonic Alteration of Construction?**

In the previous section, alterations to the building envelope in the Park Hill project have been analyzed. On the entrance deck, the 'technical concept' – energy optimization of the building envelope – has been realized through two different approaches to altering the existing construction. The first continues the style of the original in the concrete repairs and remaking of the balustrades following the original design. The second contrasts the original in the redesign of the existing building envelope into a spatial element, creating a semi-private entrance area shared by four dwellings. When analyzing the resulting spatial gestures in the building envelope, the chosen way of altering the construction allows for a visual expression in line with English Heritage's requirements at the same time as introducing new spatial qualities to the complex. On the floor above the entrance level (the living room facade), it can be seen that the energy optimizations have been realized by altering the facade elements within the existing grid. The renovation team substituted the original brick elements with colored elements, which contrasts the concrete grid's matte surface and thereby accentuates this feature. Whereas the spatial reconfiguration at the entrance level addresses the inhabitant at a

scale close to the body, the surface alterations mentioned here mainly affect the perception of the building from a cultural-historical perspective when seen from the city, as a new dialogue is initiated between the original grid and the contemporary infill of the windows and adjoining colored panels.

The aim of the analysis of the Park Hill residential area was to gain a deeper understanding of the tectonic interrelation between the technical concepts and the resulting spatial gestures. It has been established that even within the same building, the technical concept of improving the thermal performance has been realized through different degrees of alterations to the existing construction, leading to different spatial gestures. Following the analysis, the authors conclude that the renovation of the building envelope in Park Hill is an example of a tectonic alteration to the construction; it represents a high degree of mutually technical and spatial dialogue between the past and the present. The main integrity of the original architecture is preserved and reinterpreted to secure the renewed significance of the building.

The following section continues with an analysis of the Rosenhøj residential area in Aarhus, Denmark. Subsequently, the results of the analysis of both cases will be summarized and compared.

#### **ROSENHØJ, AARHUS, DENMARK**

The housing complex Rosenhøj was built from 1968 to 1970 and comprised 839 dwellings, arranged in twenty-seven four-story apartment blocks with basements (Aarhus Municipality et al. 2010). Rosenhøj was built as a part of the Sydjyllandsplanen [South Jutland plan], which was developed and administered by the Ministry of Housing and was a plan for the support of prefabricated constructions to provide good, affordable dwellings (Aarhus Omegn n.d.). The architect behind the South Jutland plan was Børge Kjær, who developed the building type in collaboration with ten housing associations. The vision was to achieve production-related advantages from developing one building type which could be mass-produced and built in a number of places across the country (Bech-Danielsen et al. 2011). The South Jutland plan can be seen as a development of earlier decades' influences from the international modernist movement and its ideals, with the aim of providing spacious dwellings with access to green areas, air, and light (Rosenberg Bendsen and

Exner 2017). The plan provided state-of-the-art dwellings with qualities such as large living rooms and bathrooms, modern kitchens, connections for washing machines, and inherent flexibility and adaptability for future changes through the merging of apartments (Bechmann 1963).

The South Jutland plan is also known as one of the so-called 'kransporsbyggerier' ['crane track developments'], which were characterized by building slabs organized in a geometrical pattern, in the case of Rosenhøj in parallel tracks. According to Jannie Rosenberg Bendsen and Anna Mette Exner, the crane track developments generally suffered from a focus on production, construction, and assembly at the expense of adaptation to local conditions and articulation of the spaces between the buildings. Other characteristics of the developments were the attention to infrastructural separation and an understanding of the settlements as independent units complete with institutions, grocery stores, and so on. Such qualities, over time, contributed to closing off the areas from the surrounding cities (Rosenberg Bendsen and Exner 2017).

Despite the good intentions in the original layout, the area experienced a troublesome development and an increasingly negative image (Nørgaard and Rudå 2021). Further, the housing blocks were generally worn down with leaking roofs and windows (Bech-Danielsen and Mechlenborg 2017). After years of preparatory work, an architectural competition was launched in 2010 (Aarhus Municipality et al. 2010). The competition was won by Viggo Madsen consulting engineers in collaboration with Arkitema Architects and EFFEKT architects (Gregersen 2011). As with the Park Hill project, the renovation formed part of a larger master plan. In Rosenhøj, there was a specific focus on opening the area to the surroundings through the redesign of the spaces in between the buildings, densifying the area through the addition of new building types, and breaking with the monotony of the area (Renover.dk n.d.).

### Existing Construction (Building Envelope)

In accordance with the South Jutland plan, the construction of the facades was based on prefabricated elements (Aarhus Municipality et al. 2010). This was reflected in the exterior, as characterized by a repetitive facade expression in all of the twenty-seven blocks. Towards the southwest, the facade was dominated by large internal balconies.

Towards the north-east, the entrance side, the building envelope was designed with continuous horizontal windows. These windows were separated by slender panels, which emphasized the impression of an unobstructed horizontal element.

Since its completion, Rosenhøj has been the subject of a number of partial alterations. In the late 1990s, for instance, the balconies were covered with glass, and the areas around the bathrooms and main entrances were reinsulated and emphasized in the facade in a characteristic postmodern way (Bech-Danielsen and Mechlenborg 2017; Petersen 2008).

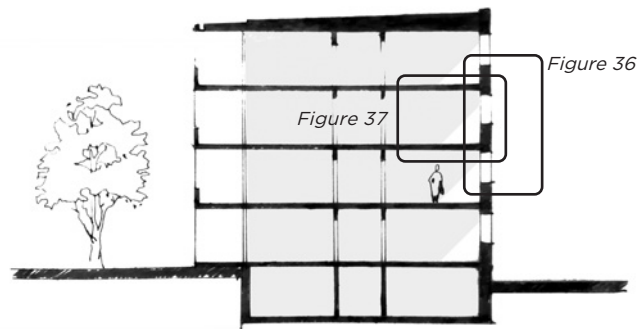
When the recent extensive renovation began, the building complex was in need of a general update. There were problems with leakage, cold bridges, and mold in the construction. As such, an important aim of the renovation was to perform extensive improvements to the building envelope (Bech-Danielsen and Mechlenborg 2017).

### Analysis of Renovation Initiatives (Building Envelope)

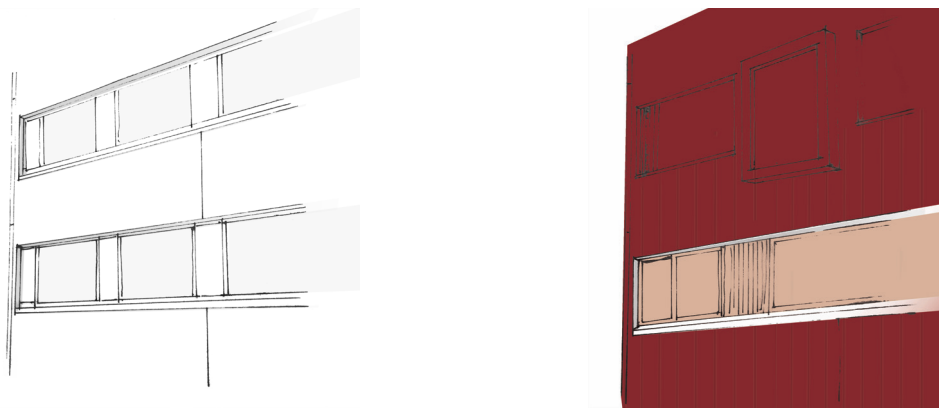
The following text presents an analysis of the tectonic interrelation between the technical concepts and the resulting spatial gestures in the renovation of Rosenhøj. As in the analysis of Park Hill, the focus will be on alterations to the building envelope, more specifically on the north facade, which is the primary entrance facade (Figure 35).

*Technical concept:* The technical intention was to update the building envelope to comply with modern-day standards for thermal insulation. In this specific case, the intention was to meet the Danish building regulations. Furthermore, the technical concept included updating the heating system and implementing a mechanical ventilation system. The alterations resulted in a reduction in energy consumption of 30–40% after the renovation (Nielsen 2017b).

*Alteration of the construction:* In Rosenhøj, the technical concept was realized through the re-insulation of the original concrete facades with 200-mm insulation mounted in wooden cassettes and new double-glazed windows. The apartment blocks are clad in either aluminum, slate, or concrete as the main materials (Nielsen 2017b). In this analysis, the focus is on a building block that has been clad in aluminum.



**Figure 35** Section through the Rosenhøj complex, illustrating the areas of analysis (prior to renovation).



**Figure 36** Spatial sketch of the exterior before and after the renovation (left and right respectively),  
 ● accentuation, and ● addition/renewal.



**Figure 37** Sketch of the interior before and after the renovation (left and right respectively),  
 ● addition of gestures.



*Spatial gestures:* The implications of the realization of the technical concepts on the perceived spatial quality are highly evident in both the exterior and the interior. Focusing on the specific section of the building envelope (Figure 35), changes in the exterior (Figure 36) will be looked at first.

### Exterior (Figure 36)

As opposed to Park Hill, it can be seen here that the majority of facade elements have been the subject of renewal (red). The building block has been dressed in a new aluminum facade, which differs greatly from the original facade. The facade renovation has followed a scheme in which the blocks are 'linked' to each other in pairs around a courtyard by means of facade materiality and expression. This allows for an experience of a more differentiated area and a reduced scale. Rather than twenty-seven identical apartment blocks, they are now clustered in smaller units that define the exterior space between them. As such, the building block, which forms the outset for the present analysis, contributes to a more diverse expression in the area and to better programming of the outdoor spaces.

Looking more closely at the facade, traces of the original horizontal window strips (sand-colored) are evident. The impression of a horizontal band is obtained through the use of wooden lamellas that visually connect the windows. The wooden elements also add a level of tactility to the surface. However, most dominantly, it can be seen that on every second story, the horizontal windows have been supplemented with new bay windows (red). The introduction of the bay windows fundamentally breaks with the original layout and adds to the overall impression of a completely altered expression, in which only a few links to the original surface articulation remain.

### Interior (Figure 37)

In the interior, the extensive alterations to the facade create a distinctly altered experience in the adjoining spaces (Figure 37). Most distinct are the aforementioned bay windows, which utilize the extra depth of the walls to create a sitting niche. According to the engineer Søren Nielsen from Viggo Madsen consulting engineers, the tenants have responded positively to the alteration, especially as a place for sitting in connection to the kitchen area (Nielsen 2017b). This utilization of the additional depth of the wall due to re-insulation creates a new spatial gesture that was not there before.

### Summary: Tectonic Alteration of Construction?

In Rosenhøj, the building blocks have undergone an extensive renovation, including re-insulation, changing window formats, and applying new facade materials. In the exterior, the technical concept – namely to optimize the thermal performance of the building envelope – has been realized in the manner of focusing on renewal of the existing construction. This, to a degree, where the original expression (which reflected the technical concept of mass production and assembly) is almost hidden. The impression of a renewed facade is further strengthened by the introduction of bay windows, which constitute a new formal motif in the area. However, traces of the original horizontal window bands, which are interpreted and accentuated through the use of wooden lamellas, can be found. The resulting spatial gestures in the exterior may be described through the ability of the building envelope to contribute to a new narrative in the area, focusing on differentiation and reduction of the experienced scale. In the interior, the alteration of the construction – the re-insulation of the building envelope and the introduction of bay windows – is utilized to create new sitting niches. In the exterior, the pairs of blocks help to define exterior courtyards. As such, the chosen way of realizing the technical concept provides new spatial gestures that were not part of the original scheme.

In summary, it can be stated that the approach presented in Rosenhøj differs greatly from that of the Park Hill project. By focusing on renewal as the main alteration strategy, the dialogue between the past and the present has a distinctly different character. It can be argued that by hiding the original intentions with a new 'overcoat,' the architects renounce that the original facade is of any value. Yet, the intention of this study is not to pass judgment on either of the two approaches presented here but rather to articulate how similar technical concepts can be realized in vastly different manners depending on the state or value of the original building. It can, however, be concluded that in relation to the building envelope, there is a limited dialogue with the past. Rather, there seems to be a focus on breaking with a somewhat shady reputation at Rosenhøj through extensive changes in architectural expression. The new facade cladding contributes to this with more than a 'facelift,' as it defines new spatial gestures in the interior and the exterior. In this light, the alterations can be viewed as tectonic.



## SUMMARY

Through a rereading of Eduard Sekler's studies of tectonic architectural theory, a simplified tectonic conceptual framework was proposed for addressing the potential joint impact of renovation initiatives on energy performance and the perceived spatial quality. This was linked to Fred Scott's understanding of the act of renovation as a dialogue between the past, present, and future – as a way to target the domain of renovation and the specific challenges related to this discipline.

In continuation hereof, the conceptual framework was applied in the analysis of two case studies of social housing projects which have undergone renovation within recent years: Park Hill in Sheffield, UK and Rosenhøj in Aarhus, Denmark. In the analysis, the framework was applied as a means to articulate if and how the constructional realization of technical concepts related to the building envelope (as an example) contributes to spatial gestures in the interior and the exterior, potentially leading to increased well-being for the inhabitants rather than providing 'mere' additional cladding.

In the Park Hill project, it was shown how technical concepts related to energy optimization had been realized in a manner that accentuates the existing concrete grid (preservation/accentuation) and adds new spatial values to the building by introducing changes such as semi-private entrance spaces at the entrance levels (renewal/addition). In Rosenhøj, it was highlighted how similar technical concepts related to the building envelope had been realized in a manner that favors addition/renewal over preservation. In this case, the tectonic exploitation of the building envelope is strengthened as the new facade (renewal/addition) induces spatial gestures in both the interior and the exterior, which the original facade failed to do and which may have been a contributing factor in its declining reputation amongst the users.

The terms 'technical concept,' 'construction,' and 'spatial gesture' were used as guiding principles in the two case studies in an attempt to move beyond the somewhat ambiguous notion of 'spatial quality' put forward in contemporary renovation discourse towards a more nuanced vocabulary for articulating the joint spatial and technical potential of renovation initiatives. This was also done to stress the importance of considering, e.g., re-insulation of the building envelope as an architectural element that lends itself to strengthening existing spatial qualities or

adding new ones through critical assessment of renovation alternatives.

Based on the analysis, the conceptual framework is seen as a potential way forward to help articulate the consequences and potentials of technical initiatives on the perceived spatial quality. And it may help direct attention to how similar technical concepts, like energy optimization of the building envelope, can be realized through different degrees of alteration to the existing construction, ultimately affecting the perceived spatial quality in distinctly different ways.

### FURTHER DEVELOPMENT BASED ON EXPERIENCES FROM RESEARCH STAY

Following the initial application of the conceptual framework as an analytical lens in the comparative analysis of two completed renovation cases, the framework was discussed and further developed as part of a research stay at the Politecnico di Milano. During the research stay, the PhD student was involved in the preparatory work for a course on sustainable renovation of social housing. Through this work, the PhD student had the opportunity to discuss the conceptual framework with teachers involved in the course based on their previous experience – and with the aim to use elements of the research in the course.

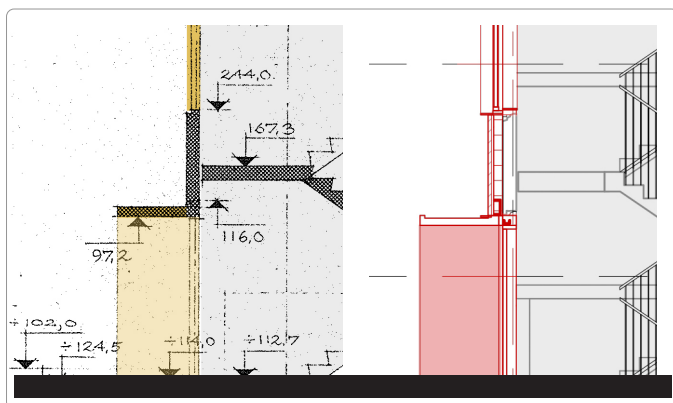
Through dialogue with especially professor Gennaro Postiglione, the PhD student added a layer of tactics for applying the framework for analysis of completed renovation projects in order to guide the students further in their analysis of synergies (Figure 40).

The proposed tactics included:

- Tactics for articulating alterations (description)
- Tactics for directing attention to synergies ‘beyond the façade’ (interpretation)

#### Tactics for articulating alterations

The division into preservation, addition/accentuation, or renewal of spatial gestures represents a layer of interpretation. When preparing for the course, it was found relevant to introduce the students to a set of tactics for



**Figure 38** Suggested tactics for graphically displaying the alterations to the construction. Using yellow/red color-coding to show which building components have been demolished (yellow, left) or added (red, right) (inspired by Boesh et al. 2017). Color-coding added by author directly to drawing material provided by Aarhus Omega/Viggo Madsen (left: original building, and right: renovated building).

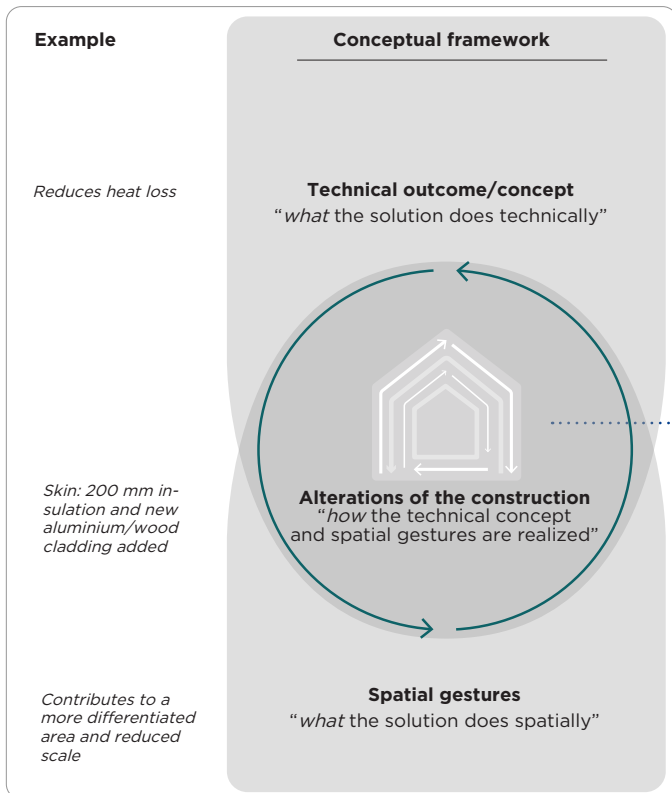
graphically displaying the alterations of the constructions, e.g., what building components have been removed and which have been added, before engaging in interpretation. In order to support the students' ability to describe the alterations as a basis for engaging in interpretation, the concept of Black/Yellow/Red color-coding by Martin Boesch (Boesh et al. 2017) was introduced. The concept of color-coding was developed by Boesch for teaching architecture students and was inspired by building permission drawings. Essentially, the concept was to redraw plans and sections of renovation cases using a yellow and red code to show the alterations of the construction. In the context of this thesis and in the course at the Politecnico di Milano, it was suggested to include construction drawings in scales 1:10-1:50 in order to increase understanding of the specific alterations of the construction (see example in Figure 38).

One of Boesch's main arguments for the approach was to help students experience "...how much can be read from plans and pictures, when not just flying through them while skimming books and magazines, but staying with, studying, and wanting to understand them as only this will reveal their content" (Boesh et al. 2017, p. 8). The value of analysis through drawing was also mentioned in the research of, e.g., Unwin (2007), who states that "*The use of drawing as a medium for the acquisition of knowledge and understanding has a long and distinguished history*" (Unwin 2007, p. 105).

This point is relevant for both the redrawing on a descriptive level (yellow/red color-coding to identify alterations of the construction) and on an interpretive level (marking of preserved, accentuated, or added spatial gestures). In the light of the above, the drawings may not only serve to supplement the analysis but in itself prompt a bigger awareness in the person undertaking the analysis. Due to limited availability and rights of drawings, the yellow/red color coding is not included in the architectural analysis in this thesis (only in the retrospective analysis of the B4 project as part of Objective 3).

#### Tactics for directing attention to synergies ‘beyond the façade’

The previous section states that: "*the term spatial gestures is used to denote the resulting spatial capabilities of the building envelope in the exterior and interior, spanning from how it is experienced from a distance [...] to the experience through tactile encounters on the smallest*

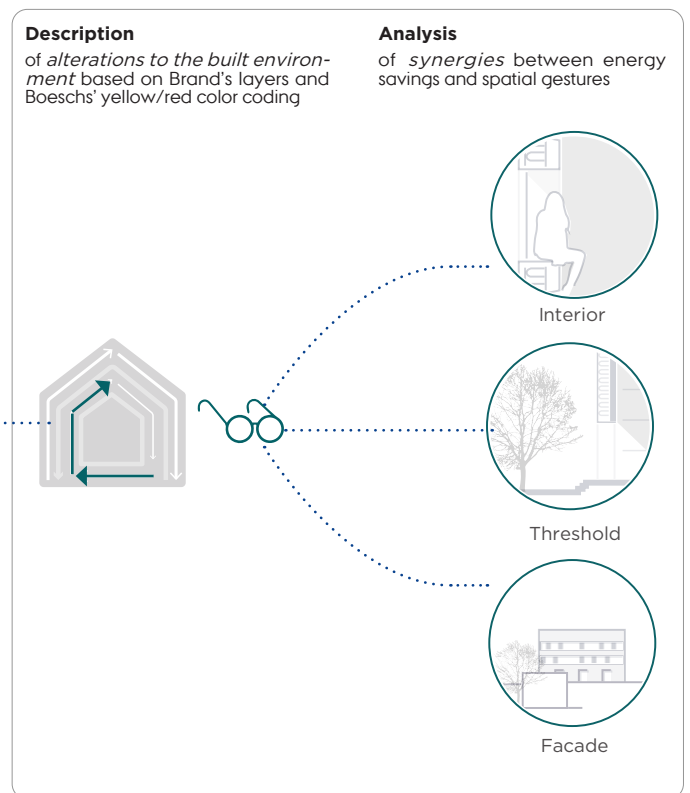


**Figure 39** Updated conceptual framework with fictive example (left). (Diagram in the centre adopted from Brand 1995, p. 13).

*scale*" (this thesis, page 73).

In order to guide the students' analysis, the framework was made more explicit by articulating where the resulting gestures may be experienced from; in the interior, in the threshold between interior and exterior, or in the façade, as it forms part of the urban fabric (Figure 39). For instance, as seen in the analysis of Rosenhøj, the addition of insulation and new façade cladding (alteration of the construction) influenced the perception of the building in the interior (addition of sitting niche) as well as the exterior in the façade expression. Further, the façade renovation was used as an occasion for altering the entrance (threshold). As such, the three themes/scales may be a way to promote an understanding that technically motivated alterations may influence resident well-being through spatial gestures not 'only' in the façade expression, but also in, e.g., the threshold and the interior. Inattention to the influence of exterior re-insulation in the interior may lead to, e.g., loss of daylight.

The division into the three themes is not to be considered

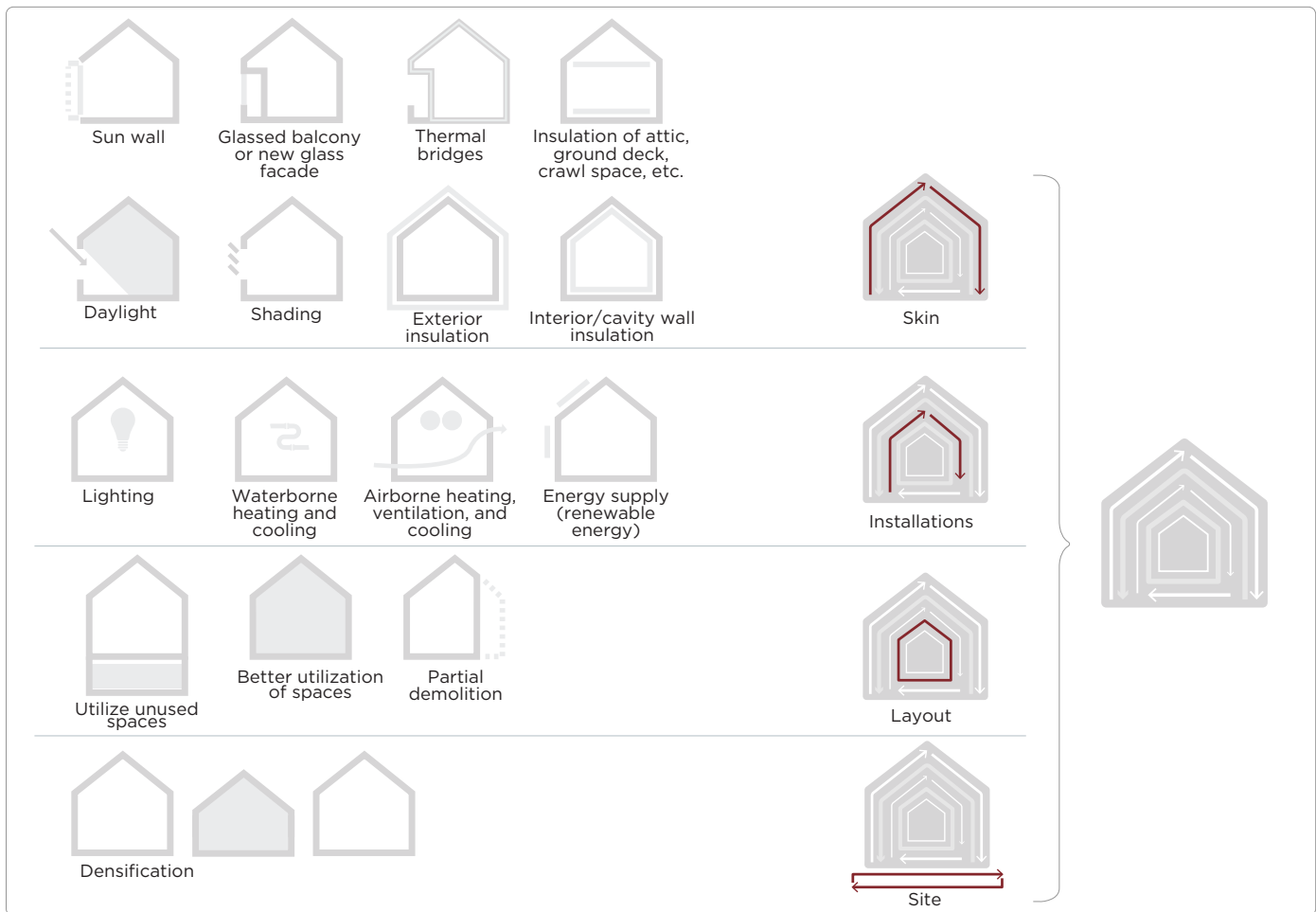


**Figure 40** Proposed accompanying tactics to aid the analysis.

a rigid subdivision. Rather, a way to guide the analysis and signal that, e.g., improving the thermal performance of the façade may result in changed spatial gestures across scales depending on the specific alteration of the existing construction.

### SUGGESTING AN UPDATED CONCEPTUAL FRAMEWORK

Figure 39 displays an updated version of the diagram in Figure 31 on page 75 based on the reflections from applying the conceptual framework in the analysis of two complementary cases and discussing it with teachers at the Politecnico di Milano. The conceptual framework thus presents a vocabulary for articulating potential synergies between energy savings and increased resident well-being through spatial gestures. The intention is to signal that in sustainable renovation, all alterations to the construction should preferably promote both energy savings and resident well-being (amongst other concerns). In the following, each of the key terms of the diagram in Figure 39 is explained.



**Figure 41** Examples of typical strategies for implementing energy savings. Each strategy, e.g., exterior insulation may be implemented in different ways (through specific alterations measures). (Based on Tommerup 2010; Marsh et al. 2013; Smidt-Jensen & Nørgaard 2011).

### Alteration of construction

Alteration of the construction refers to the physical measures applied to the existing construction. These include decisions on two levels; which components to alter and how to alter them.

One of the most pronounced changes from Figure 31 on page 75 is that the timeline is substituted by an interpretation of Stewart Brand's "Shearing layers"-diagram. In 1994, Stewart Brand presented a visual representation of 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 1995). This idea resonates with

Scott's understanding that buildings must be understood as part of a spatial continuum in constant alteration. Further, the non-linear representation by Brand may be a better way to illustrate the circular and interdependent nature of all alterations, including energy-motivated ones.

In the analysis of Park Hill and Rosenhøj, the focus was on alterations of the thermal envelope and the spatial changes these alterations triggered. If the framework is to be used more broadly as a basis for articulating the implications of all energy-related alterations (not "only" alterations of the thermal envelope), it is found relevant to signal that alterations may be carried out in different 'layers' of the building and at different rates.

Most of the reviewed literature on energy efficiency and renovation 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 utilization of the space plan (Marsh et al. 2013). Figure 41 exemplifies typical energy renovation strategies and which building layers are altered if the strategies are executed.

Using Brand's diagram as a reference could be a way to signal that the alteration to the skin, services, and space plan should be seen as part of a larger (circular) system, where we continuously *"...work the existent and the ideal together through the process of intervention"* (Scott 2008, p. xviii) to prolong the lifespan of the building to prolong the lifespan of the building.

While 'alteration of the construction' refers to the physical measures applied to the existing construction, e.g., 200-mm insulation and aluminum cladding, it is relevant to note that there may be different understandings of such alteration measures within the interdisciplinary group of stakeholders in a renovation project. For instance, the mentioned strategies in terms of energy savings may be referred to as alteration measures. Also, architects may refer to architectural quality themes, such as materiality, scale, and proportions (e.g., evident in the writings of Steen Eiler Rasmussen (Rasmussen 1975)). This is important to bear in mind to avoid misunderstandings of the conceptual framework.

#### *Spatial gestures*

The term 'gesture' refers to what the built environment "does" spatially; whether the alteration of the construction supports individual residents' physiological and psychological well-being through spatial gestures. Depending on the specific implementation, the alteration of the construction may serve to preserve, accentuate, or add new spatial gestures, perceptible across scales in the exterior, the threshold, and/or the façade.

#### *Technical outcome/concept*

The term 'technical concept' refers to what the built environment "does" technically; whether the alteration of the construction supports energy savings, e.g., by reducing the heat loss through the façade.

#### **SUMMARY**

This section has presented Phase A in developing an architectural conceptual framework based on references from tectonic architectural theory and renovation theory. The framework was applied in a comparative analysis of two completed MSH renovation cases and subsequently discussed and developed during a research stay at the Politecnico di Milano.

Based on Phase A, the proposed conceptual framework is seen as a possible way forward for lending the architect a vocabulary for articulating alterations of the built environment as something that potentially influences both the energy performance of the building and the well-being of the residents through spatial gestures.

The conceptual framework (Figure 39 on page 85) has formed the basis for architectural analysis of case studies as part of Objective 2, focusing on identifying examples of synergies. Further, the conceptual framework has formed the basis for retrospective analysis of the research-through-design case, B4, In Gellerupparken, Aarhus and, as part of Objective 3, focusing on visualizing potentials for synergies.

The sub-section 'Proposing an updated conceptual framework' and Figure 44 are developed from the paper "Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation" (Jensen et al. 2020).

# Towards a conceptual framework phase B

## BEYOND "INTENDED" GESTURES

The previous sections have accounted for a proposed conceptual framework based on tectonic architectural theory and renovation theory. The subsequent analysis has demonstrated a potential for articulating how different ways of implementing similar technical concepts can lead to altogether different spatial gestures depending on the specific alteration of the construction.

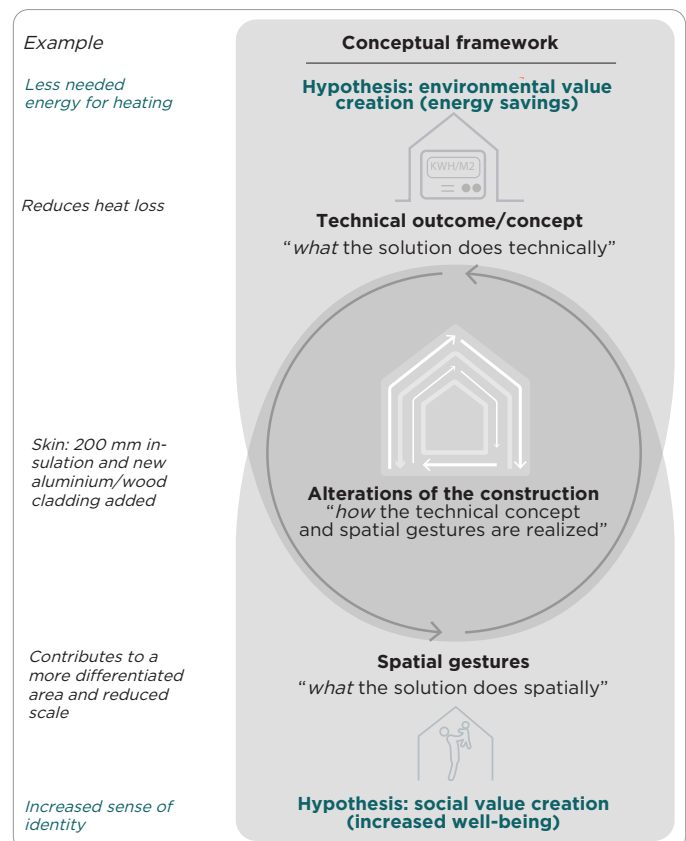
As an analytical tool, the conceptual framework can be used by a practicing architect to frame his/her study of a reference project as a basis for informing future projects (Objective 2). Alternatively, the conceptual framework may form the basis for the practicing architect suggesting certain alteration measures based on an 'intention' to increase the well-being of the residents (Objective 3). However, as a reflection from 'Phase A' in this chapter (and the research through design study performed as part of Objective 3), the articulated social value creation in terms of resident well-being remains a hypothesis, which has not been tested with the residents themselves (Figure 42 – green marking).

In the case of analysis, the person doing the analysis becomes the assessor of whether the specific way of altering the construction has successfully contributed to synergies between energy savings and spatial gestures, which may increase the resident's well-being.

For instance, the analysis of Park Hill includes the following statement: *"In the interior, the alterations of the 'infill' provide increased access to daylight, which, together with partial demolition of inner walls, contributes to a spacious and light atmosphere"* (this thesis, page 79). The conceptual framework helps direct attention to the synergies between energy savings and spatial gestures. Yet, the 'claim' that the alterations influence the well-being of the residents through spatial gestures here relies on the author's assessment and not the actual residents' own assessment.

Further, critical voices may state that it reflects an assumption that the building alone triggers a change, in this case, a change in the well-being of the residents. It is important to emphasize that this is not the case. Change may occur in the complex interrelation between the experiencing subject and the built environment.

In this light, the conceptual framework may be further strengthened by including the account of the residents.



**Figure 42** Updated conceptual framework with addition of the implicit goal of creating social and environmental value marked with green.

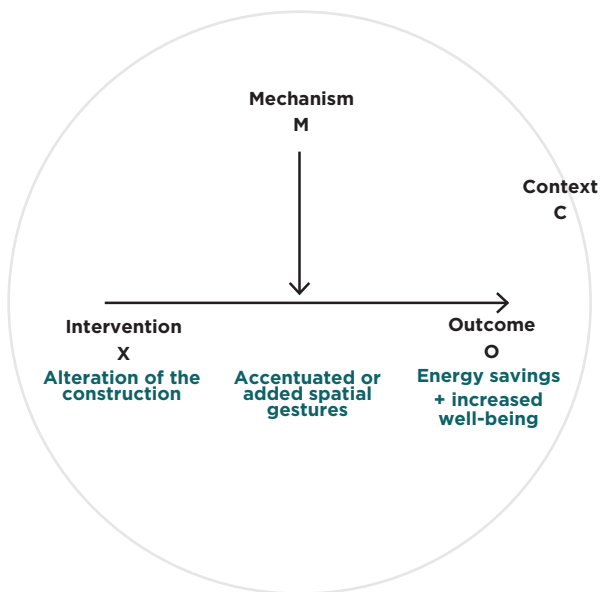
And by providing a vocabulary for documenting if and how the alteration of the construction has actually led to accentuated or added spatial gestures, influencing the well-being of the residents.

Revisiting the proposed architectural conceptual framework, it is thus relevant to distinguish between 'potential/intended gestures' and what we refer to as documented 'lived gestures' when looking to identify potentials for synergies between energy savings and resident well-being (Objective 2), which could inform future renovation cases (Objective 3).

## COMBINING THE ARCHITECTURAL CONCEPTUAL FRAMEWORK WITH EVALUATION THEORY

In order to articulate 'lived gestures' as part of efforts to identify and visualize synergies between energy savings and resident well-being, the thesis leans on the field of





**Figure 43** Context, mechanism, and outcome-configuration adapted to the problem field of this thesis (Pawson and Tilley 1997, p. 58).

evaluation research. The aim is to combine the terminology adopted from architectural theory (tectonic theory and theory on renovation) with the terminology associated with evaluation theory. This combination is introduced to put focus on the documented social impact of alteration measures.

Different schools exist within evaluation research. This thesis leans on a ‘Realistic Evaluation’-approach, first developed by social scientists Pawson and Tilley (1997), who introduced the so-called Context-Mechanism-Outcome configuration (CMOC) (Pawson and Tilley 1997). The method focuses on the complex contextual dependency of an outcome rather than ‘traditional’ cause-effect methods found in experimentalist evaluation, which may consider context as something which can be held constant (Blamey and Mackenzie 2007). As such, it provides a theoretical basis for articulating that causal relationships may exist *under certain conditions* that are only partly controllable

by the stakeholders of a renovation project.

Though originally developed for evaluating programs within sociology, social policy, criminology, health, and education, the approach is found applicable when articulating documented ‘lived gestures’ within the highly complex context of MSH renovation.

Figure 43 graphically displays what Pawson and Tilley refer to as the Context-Mechanism-Outcome-configuration. In brief, a realist evaluation would include explicit attention to what mechanisms, as a subset of the contextual conditions, have served to promote or inhibit a certain outcome in the given project. Green writings illustrate the focus of this thesis relative to the CMOC.

#### PROPOSING AN UPDATED CONCEPTUAL FRAMEWORK

In the following, an updated conceptual framework is proposed (Figure 44 on page 91), summarizing the combined terminology adapted for use in this project. Figure 44 and the accompanying explanatory text further develop content published in the paper “Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation” presented at the World Sustainable Built Environment conference in Chalmers 2020 (Jensen et al. 2020).

In the conceptual framework (Figure 44), the elements of the Realist Evaluation method are integrated, however, using terms closer to the specific context of this thesis. The terms are positioned in a circular diagram to emphasize the need for holistic strategies, where a given intervention adds environmental, financial, and social value. This is also a way to position the conceptual framework relative to the prevailing triple bottom-understanding of sustainability in the building sector.

Each of the elements in Figure 44 is accounted for in the following section.

#### *Alteration of the construction*

As in the conceptual framework presented in Phase A, alterations to the construction here refer to the physical alteration measures applied to the existing construction. These include decisions on two levels: which components to alter and how to alter them. As accounted for in section Phase A, different professions may have different ways of articulating alteration measures. Nevertheless, independent of “language,” alterations would include decisions

on which components to alter and how to alter them. Alteration of the construction corresponds to “interventions” in evaluation research.

#### *Spatial gestures*

The term ‘spatial gesture’ refers to what the built environment “does” spatially to support residents’ physiological and psychological well-being. Depending on the specific implementation, the alteration of the construction may serve to preserve, accentuate, or add new spatial gestures, perceptible across scales in the exterior, the threshold, and/or the façade.

At this level, the spatial gestures remain an intention by the architect, informed by existing knowledge. As such it represents a potential which is then mediated by mechanisms in the context.

*Context* refers to the prevailing contextual conditions of the renovation intervention which may serve to inhibit or promote the successful implementation of an intervention. Such contextual conditions may be related to, e.g., individual, organizational, or societal conditions or more material conditions related to the built environment (Entwistle et al. 2015; Entwistle and Rasmussen 2014). In this regard, it is important to stress that contextual concerns include attention to different sub-user groups within the target group of residents in MSH. Further, the residents should not be considered passive reactors to spatial gestures. Rather, it is important to acknowledge the complex sensory interaction between the individual and the material, built form (construction).

Context corresponds to “context” and “mechanisms” in the Realistic Evaluation approach (Pawson and Tilley 1997).

#### *Well-being (documented well-being in the built environment)*

‘Well-being’ refers to whether and how the alterations of the construction have served to accentuate or add spatial gestures, contributing to increased resident well-being. In order to document increased well-being in the built environment, it is necessary to identify indicators for well-being. This thesis proposes that well-being can be established through documented changes in residents’ experience and/or behavior due to accentuated or added spatial gestures. In this regard, the thesis leans on Spradley (1980), who distinguishes between explicit and tacit knowledge in a population (Spradley 1980). In this understanding, the thesis proposes that ‘lived gestures’ refer to both explicit and tacit experience and knowledge

about how specific alterations of the constructions have influenced the well-being of the residents; explicit meaning the experiences that the residents themselves articulate when asked about it, and tacit referring to knowledge embedded in the practices of the residents. This distinction is important because the uncovering of explicit and tacit knowledge requires different methods for data collection; tacit knowledge can be uncovered through, e.g., anthropological (participant) observational studies, whereas explicit knowledge can be uncovered through, e.g., interviews and questionnaires.

The headline ‘Well-being’ corresponds to “Outcome” in the Realistic Evaluation approach (Pawson and Tilley 1997).

#### *Social value creation*

Social value creation signals that efforts to promote resident well-being in the built environment can be seen as a way to create social value.

#### *Informing new processes*

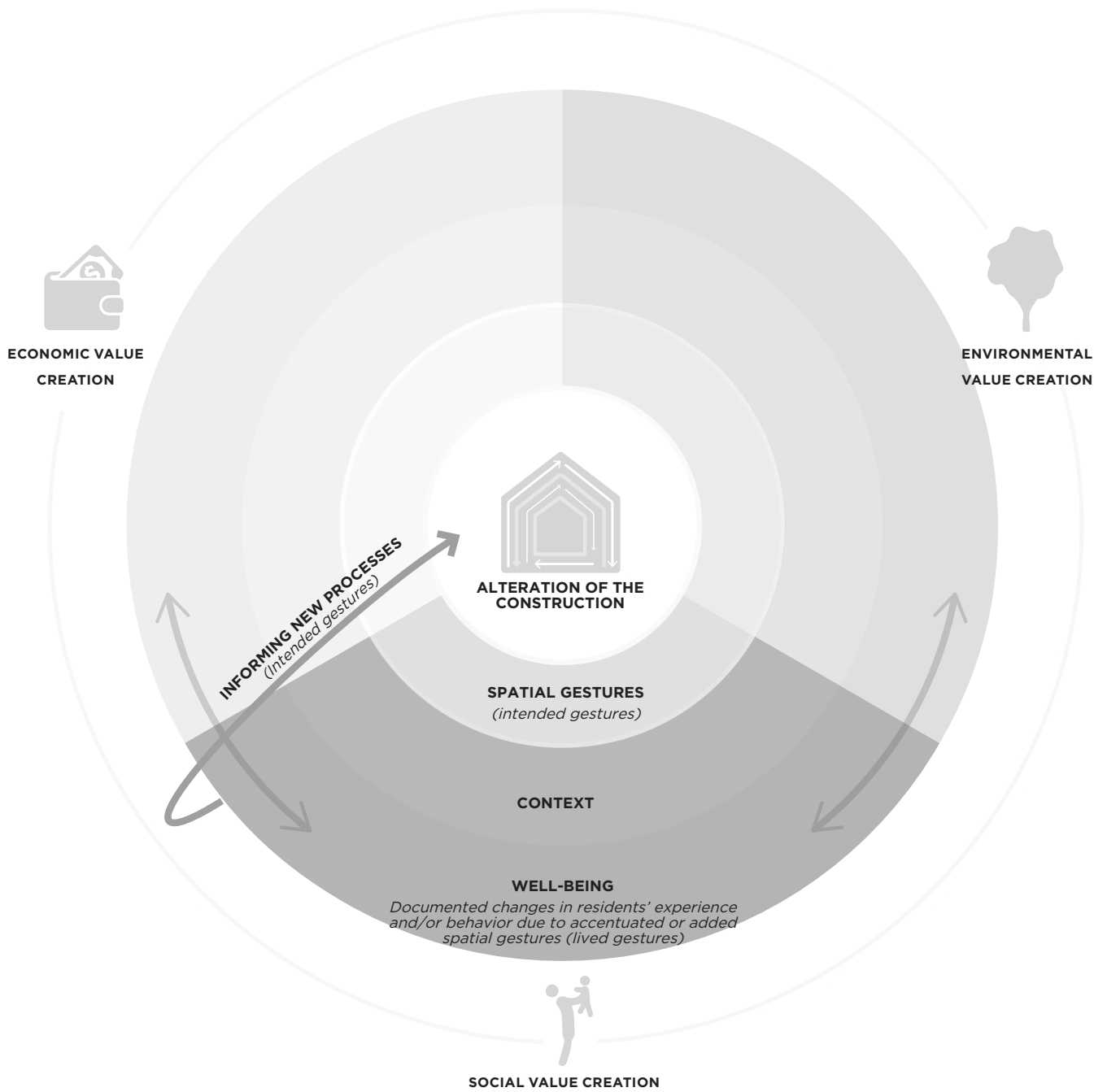
Knowledge about the outcome of certain alterations (through the spatial gestures they induce under certain contextual circumstances) may then form the basis for informing future projects with ‘intended/potential’ gestures.

The grey arrows in Figure 44, Figure 44 connecting the three parts of the circle, serve to graphically indicate that the social value creation should have a close synergy with environmental value creation (right arrow) and financial value creation (left arrow) to support holistically sustainable renovation. In the context of this study, the environmental focus is on the potential for energy savings. The focus in terms of economic value creation is on illustrating the economic value of the documented social value creation.

#### **SUMMARY**

In this section, the conceptual framework developed in Phase A was combined with perspectives from Realistic Evaluation to articulate documented ‘lived gestures’ as part of the framework; that is, how alterations of the construction influence residents’ experiences and behavior in the built environment due to accentuated or added spatial gestures.

The proposed updated framework will form the basis for a literature review and empirical studies (Objective 2) and as the basis for using documented insights to inform the early-stage interdisciplinary creative process (Objective 3).



**Figure 44** Diagrammatic overview of proposed conceptual framework. (Diagram in the centre based on Brand 1995, p. 13).

# Summary

This chapter was devoted to Objective 1: *To develop a conceptual framework for articulating synergies between energy savings and improved resident well-being in renovation from an architectural perspective.*

The aim was to gain a theoretical foothold and lay the ground for Objectives 2 and 3, focusing on identifying and visualizing synergies between energy efficiency and improved resident well-being in the renovation of MSH.

The chapter was divided into three sections, including an introduction to different approaches to the term 'well-being' in the built environment and the understanding promoted in this thesis. After that followed an account of Phase A and Phase B in developing a conceptual framework.

## Well-being in the built environment

In summary, the first section stressed the importance of breaking with existing delimited understandings of architecture as an artistic supplement and focusing on how the built environment influences the everyday lives of residents. The section provided an introduction to some different perspectives on the concept of well-being in the built environment. Subsequently, it accounted for the understanding promoted in this thesis; the thesis promotes a broad understanding of the well-being term, spanning physiological and psychological well-being aspects, and focuses on limiting negative stimuli and promoting positive stimuli.

## Phase A

This section included an account of Phase A in developing the framework based on architectural tectonic theory and renovation theory. This phase reflected the main efforts to respond to Objective 1. During this phase, it was emphasized that all alterations, including energy-motivated ones, influence how a building is perceived. When choosing specific measures for altering the existing construction, awareness about this relation represents a potential for creating synergies between energy savings and improved well-being. It was proposed to reintroduce the notions of '*construction*' and '*spatial gestures*' to the context of sustainable renovation of MSH to articulate how *alterations of the construction* may contribute to improved well-being through the *spatial gestures* they *preserve, accentuate, or add*.

The proposed conceptual framework was applied as an

analytical lens in a comparative analysis of two completed renovation cases. Based on the analysis and subsequent dialogue with academics involved in teaching architecture students related subjects, the framework was updated with accompanying tactics to support using the conceptual framework as an analytical framework.

Based on Phase A, the combination of tectonic theory and renovation theory was seen as a possible way forward for articulating the dual implications of sustainable renovation on energy performance and resident well-being. Especially, the conceptual framework may help direct attention to how similar technical concepts, like energy optimization of the building envelope, can be realized through different degrees of alteration to the existing construction, ultimately affecting the perceived spatial quality in distinctly different ways.

The Phase A-conceptual framework (Figure 39 on page 85) was used 'in its own right' as a basis for the architectural analysis of completed cases as part of Objective 2 and a retrospective analysis of an example of a creative interdisciplinary process as part of Objective 3. Further, it formed the basis for the development in Phase B, described below.

## Phase B

The developed conceptual framework holds the potential for strengthening the process by providing a common architectural vocabulary. However, it became evident that the conceptual framework does not reflect if the resulting spatial gestures actually impact the residents' well-being through their encounters with the built environment. During Phase B, the conceptual framework was therefore combined with concepts from evaluation theory to distinguish between 'potential/intended gestures' and actual 'lived gestures'. 'Lived gestures' were defined as documented insights that certain alterations of the built environment have positively influenced the residents' experience and behavior through accentuated or added spatial gestures.

The Phase B-conceptual framework (Figure 44 on page 91) was used to structure a literature review and quantitative and qualitative studies as part of Objective 2. Further, it served as a basis for Objective 3, focusing on using documented insights to inform the interdisciplinary creative process.



# Part 4 : Identification







# Identification of value creation

The previous chapter presented two phases in the development of a conceptual framework for articulating synergies between energy savings and improved resident well-being in renovation from an architectural perspective (Objective 1). Figure 45 displays the final conceptual framework – including an indication of what is referred to as Phase A and Phase B.

This chapter is devoted to objective 2:

*2a. To identify examples that renovation measures can impact resident well-being in a broad understanding.*

*2b. To identify examples for synergies between increased well-being and energy savings.*

The background for Objective 2 was an identified need for gathering examples of synergies between energy savings and resident well-being in completed renovation cases, which can inform the interdisciplinary creative process in new projects (Objective 3). The intention has not been to establish an exhaustive account of examples.

Objective 2 was explored through architectural analysis of completed renovation cases, empirical studies, a literature review, and a subsequent synthesis of the findings of the three studies. The focus of each study was on well-being through spatial gestures (Objective 2a). Synergies with energy reductions (Objective 2b) were addressed in connection with each of the three individual studies and by relating the synthesis findings to typical energy renovation measures (red arrow in Figure 45).

## Architectural analysis of completed cases

Much knowledge in the field of architecture is embedded in built cases. In order to address this otherwise “tacit” knowledge, this chapter includes an architectural analysis of completed cases to shed light on synergies between energy efficiency and well-being. The studies are carried out using Phase A in the conceptual framework (Figure 45). The examples identified through the analysis of completed cases illustrate how similar technical strategies for improving the operational energy of a building (here focusing on improving the thermal performance of the facade) may be implemented through very different alteration measures to improve the well-being of residents by preserving, accentuating, or adding new spatial gestures.

## Empirical study

The architectural analysis of completed cases is based on the assessment by an “external” interpreter, the author of this thesis. This chapter draws attention to the residents’ accounts by including quantitative and qualitative empirical studies.

The findings presented in this section are based on empirical studies in three housing areas in Aarhus, Denmark, before extensive renovation. Process-related delays, as well as the COVID-19 Pandemic, have made it impossible to make follow-up studies within the time frame of the PhD project. Nevertheless, the pre-renovation findings allow a discussion of potentials for improving the residents’ well-being based on their experience of the existing built environment. As such, the proposed methodological setup can be used to gather project-specific insights as part of the early phases of a renovation project and provide a baseline for follow-up studies after completion.

The studies are carried out using Phase B in the conceptual framework (Figure 45), however, applied to a study of the conditions *before* renovation.

## Literature study

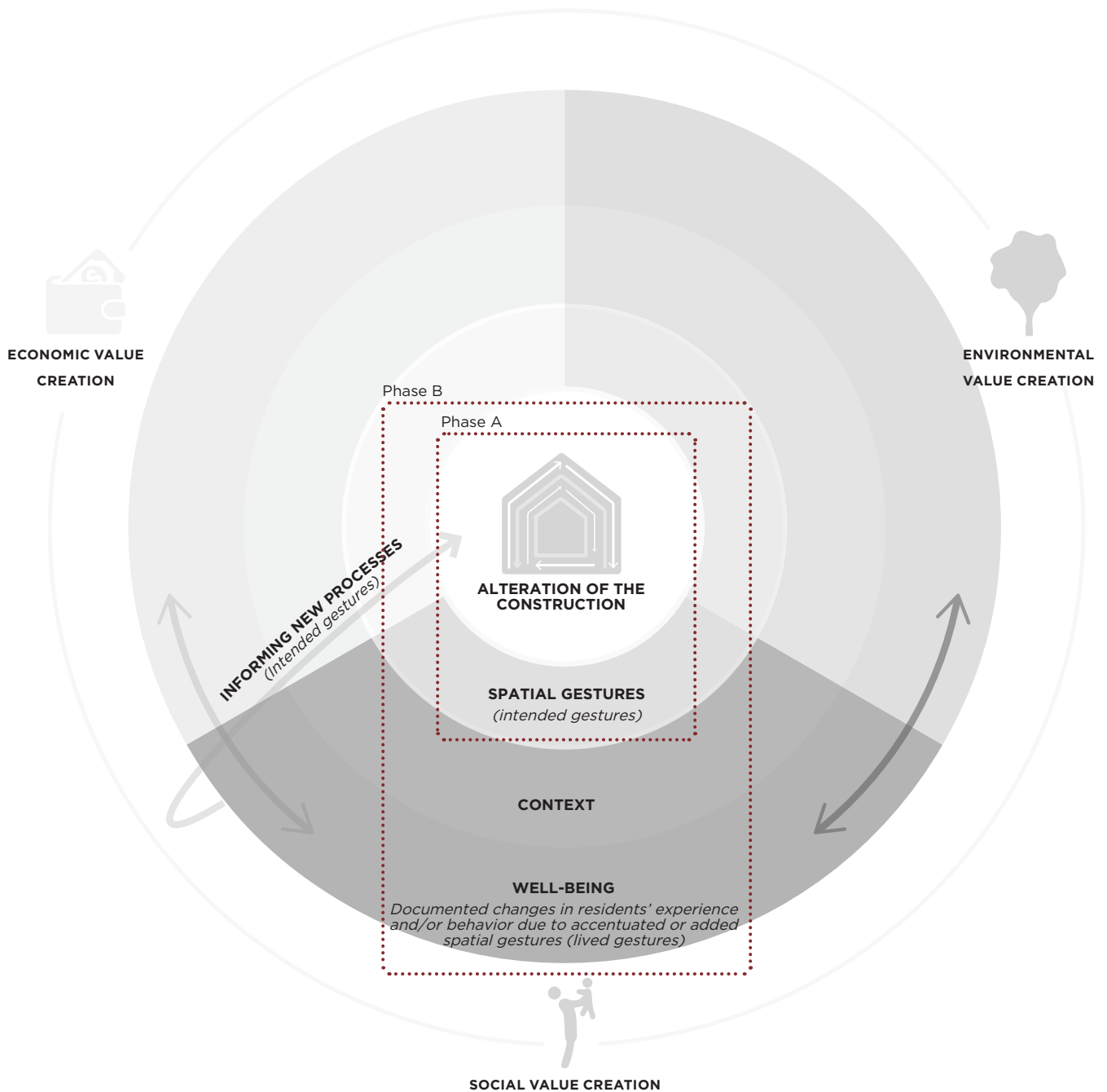
A literature review has been included to supplement the findings of architectural analysis and empirical study with examples of documented ‘lived gestures’ based on follow-up/post-occupancy studies. That is, documented accounts that certain ways of altering the construction have accentuated or added new spatial gestures, influencing the well-being of the residents.

The studies are carried out using Phase B in the conceptual framework (Figure 45). Since the subject of synergies between resident well-being and energy savings is interdisciplinary in nature, the study has included research findings from different disciplines based on varying methodological foundations.

## Synthesis

The three different approaches for identifying examples of value creation in previous projects have been synthesized in the last part of the chapter, where each source of knowledge serves to substantiate the findings.

As part of the synthesis, each of the identified themes is related to the Danish social housing context and to typical energy renovation measures.



**Figure 45** This chapter focuses on identifying examples of alteration measures which have influenced resident well-being through spatial gesture. Further, it focuses on illustrating how efforts to increase resident well-being may form synergies with energy savings. The red dotted squares indicate that the three studies in the chapter relate differently to the proposed conceptual framework (Phase A or B).

# Value creation identified through architectural analysis

The following section is devoted to a summary of the findings of an architectural analysis of synergies between energy savings and spatial gestures in four case studies. The study was based on the conceptual framework developed to answer Objective 1 (Phase A).

The author conducted the included architectural analysis as part of the development of a “case atlas” for educational purposes at the Politecnico di Milano. It is a point in the developed conceptual framework that alterations to the construction may influence the spatial perception across scales. However, in the following, only a condensed version of the case studies is included, focusing on one or two examples of identified spatial gestures in each project. This is done to visualize examples of synergies, knowing that single alteration measures may influence spatial gestures – and therethrough the well-being of residents – across scales and that spatial gestures cannot be considered isolated entities.

The case studies include a background account and a brief introduction to the characteristics of the existing building. Thereafter follows a description of applied measures of alteration of the construction. On the basis of the description follows a discussion of synergies between

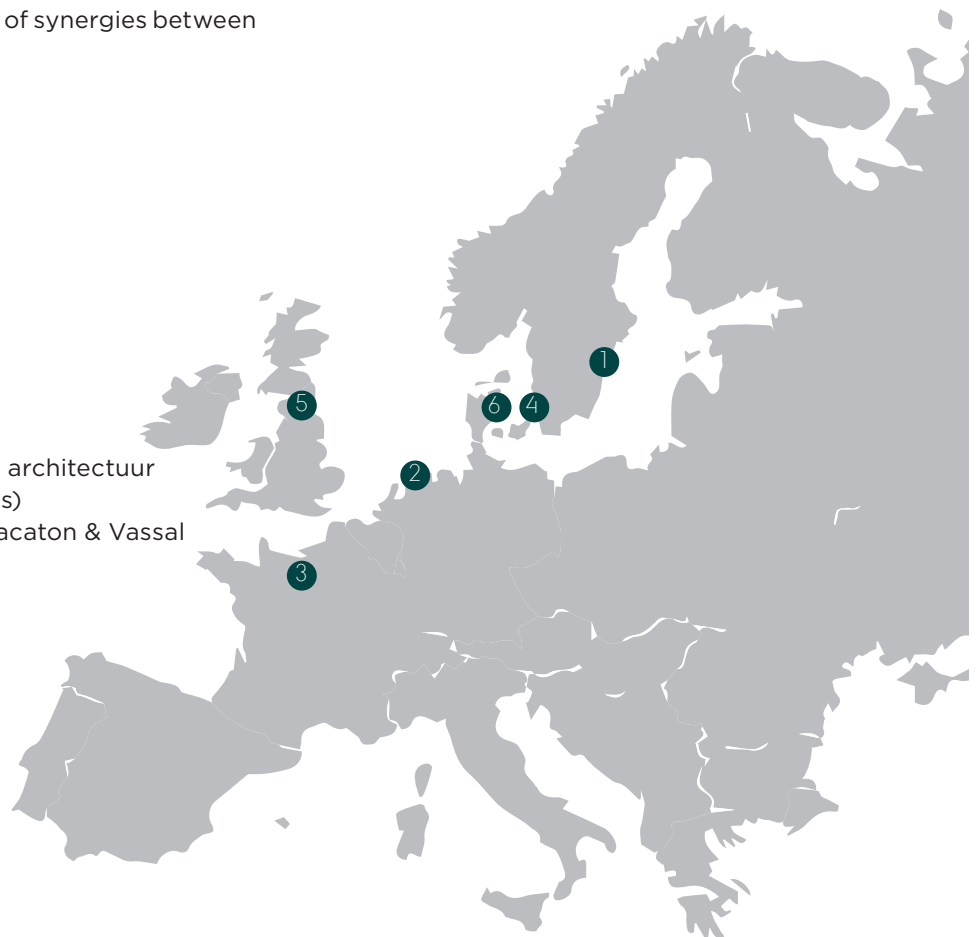
energy savings and spatial gestures, supplemented by sketches that indicate preserved, accentuated, or added spatial gestures.

The included cases are listed below and plotted into a map of Europe (Figure 46).

The projects Park Hill and Rosenhøj are represented in Figure 46. However, they are not included in this section as they have already been included in relation to Objective 1 (presented as part of “Part 3: Articulation”). The findings from the analysis of Park Hill and Rosenhøj are included as part of the summary.

“Part 2: Methodology” includes an account of the selection criteria. In brief, the cases are included because they all include upgrading the thermal performance of the building envelope. This allows for a comparison of different alteration measures applied to implement the same technical strategy and how these alteration measures contribute to preserving, accentuating existing spatial gestures, or adding new gestures, which may influence the well-being of the residents.

1. Fittja people's palace - Spridd
2. Kleiburg - NL Architects & XVW architectuur (converted to new ownership types)
3. La Tour Bois le Prêtre - Druot, Lacaton & Vassal
4. Ellebo - Adam Khan Architects
- (5. Park Hill - Studio Egret West)
- (6. Rosenhøj - Arkitema/Effekt)





▲ **Figure 47** Architectural analysis of completed renovation projects in Europe.

◀ **Figure 46** Overview of the location of each of the case projects representing examples of contemporary renovation projects.

## FITTJA PEOPLE'S PALACE

### Background

The building block "Krögervägen 2" was built as part of the so-called Million Homes Programme and is an example of the post-war welfare architecture in Sweden in the 1960s and 70s (Hall and Vidén 2005). The Million Homes Programme was put forward by the Swedish parliament to end the housing shortage. It included plans for a million new dwellings to be built in the period 1965 to 1974 (Hall and Vidén 2005). The ambition was to provide spacious, modern affordable housing. However, the areas soon met criticism. According to Hall & Vidén *"...the housing shortage was replaced by a housing surplus, partly caused by the rapid expansion of the housing stock and by the fact that economic growth gave way to stagnation. At the same time, criticism began to be heard about what some people perceived as uniform and poor architecture"* (Hall and Vidén 2005, p. 301).

This description is also true for Fittja in Botkyrka. When the municipal real estate company Botkyrkabyggen AB initiated the recent renovation project, a complex task lay ahead, and the proclaimed aim was to solve *"urgent technical problems without considerably increasing the rent while at the same time contributing to the area's long-term development"* (Spridd n.d.-a, para. 3). In 2013 the architectural studio Spridd, in collaboration with NCC, won the Swedish part of the Nordic Built Challenge 2013 under the headline "Fittja People's Palace" (Spridd n.d.-a). The renovation project focused on one building on Krögervägen in Fittja. It included technical upgrading, improving the energy performance of the building, and improving common spaces. An important aspect was

that the tenants were to stay in their apartments during the renovation process (Spridd n.d.-a).

The intention with the competition was to find a solution that was *"affordable for the existing customers [...] helps to solve some of the acute problems (plumbing, energy waste caused by windows etc. [and] helps Botkyrkabyggen to reach the long-term goals regarding sustainability (environmental, social, economical etc.)"* (Nordic Built 2012, p. 3). The winning proposal suggested a method intended to be scaled to the remaining blocks (Spridd n.d.-a).

### Existing building

The building consists of 68 apartments over 11 floors, excluding the basement and ground floor (Nordic Built 2012, Appendix 1). The building is made from precast concrete. It consists of a bearing frame of concrete and facades based on a "sandwich construction", also of concrete (Nordic Built 2012).

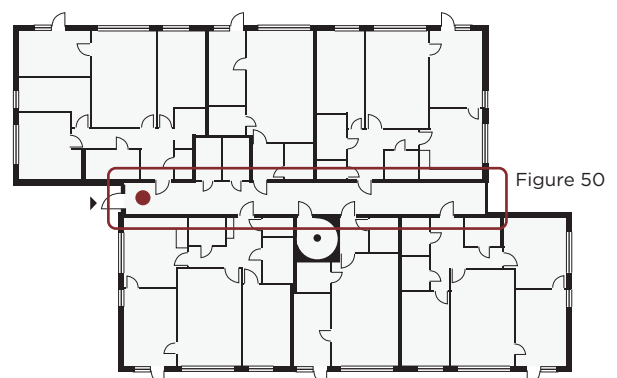
The building is part of a larger residential area, where Botkyrkabyggen (at the time of the competition) owned 1393 apartments, inhabited by 4060 people (Nordic Built 2012).

### Alteration of construction

In general, as much as possible has been preserved, and the alterations are carried out in line with the original scheme.

In this account, mainly alterations relevant to the exemplary synergies are described. The renovation included measures to secure the airtightness of the facade – espe-

- Stockholm – Sweden
- 1973 Arkitekterna Höjer & Ljungvist – renovated 2013- 2016 by Spridd and NCC
- 68 apartments (Nordic Built 2012), 5,320 m<sup>2</sup> gross area (Nordic Innovation 2015)
- Energy saving: energy savings of 28 kWh/m<sup>2</sup> (estimated before renovation) (Nordic Innovation 2015)



**Figure 49** Basic information about the project (left) and principle plan drawing, entrance level (right). NB. The plan drawing is based on drawing material from the construction of the building - hence, the position of inner walls may have been changed over the years. (Based on drawings provided by Spridd architects). The red dot indicates the position of the viewer in Figure 50.



cially the joints between the facade elements (Spridd 2014; Spridd n.d.-b). Windows were replaced, and the original facade in crushed marble and red porphyry was cleaned. The electrical system and elevators were changed and the ventilation system adjusted (Lundgreen 2017). In relation to the threshold, a large window towards the park was implemented at the entrance level). Further, larger openings and glazed panels were introduced between adjacent spaces (Spridd n.d.-b).

### Synergies

The analysis focuses on synergies in the entrance area on the ground floor.



#### Threshold

In the basement and on the entrance floor, the renovation of the thermal envelope is used as an opportunity to rethink the threshold; the original building included two entrances. However, the one towards the park was blocked at some stage due to shell protection issues [Swedish: skalskyddsfrågor] (Spridd n.d.-b). According to the architects, it was not possible to reintroduce a door as part of the renovation. However, the architects reinterpreted the original intentions by adding a large window (Figure 50, right). This large window at the far end of the corridor allows for a greater degree of transparency and increased access to daylight in the entrance lobby. The implementation of the window forms a direct synergy with energy optimization, as it forms part of efforts to improve the thermal performance of the building envelope. The spatial rearrangement of the entrance lobby does

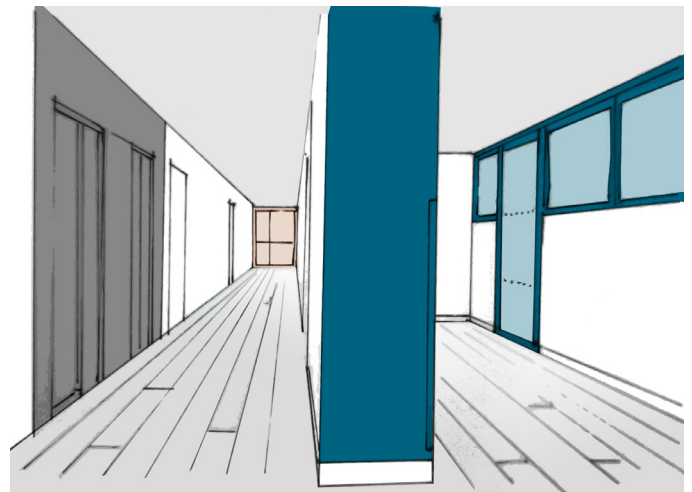
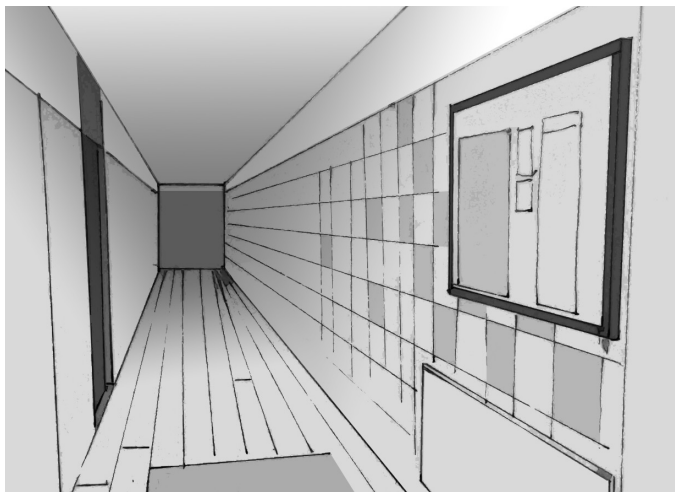
not represent a direct synergy with energy optimization. However, it may increase the sense of safety of the entrance situation as a whole, contributing to greater transparency and daylight.



#### Facade

In the exterior, the alterations have been carried out in a manner that preserves the original appearance. The facade was considered by the architects to hold architectural value – and the materials are considered robust and crucial to the identity of the building. Further, it has been an important focus to minimize alteration measures to limit rent increase.

As such, the question of optimizing the thermal performance of the building envelope has been reduced to a matter of sealing vertical joints between the concrete panels and replacing windows. For instance, the façade has not been re-insulated – unlike several other contemporary renovation projects. When viewing the building from a distance, the resulting expression is, thus, very much in line with the original design.



**Figure 50** Sketch of the ground floor main entrance area before and after renovation (left and right respectively). ● Interpretation/ accentuation of spatial gestures (window towards park), and ● addition of spatial gestures (opening up towards adjacent spaces).

## KLEIBURG (BIJLMERMEER)

### Background

Kleiburg is part of the residential area Bijlmermeer, constructed in the southern part of Amsterdam in the 1960s and 1970s to respond to housing shortages (Visser 2013; Lindroos 2018). The Bijlmermeer was designed as a single project consisting of “*A composition of slabs based on a hexagonal grid*” (NL architects n.d., slide 7).

The enthusiasm towards the complex in its first years gradually faded (NL architects n.d.). The project was subject to budget cuts. E.g., the planned shops, social center, and public swimming pool were not built as promised, and the metro did not start running until five years later (Visser 2013).

In the mid-’90s, a renewal process began. A number of building slabs were replaced by low-rise developments (NL architects n.d.). When the renovation of the Kleiburg slab was initiated, it was the last building in the area still in its original state (Lindroos 2018). In the ’00s the Municipality of Amsterdam authorized the demolition of the Kleiburg building and the construction of a new building in its place. However, the financial crisis in 2008 put a stop to the plans. At the same time, neighbors started to come together to campaign to preserve the Kleiburg building block. A consortium (Consortium deFlat) was established, which bought Kleiburg with its 500 apartments for one euro (Lindroos 2018).

In order to limit the renovation expenses, the consortium proposed to renovate only the necessary common facilities (elevators, installations, and galleries) and leave the responsibility for the apartments for the future residents themselves (Lindroos 2018). This resulted in a sort of “do-it-yourself” concept. In Dutch, this is referred

to as ‘klusflat’ – where “Klussen translates as *to do it yourself*” (NL architects n.d., slide 20 (italic emph. part of the original reference)). In practice, this meant that the apartments were left unfinished for the residents to renovate themselves.

It is relevant to note that the renovation was accompanied by changed ownership forms, including converting rental dwellings into privately owned dwellings (Valencia 2017).

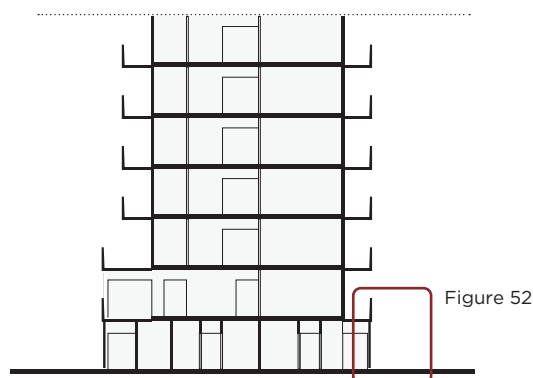
### Existing building

The block is 400 meters long, bent in a curved shape, and 11 stories high (NL architects n.d.). The building was made from prefabricated concrete elements (XVW architectuur n.d.). It had a dominating horizontal expression with relatively anonymous individual dwelling units. The ground floor level was dominated by storage/technical spaces, and on the first floor there was an elevated interior “street”. On the remaining floors, a continuous circulation deck provided access to the individual dwellings.

### Alteration of construction

The renovation included a facade renovation, replacing the existing doors and windows with new thermally efficient ones. The architects created a catalog of modules from which the residents could choose (“*openable parts, sliding doors, double doors, and a set-back that creates space for plants or people*”) (NL architects n.d., slide 73). In the ’80s, external elevators were added; as part of the most recent renovation, these were removed and replaced by elevators within the main volume (NL architects n.d.). The two lower floors were reprogrammed, and now house living/work units rather than storage and technical

- Amsterdam – The Netherlands
- 1971 - Fop Ottenhof (Bokern 2017) – renovated 2012-2016 by XVW architectuur & NL Architects (NL architects n.d.)
- 45000 m2 heated floor area (XVW architectuur n.d.)
- Energy saving: designed to meet the national building code (Screuder Groep Ingenieurs/Adviseurs 2012).



**Figure 51** Basic information about the project (left) and principle section from before the renovation (right) (based on NL architects n.d., slide 55). The red square indicates the focus of Figure 52.

spaces. As part of the reprogramming, public passages under the building have been changed from several narrow passages to fewer, larger ones. Further, the building envelope at ground level has been altered and is now dominated by glass rather than solid walls.

Coats of paint were removed from the concrete in the renovation, and parapets were sand-blasted, thereby exposing the concrete (Bokern 2017).

### Synergies

In the case of Kleiburg, the analysis focuses on potentials for social value creation through spatial gestures in the threshold and façade.



#### Threshold

The renovation of the building envelope has been used as an opportunity to rethink the lower floors. In reprogramming and opening up the floors, the threshold between interior and exterior has been activated, which could help to generate a more safe and lively environment (Lindroos 2018). From an environmental perspective, reprogramming can be seen as a way to optimize the square meters. Some dwellings now open directly towards the terrain, offering direct access to the park. Nevertheless, from available image materials, the dwellings would benefit from a further articulation of the threshold through the creation of private and semi-private outdoor spaces which can form a buffer between the private and public spheres. On the first floor and upwards, overhangs are an integral part of the original layout in the threshold. The dwellings on the ground floor towards the southwest do not have the

same overhang. Some parts are 'pushed' back, forming a covered terrace. It may be necessary to include shading devices for thermal comfort in the interior spaces.



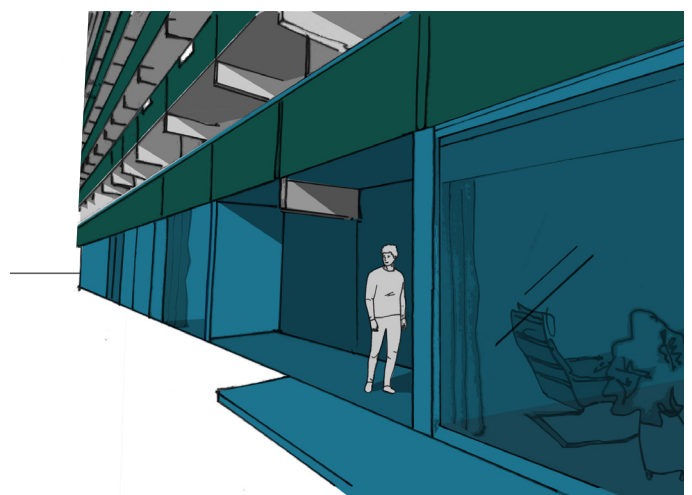
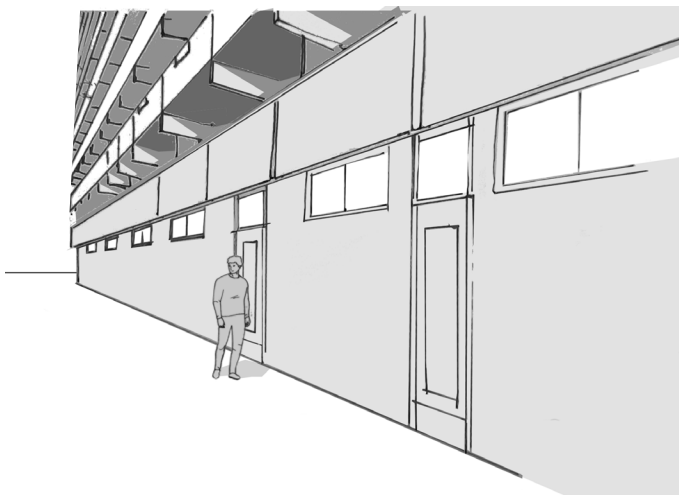
#### Façade

When considering how the changes influence the experience of the facade, the project reflects a clear preservative approach.

By removing the exterior elevator shafts, the clear horizontal expression has been restored. As such, the impression of the building from afar stays true to the original intentions.

In the case of Kleiburg, the main changes in the perception can be found on the ground floor, where the reprogramming and physical alterations may result in a more welcoming and permeable gesture.

The clearest synergies between energy-saving and spatial gestures may be seen in the articulation of facade elements throughout the building. The design proposal for the renovation featured wooden frames and cladding (Grieco 2012), resembling the original materiality. This, however, has changed in the final project. The wood would have posed a tactile, visually warm contrast to the rough concrete, whereas the chosen solution of grey aluminum appears to 'blend in' with the concrete. It could, however, be viewed as a more energy and maintenance-friendly solution. In the final project, the wood appears (in a reduced version) in the hand-rails, which is a pleasing detail, considering that this is where people get into close contact with the building (Figure 52).



**Figure 52** Sketch of the ground floor threshold before and after renovation (left and right respectively). ● Restoration/preservation (repairs of concrete and restoration of balustrades), and ● addition of spatial gestures (transparency/permeability in ground floor facade).

## TOUR BOIS-LE-PRÊTRE

### Background

The original building block was designed by Raymond Lopez in 1959. It comprised 17 floors and 96 apartments (Dana 2011).

According to Craig Buckley, the transformation of the Bois-le-Prêtre should be understood in the light of (and as a counterweight to) the favored strategy in France in relation to social housing blocks: to perform large-scale demolitions. In 2003, an urban renewal act, the so-called Borloo Law, was put forward. The potential result of the Law would be the demolition and reconstruction of nearly 200,000 housing units in areas designated as “sensitive urban zones” (Buckley 2012, p. 43). As a response, Druot, Lacatón, and Vassal (financed by the French Ministry of Culture and Communication) set out to make a study of alternatives to demolition. With the opening line “Never demolish,” they suggested strategies, such as enlarging the existing surface area of the individual units, reorganization of circulation and access points, and introducing a greater degree of transparency.

In 2005, Druot, Lacatón & Vassal won the competition to rehabilitate the Bois-le-Prêtre. The competition was put forward by the public housing agency Paris Habitat as part of a larger redevelopment plan for the area) (Buckley 2012). The redevelopment plan included the demolition of an identical tower and a slab – both buildings which were part of the original design by Lopez – because they were considered to be too close to the nearby elevated highway (Buckley 2012).

### Existing building

The original building was a prefabricated highrise building situated in a park-like context remote from the grid of the city (Aaronson 2012; Kimmelman 2012).

The existing structure was comprised of concrete floors and cross walls on a 7.5 m framework (Dana 2011).

The building as it appeared in 2005 was the result of previous renovations – most extensively in 1990 (Buckley 2012). As such, the building appeared with facades in a color scheme spanning tones of red and sandy colors. “The old facades of curtain walling [were made of] double-skin asbestos-fibre parapets and inwards-opening panels” (Dana 2011, p. 59). When the recent competition was launched, the time of neglect and decay had left its imprints on the building (Kimmelman 2012).

### Alteration of construction

On the dwelling scale, the most significant transformation was related to the bathrooms and the facade. This analysis focuses on the latter. As part of the transformation, the existing facade was removed.

Most notably, new winter gardens and balconies, measuring 7,5 m by 3 m, were mounted. They came with a prefab metal frame and concrete floor (Dana 2011). The additions are thermally and structurally separate from the existing building (Buckley 2012).

The innermost layer of the winter garden is made of triple glazing, with aluminum sliding doors with a flush sill. The winter garden has fixed and mobile panels composed of two-thirds translucent polycarbonate and one-third glass. The balcony parapet is made of glass (Dana 2011; Buckley

- Paris – France
- 1959 raymond lopez – renovated 2005-2011 by Druot, Lacaton & Vassal
- 8 900 m<sup>2</sup> existing + 3 560 m<sup>2</sup> extension (Lacaton & Vassal n.d.)
- Energy saving: 50-60 % (Birk 2012)



**Figure 53** Basic information about the project (left) and principle section from before the renovation (right) (based on Lacaton & Vassal n.d.). The red square indicates the focus of Figure 54.

2012). Thermo curtains run the width of the apartments with a reflective face to the garden and fabric to the interior (Birk 2012; Buckley 2012). In the case of the Tour Bois-le-Prêtre, it is interesting to note that the alterations were carried out while a number of residents stayed in the building (temporarily relocated to empty apartments, while renovations were carried out) (Buckley 2012).

### Synergies



#### *Interior*

Optimizing the thermal performance of the building envelope has been a key element in the efforts to reduce the overall energy use of the building.

Compared to, e.g., Kleiburg, the goal of saving operational energy has been achieved through different means of alteration. The introduction of triple-layer glazing is only part of the solution; new winter gardens contribute to establishing a thermal buffer zone and an overhang that provides passive solar shading. As such, the entire 'system' of the windows and winter gardens contributes to energy savings.

At the same time, the entire 'system' contributes to adding new spatial gestures (Figure 54, right). The floor-to-ceiling windows improve the connection to the new exterior spaces. The addition of the winter gardens has increased the area of the existing apartments by 40 % (Dana 2011). The extra square meters are not part of the heated floor area yet add usable floor area to the dwellings. During mild weather, it has the potential to become an extension of the living room, while colder weather would most likely

leave the area for outdoor activities.

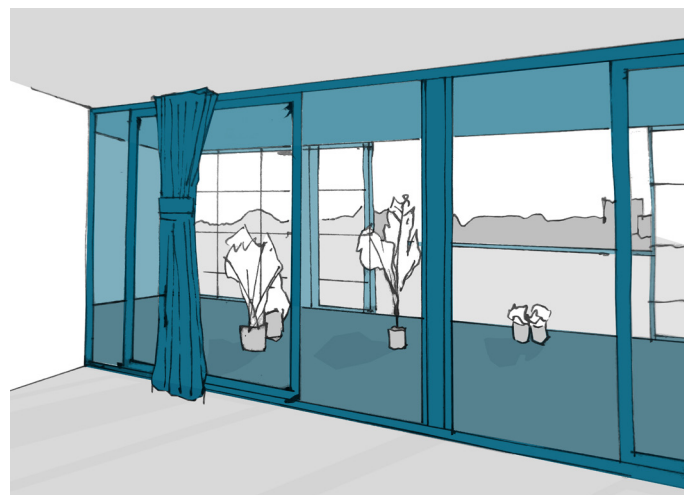
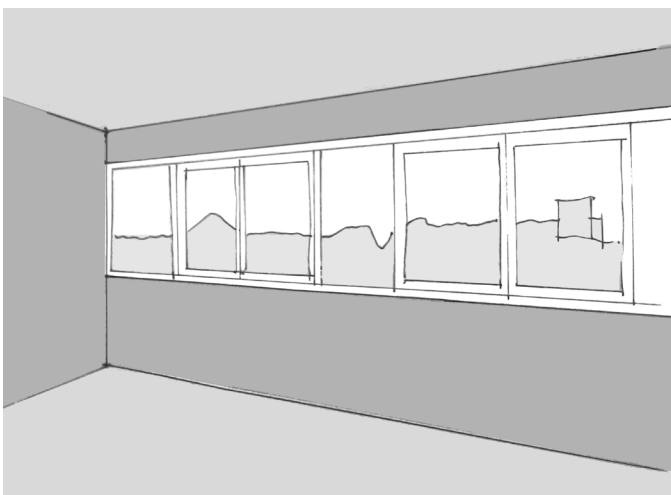
The addition of the new decks creates an overhang, which could have left the dwellings quite dark. However, as the new facades are fully glazed, the solution allows for increased illumination and views.

The winter gardens make up an intermediate space between interior and exterior. Together, with the different degrees of transparency/translucence, these allow for a certain degree of transformability of the apartments by the residents and to influence the indoor climate of their dwelling through the active use of the panels and curtains. These elements also allow the residents to decide for themselves the level of privacy towards the exterior. The introduction of the winter garden raises an interesting discussion, as it considers the thermal envelope, not as one layer but multiple layers, which work together and allow the residents to inhabit the threshold in a new way.



#### *Façade*

In this condensed version of the analysis of Tour Bois-le-Prêtre, the focus is on the interior. However, it is relevant to note that the façade expression was changed considerably as a consequence of the alterations; the proportions of the building were altered as a result of the extensions. Further, the glass, polycarbonate, and curtains allow for different degrees of transparency and glimpses to plants, furniture, and other of the resident's belongings (as well as to the residents themselves).



**Figure 54** Sketch of the ground floor threshold before and after renovation (left and right respectively). ● Addition of new spatial gestures.



## ELLEBO

### Background

The Ellebo housing area was built in 1963 (Keiding 2014). It is period architecture from the '60s and is built as four building blocks surrounding a green area (KAB 2019). The complex was renovated in the '90s, including a renovation of the facades (Keiding 2014). When the recent renovation was initiated, the buildings were characterized by white and rosy façade cladding and winter gardens.

The project was a case for the Danish part of the so-called Nordic Built Challenge, a series of competitions in the Nordic Countries (Johansen 2019b). Adam Kahn architects won the competition with the project "Ellebo Garden Rooms".

### Existing building

When the recent renovation was initiated, the buildings were in a poor state. The issues were typical for the architecture of the time; damages caused by, e.g., the flat roofs, worn windows, and installation (Keiding 2014).

During the recent renovation of the first building block (the focus of this section), the technical consultants discovered flaws in the foundation and asbestos in the construction, increasing the renovation costs considerably (Johansen 2019b). Because the issues were discovered relatively late in the process, the involved stakeholders decided to continue the renovation rather than demolish the building (Johansen 2019b). However, the unforeseen challenges had a considerable influence on the project's economy. Therefore the overall project has been revised; one of the

remaining blocks will be renovated less thoroughly, and two blocks will be demolished (KAB 2019).

This study focuses on the renovation of the first building block. In brief, the building consists of four stories plus a basement. It is made from prefabricated concrete with a built-up roof (Keiding 2014).

### Alteration of the construction

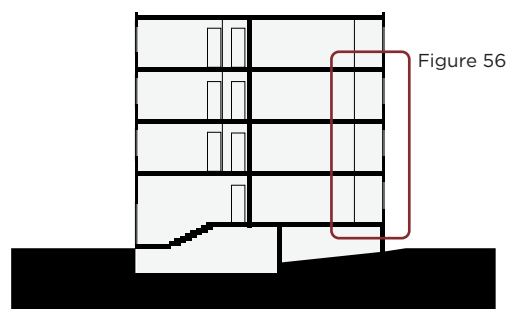
As part of the competition project, the architects suggested a new common garden, subdivided by functions. Further, the suggested garden design included the collection of rainwater (Keiding 2014).

On a building level, a new story was added with so-called penthouse apartments.

Towards the common courtyard ("garden"), new concrete pillars and decks were mounted to form balconies in front of all dwellings. Elevators and larger bathrooms were included in chosen parts of the building to secure accessibility (Johansen 2019b).

In the interior, the renovation included upgrades of kitchens and bathrooms. Further, the renovation included establishing mechanical ventilation with heat recovery. This study focuses on the South façade with winter gardens, towards the outer periphery of the complex (towards the south). Smaller unheated winter gardens were included as part of the '90's renovation' and enlarged as part of the recent renovation. The 'parapets' in the façade between the living room and winter garden were

- Ballerup - Denmark
- Built: 1963 (Keiding 2014) - renovated 2016-2019 by Adam Khan Architects and Rambøll (with additional consultants) (Ballerup Ejendomsselskab n.d.; Ballerup Ejendomsselskab 2015).
- 200.000 m<sup>2</sup> (Keiding 2014). 274 dwellings (Johansen 2019a).
- Energy saving: before renovation: 136 kWh/m<sup>2</sup>/year; after renovation (calculated): 30 kWh/m<sup>2</sup>/year (Johansen 2019a).



**Figure 55** Basic information about the project (left) and principle section from before the renovation (right) (based on Kahn 2015, p. 17). The red square signifies the focus of Figure 56 .



removed and replaced with fully glazed panels. Similarly, the parapet in the winter garden towards the exterior was replaced by fully glazed panels, which can be opened 180 degrees, fronted by a steel balcony. In connection with the ground floor apartments, a small terrace was added and a staircase leading to a new private outdoor space on the terrain.

### Synergies

This study focuses on synergies identified in relation to alterations of the South façade.



#### Interior

The new façade with its enlarged windows allows more daylight into the living room. Further, the upgrades of the winter garden effectively represent an increase in the useful floor area for the residents.



#### Threshold

The ability to open the glass doors to the balcony 180 degrees allows the residents to open a large part of the façade, potentially increasing the sense of connection

with the outdoors. Further, pragmatically, it allows for washing the windows from the interior.

The new balconies and staircases lead to private outdoor gardens encircled by hedges to allow privacy (Figure 56, right). This added spatial gesture does not contribute directly to energy savings. Yet, it may make the dwell-

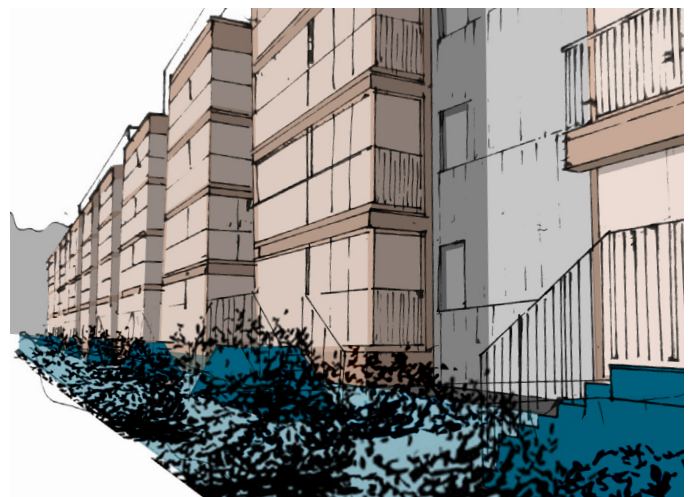
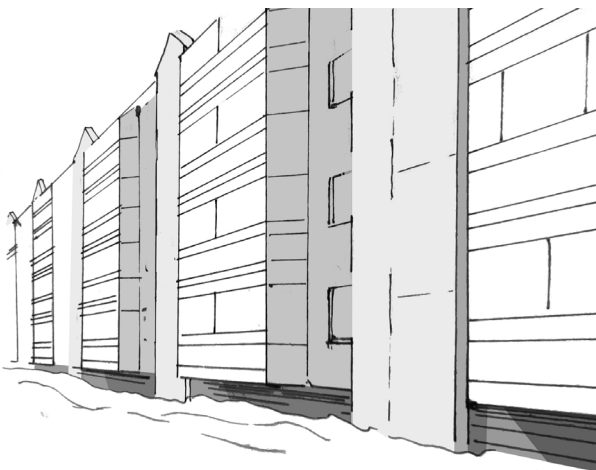
ings more attractive to existing and new residents by allowing an altogether new usage of the dwelling and its surroundings.



#### Façade

The façade alterations are carried out in a manner that marks a complete renewal of the expression. According to Daniel Serafimovski, part of the architects' team (quoted in Keiding 2014), the renovation during the '80s and '90s had erased any traces of the original building. Further, the expression from the earlier renovation was not considered to hold any value (Keiding 2014).

One can question if the fiber cement façade elements add any tactile, experiential value. Yet, it is easy to tell that the façade renovation is used as a lever to mark a shift from the rosy, postmodern expression with its pitched roof-triangular elements. Towards to north, the new concrete pillars and decks may provide a more 'honest' interpretation of the original construction from the '60s in terms of materiality.



**Figure 56** Sketch of the ground floor threshold before and after renovation (left and right respectively). ● Accentuation (winter gardens), and ● addition of new spatial gestures (direct access to private outdoor spaces).

Figure 57 (only the principle section from Rosenhøj) was included in the paper "A tectonic approach to energy renovation of dwellings - the case of Gellerup" (Jensen et al. 2019b). The figure text has been altered and the principle sections from Tour Bois-le-Prêtre and Park Hill have been added.

## SUMMARY AND DISCUSSION

The above section has included an analysis of four case projects based on the architectural analytical framework developed as part of Objective 1. This subsection summarizes the analysis findings in the above and of Park Hill and Rosenhøj.

The examples illustrate that energy-saving measures can be combined with attention to spatial gestures, which may improve the well-being of residents. Below is a summary of identified "spatial gestures" relative to where they will be experienced from: in the "interior", in the "threshold" between interior and exterior, or when experiencing the "façade" as part of the area.

### Interior

When adding exterior re-insulation to a building, the depth of the wall increases. This may reduce access to daylight if not accounted for. However, it can also be seen as an opportunity to add new spatial gestures. In the example of Rosenhøj, the increased wall depth is used to establish sitting niches in the interior, adding a new kind of spatial experience.

In Park Hill an interpretation of the "infill" in the concrete grid allows for a larger amount of glazed area - allowing for more daylight to access the interior spaces. Further, a new non-bearing thermal envelope towards the "street in the sky" is alternately pushed back and forward to allow for new spatial distribution in the threshold and interior.

### Threshold

In Fittja People's Palace, the process of changing windows and doors to more thermally efficient ones has been used strategically to allow more daylight to penetrate the common entrance areas. In combination with the use of a brighter color scheme and demolishing of inner walls, this provides transparency and overview.

In the Kleiburg-project, the reprogramming to include more open ground-level functions (and the physical alteration from closed concrete facades to glazed facades) may instigate a livelier environment. In Park Hill the described non-bearing thermal envelope towards the "street in the sky" has been used to create new semi-private spaces by the entrances.

In Tour Bois-le-prêtre, the winter gardens make up an intermediate space between interior and exterior - which work together and allow the residents to inhabit the threshold in a new way. Further, it allows the resident to adjust the level of daylight and transparency.

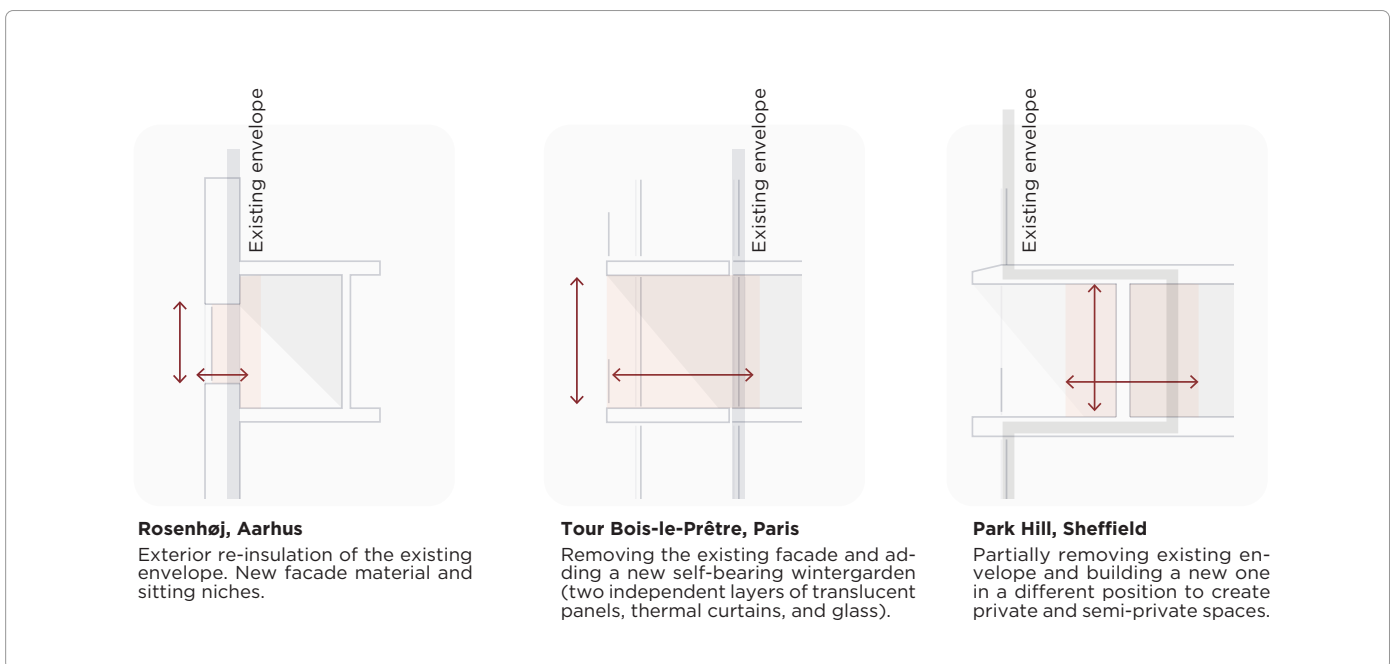
### Façade

The cases display different approaches to preserving or accentuating value in the existing façade or to adding new value. In Fittja, a preservatory approach has been applied; in Park Hill the bearing concrete frame has been preserved and accentuated by reinterpreting the non-bearing elements in the façade; in Rosenhøj, exterior re-insulation has been used as an opportunity to "dress" the building in a new "overcoat", which partly interprets the original, but mostly presents a completely new expression, forming part of an effort to rebrand the area. The projects demonstrate that efforts to reduce energy use and efforts to preserve, accentuate, or add spatial gestures are two sides of the same coin. E.g., preservation of the concrete frame in Park Hill comes at the "expense" of thermal bridges but is assessed by the stakeholders to represent culture-historical value. As such, the weighing of values requires careful attention to the value of the existing building amongst other parameters in play.

### Different levels of synergies

The examples in this section suggest that synergies between energy savings and attention to well-being through spatial gestures may be more 'direct' or 'indirect'. By 'direct', the thesis refers to instances of an evident synergy between energy savings and spatial gestures. By 'indirect', the thesis refers to alterations to the construction, which may not contribute directly to savings in operational energy (and may even pose added construction costs). However, they are relevant to consider because they are expected to improve the well-being of the residents in the built environment and may therefore contribute to prolonging the life of the building. This issue is exemplified in Figure 57, which displays three different approaches to realizing the same energy-saving strategy, improving the thermal performance of the envelope. In Rosenhøj through re-insulation of the existing façade, in Tour Bois-le-prêtre by replacing the existing façade with a double-layered skin, and in Park Hill by partially removing the existing envelope and building a new one in a different position to create private and semi-private spaces.

The costs of constructing a new wall in a new location in Park Hill may only be partly justified by improving the thermal performance. However, the specific alteration measure is expected to add value for the residents, thus making it a more valuable alternative in the long run.



**Figure 57** Each strategy for energy savings can be realised in different ways. Which approach brings more value depends on multiple contextual factors. In the figure, three different approaches to altering the "skin" are visualised.



**Figure 58** Ellebo. Two interior photos of ventilation pipes (left) and ventilation aggregate (right) in the same apartment. When implementing energy efficiency measures, we risk losing existing values (closet space) in efforts to add new ones (improved air quality).

### Methodological reflections

The analysis has focused on alterations to the façade to delimit the study. However, as emphasized in ‘Part 3: Articulation’, energy-related alterations may be carried out in different layers of the building. E.g., in Ellebo, several spaces in the apartments have been “seized” for technical purposes (Figure 58) to allow space for vertical ventilation pipes and decentral aggregates (Johansen 2019b). Discovering such hidden elements as part of this kind of architectural analysis requires careful attention to plan drawings before and after renovation.

The analysis was based on visual and written material. Physical visits to the sites would always be advisable to allow the person doing the analysis a full first-hand sensory experience of the building. Nevertheless, applying the conceptual framework as an analytical lens based on visual and written material may provide a useful tool for systematic inquiry in situations where physical visits are not an option, e.g., as part of an educational course with time and resource restrictions.

As mentioned in relation to Objective 1 (in “Part 3: Ar-

ticulation”), the introduction of yellow/red color-coding of detail drawings in future studies may increase the architect’s understanding of specific alteration measures and thus support the analytic process.

### Intended vs. lived gestures

The analysis is based on a third-party interpreter, i.e., the architect, analyzing available visual and written material. The architectural analysis of spatial gestures does not include testimonies of the actual ‘lived’ gestures by residents themselves. As such, the findings of this section could be referred to as possible or ‘intended’ gestures.

For instance, the local newspaper “Ballerupbladet” in 2019 featured an article on an unsatisfied resident complaining about, e.g., the mentioned addition of ventilation pipes and aggregates in closets:

*“There are so many errors, old doors, old door frames, and closets, which are now filled with pipes and ventilation shafts. Furthermore, we have rent increases due to a garden, which we did not ask for. It is unbelievable*

*that they treat elderly people like this”* (Gerda Andersen in Wolf 2019, translation by author).

The chairman of Ballerup Ejendomsselskab (Ballerup property company) and fellow resident in Ellebo, Inge Støring Petersen, agrees that compromises have been made due to unexpected costs. However, she disagrees that residents were not informed about the ventilation solution and the future rent increase due to the new gardens (Inge Støring in Wolf 2019).

The intention of including the example from Ellebo is not to argue for or against the introduction of mechanical ventilation or for or against the new garden. Rather, the intention is to demonstrate that many contextual factors influence whether or not a potential spatial gesture results in increased well-being; in this case, e.g., information before and during the renovation process, level of income, and unforeseen expenses related to the renovation.

The mentioned example emphasizes the importance of including the residents' account and promoting an understanding of the complex contextual mechanisms which promote or inhibit the successful implementation of spatial gestures.

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The section is based on the paper “Potentials for increasing resident wellbeing in energy renovation of multi-family social housing” (Jensen et al. 2021). The chapter is identical to the results part of the paper, except for page layout, addition of images, and minor adjustments to form a coherent part of the thesis.

# Value creation identified through empirical studies

The following section is devoted to a summary of the findings of empirical studies in three MSH areas in Aarhus, Denmark. The study was previously published in the paper “Potentials for increasing resident wellbeing in energy renovation of multi-family social housing” in the Journal of Indoor and Built Environment (Jensen et al. 2021). The text, images, and tables are based on the results and discussion section in the paper and have been edited to form a coherent part of this thesis.

The architectural analysis of cases in the previous section was based on the PhD student performing an analysis of spatial gestures in completed projects. The architectural analysis exemplified that the same energy renovation strategy (improving the thermal performance of the building envelope) may result in different spatial gestures depending on the specific implementation (alteration of the construction). This may ultimately influence resident well-being in very different ways.

When aiming to understand the impact of renovation measures on resident well-being, it is, however, natural to investigate residents’ own account of how they perceive such gestures in the built environment before and after renovation.

This section presents the findings of empirical studies before extensive renovation in three MSH areas. Process-related delays and the COVID-19 Pandemic have made it impossible to make follow-up studies within the timeframe of the PhD project. Nevertheless, the pre-renovation findings allow a discussion of potentials for improving the residents’ well-being based on their experience of the

existing built environment.

Further, the approach may be valuable in gaining project-specific inputs on potentials for synergies between improved resident well-being and energy savings in larger renovation projects.

To recap, this thesis promotes a broad understanding of resident well-being, spanning interrelated physiological and psychological well-being aspects and focusing on limiting negative stimuli as well as promoting positive stimuli. In talking about potentials, the thesis leans on the following definitions from the Merriam-Webster and Cambridge Dictionary, respectively: “*something that can develop or become actual*” (Merriam-Webster 2022a, “potential” entry) or “*someone’s or something’s ability to develop, achieve, or succeed*” (Cambridge Dictionary n.d.-a, “potential” entry).

In the context of this section, the term ‘potential’ is subsequently understood as potentials for increasing the residents’ physiological and psychological well-being which can become actualized through careful renovation.

The presented study sheds light on potentials for increased resident well-being based on an explorative, descriptive analysis of the residents’ experience of the existing built environment before renovation in three MSH areas in Denmark. More specifically, this is done by asking the residents about their satisfaction with the existing built environment.

The study further examines if the empirical data also provides a starting point for discussing potential related

## Potentials for increased resident well-being

Potentials for added value through heightened

### Experience

(The residents’ level of satisfaction as a consequence of experienced gestures in the built environment)



Potentials for added value through improved

### Health

(The residents’ general perception of their own state of health)



**Figure 59** The study focuses on identifying potentials for increased resident well-being by identifying trends in the residents’ experience and satisfaction with the built environment, and by providing a descriptive overview of experience and satisfaction with the built environment relative to residents’ subjective health.





**Figure 60** Empirical studies in three social housing areas in Aarhus, Denmark.

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health effects. This is examined through descriptive analysis, exploring if the same people who express dissatisfaction with the built environment also experience poor health (Figure 59).

The study applied a mix-methods approach, where quantitative questionnaires were used to identify overall trends. Qualitative interviews and observations were used to gain a more in-depth understanding of identified trends.

The study was based on the vocabulary developed in 'Part 3: Articulation'. As such, the study leans on tectonic architectural theory and renovation theory to articulate how specific ways of constructing the built environment (or altering the built environment in the case of renovation) may induce certain experiences through the spatial gestures they accentuate or add – for instance, inviting for social interaction or allowing for privacy. One might say that if attention is not paid to residents' well-being when performing energy renovation, it may lead to solutions, which – in the best case – contribute with no spatial gestures and – in the worst case – destroy existing gestures or add 'hostile' gestures because they overlook the residents and their everyday practices as part of the energy renovation efforts (Jensen et al. 2019a; Hvejsel et al. 2015). Reintroducing architectural tectonic theory as the theoretical framework for this study provides a point of departure for articulating not 'only' the aesthetic properties of the built environment but also how certain characteristics of the built environment (and alterations hereof) may contribute to the residents' sense of well-being in a deeper understanding. As mentioned above, this is done by investigating the residents' 'Experience' of their existing built environment and 'Health' referring to their perception of their state of health (Figure 59 on page 112).

While the study's emphasis is on identifying potential gestures in the interior, energy-motivated alteration of, e.g., the façade, may hold a range of potentials for gestures across scales, depending on where the changes are experienced from. To demonstrate how renovation measures may hold potentials for a broad spectrum of added values, the results section's summary and exemplification are structured relative to the themes: 'interior', 'threshold', and 'façade' introduced in 'Part 3: Articulation'.

## DESCRIPTION OF MSH AREAS

The study was based on empirical data collected in three MSH areas in the Western part of Aarhus, Denmark, named Toveshøj, Søvangen, and Gellerupparken. See Table 6 for a description of selected physical characteristics of the built environment in these housing areas.

As mentioned in 'Part 2: Methodology' the housing areas are administrated by the Housing Association named Brabrand Housing Association (BBBO), a partner in the ReVALUE-project. The housing areas were selected for the study because their built environments represent a widespread Danish postwar housing type built before the tightening of building code energy requirements due to the energy crisis in 1972. Nationally, there are approximately 229.600 MSH units constructed in the period from 1945-1974 (Landsbyggefonden 2014), and many of these face extensive renovation during the coming years.

All three housing areas are located in the same suburb, and they all have east-west facing facades. The studied buildings are naturally ventilated (with mechanical exhaust from kitchens and bathrooms) and heated by radiators connected to the local district heating system. The total energy use for space heating and domestic hot water is in the range of  $90 \pm 30$  kWh/m<sup>2</sup> per year (Kristensen and Petersen 2020). Previous renovations of similar MSH areas have typically resulted in operational energy savings of around 30%. In some cases, the savings have been as high as 60-90%, demonstrating the vast potential of the housing typology in this regard (Hansen et al. 2014).

## RESULTS AND ANALYSIS

The following section includes results from the mixed-methods study in the three MSH areas. The identified potentials for improving the residents' sense of well-being are summarized in Table 7 on page 117 and the written summary. The underlying data can be found in Appendix E.

Following the summary, three of the identified potentials (highlighted with grey background in Table 7) are covered in more detail. This is done to exemplify how one typical energy renovation strategy – improvement of the thermal performance of the façade – may contribute to increasing residents' sense of well-being through added gestures in both the interior, the threshold zone, and the façade.

**Table 6** Physical characteristics of the built environment in the three included housing areas. Drawings are not to scale.

	Toveshøj	Søvangen	Gellerupparken
Area plan Image credits: Google Maps (not to scale)			
Entrance façade (east)			
Typical apartment plan (not to scale)  Image credits: BBBO***			
Year of constr.	1968-72 (Pluskontoret Arkitekter and Rambøll Danmark A/S 2017)	1952-57 (Hangaard et al. 2011)	1967-72 (ArkitekturDK 1974)
No. of dwellings	624 (Brabrand Boligforening, n.d.-a)	444 (Hangaard et al. 2011)	1776 (Brabrand Boligforening, n.d.-c).
Primary materials	Standardized concrete elements (Exner et al. 2019). Glazed balconies (Brabrand Boligforening, n.d.-a).	Yellow brick. Balconies, parapets, and "infill"-buildings on the entrance side are made from concrete (Hangaard et al. 2011).	Standardized concrete elements (Exner et al. 2019; Pluskontoret Arkitekter & Rambøll Danmark A/S, 2016b).
Typology	Four-story MSH blocks (Brabrand Boligforening, n.d.-a).	A mix of four-story MSH blocks, terraced and detached houses (Hangaard et al. 2011; Brabrand Boligforening, n.d.-b).*	A mix of four- and eight-story MSH blocks (ArkitekturDK 1974).
Dwelling types	1-4 room rental dwellings.**	1-5 room rental dwellings.**	1-6 room rental dwellings.**

\*For comparison, terraced houses and detached houses are excluded from the study. \*\*Based on data from BBBO. \*\*\* Original plan drawings from the construction of the buildings. Color shading and north arrow added by author.

### Summary - Identification of potentials for improved resident well-being

As stated above, Table 7 summarizes the identified potentials for improving residents' sense of well-being. The left column summarizes overall themes. The middle column includes a description of subthemes related to the built environment, with which the residents express dissatisfaction before renovation. These subthemes represent a potential for added value when the renovation is carried out. The right column includes a description of subthemes, where participants who experience poor health also express dissatisfaction with the built environment. The identified subthemes are seen to represent indications of potentials in terms of possible health effects, worthy of more detailed examination in future studies. In order to structure the summary, potentials for improving residents' well-being are categorized under 'interior,' 'threshold,' or 'façade' (Table 7).

In brief, there is an identified potential for increasing residents' sense of well-being by improving the perceived visual, thermal, atmospheric, and acoustic comfort in the dwellings, performing a general upgrade of the materials in the dwellings, and improving the accessibility when accessing the dwellings and in the bathroom, by improving the usefulness of the shallow balconies and providing enough space for installation of washing machine and tumble dryer in the bathrooms. Also, there is an identified potential for improving the sense of privacy on balconies, the ability to influence conditions in the built environment, and being tentative to the user's negative perception of the buildings' expression. In addition to these themes, there is an identified need for addressing uncertainties related to the process. Since this need is not directly related to gestures in the built environment, it lies outside of this project's scope. Nevertheless, it is relevant to mention because it has been a recurring theme in the qualitative interviews.

As mentioned, the right column in Table 7 summarizes themes, where the group of participants who experience poor health also expressed dissatisfaction with the built environment. The identified themes are seen to represent indications of potentials for added value in terms of possible health effects when carrying out the renovation. The findings suggest that there are indeed potentials for related health effects. In this connection, it is relevant to note that even though the identified themes fall within

the defined threshold of the descriptive screening, they do not necessarily indicate a causal relation. For example, dissatisfaction with the materials and expression does not necessarily directly relate to experienced health – even if many participants expressed both as part of their response. Likewise, dissatisfaction with the ability to arrange/furnish spaces may not reflect that the existing built environment has negative health effects. However, it could indicate that residents with physical health issues have different spatial needs. As such, Table 7 serves as a stepping stone for further in-depth studies in line with those of, e.g., Howden-Chapman and Preval (2014), Ortiz et al. (2019), and Volf et al. (2019) (Howden-Chapman and Preval 2014; Ortiz et al. 2019; Volf et al. 2019). Such further studies could serve to supplement existing guidelines in the field – not least the extensive work carried out by WHO: “WHO Housing and health guidelines” (WHO 2018).

### Exemplification of findings

In the above, identified potentials for increasing the well-being and health of residents have been summarized. In this section, three examples of the identified potentials are further unfolded (highlighted with grey background in Table 7). The examples are emphasized because they demonstrate how one typical energy renovation strategy – improvement of the thermal performance of the façade (Tommerup 2010) – may hold several potentials for increasing the well-being of the residents if careful attention is paid to these potentials during the renovation process. As such, the emphasized themes represent different scales and span physiological and psychological concerns.






#### Example 1: thermal comfort (interior)

The quantitative and qualitative findings show a tendency that the residents feel cold or too cold in all spaces during wintertime across the three MSH areas (e.g., 67% in Toveshøj, 60% in Søvvangen, and 64% in Gellerupparken in the living rooms) (Table 8 on page 118).

Further, both the quantitative and qualitative results show a clear trend that the majority of residents experienced draught in all three housing areas (Table 8).

*“I think that the apartment is difficult to heat up. I have two radiators, but it [the heating system] does not function optimally. The cold, which comes from the windows – they are leaking, and there is a draught from them. So, if it is really cold and moist, it is difficult to keep warm in here, and typically I cannot really do anything about that”* (Male resident, Toveshøj).

**Table 7** Summary of identified potentials for improving resident well-being. The middle column includes identified potentials in terms of experience and satisfaction (The subscript letters depict if the potential has been identified in T = Toveshøj, S = Søvangen, or G = Gellerupparken). The right column includes themes where the study has revealed indications of potential health effects (not linked to a specific MSH area, as the health data has not been examined for the separate areas). Themes with a grey background are addressed in more depth in the following section.

			
	Wellbeing theme	Potential - Experience and satisfaction	Potential - Health
Interior 	<b>Indoor comfort</b>		
	Visual comfort	<ul style="list-style-type: none"> <li>Address the excess of light in sleeping rooms during summertime.<sup>T</sup></li> </ul>	
	Thermal comfort	<ul style="list-style-type: none"> <li>Ease overheating during summer.<sup>T,S,G</sup></li> <li>Reduce heat loss and draught during winter.<sup>T,S,G</sup></li> </ul>	<ul style="list-style-type: none"> <li>Ease overheating during summer.</li> <li>Reduce heat loss and draught during winter.</li> </ul>
	Air quality	<ul style="list-style-type: none"> <li>Make initiatives to reduce stuffy smells<sup>T,S,G</sup> and tobacco<sup>T,S,G</sup> and cooking* smells from neighbours.</li> <li>Improve the ability to influence the dampness.<sup>T,S</sup></li> <li>Introduce more ventilation.<sup>T,S,G</sup></li> </ul>	<ul style="list-style-type: none"> <li>Improve air quality.</li> <li>Introduce more ventilation.</li> </ul>
	Acoustic comfort	<ul style="list-style-type: none"> <li>Reduce nuisances from traffic vandalism* and noise between neighbouring apartments.<sup>T,S,G</sup></li> </ul>	<ul style="list-style-type: none"> <li>Reduce nuisances from neighbouring apartments.</li> </ul>
	Materials and expression	<ul style="list-style-type: none"> <li>General renovation of the surfaces in the apartments.<sup>T,G</sup></li> <li>Manage wishes for retaining individual upgrades.*</li> </ul>	<ul style="list-style-type: none"> <li>Be attentive to the residents' perception of the materials.</li> </ul>
	Sense of influence on conditions in the built environment	<ul style="list-style-type: none"> <li>Possibilities for regulating sound/acoustic conditions,<sup>T,G</sup> temperature,<sup>T,S</sup> air circulation,<sup>S,G</sup> and dampness.<sup>T,S</sup></li> <li>Manage wishes for retaining individual upgrades during the renovation.*</li> <li>Manage user wishes for the renovation solutions.*</li> </ul>	<ul style="list-style-type: none"> <li>Improve the possibility to adjust/influence temperature and air circulation.</li> </ul>
Supporting everyday practices	<ul style="list-style-type: none"> <li>Investigate if the general layout of spaces could be optimised to support everyday practices better.<sup>T</sup></li> <li>Allow enough space - and water/electricity connection - for a washing machine and a tumble dryer.*</li> <li>Accessibility (elevator* and layout of the bathroom<sup>T,G</sup>).</li> <li>Regulation of temperature<sup>T,S</sup> and prevention of draught.<sup>T,S,G</sup></li> </ul>	<ul style="list-style-type: none"> <li>Improve the possibility to arrange/furnish, especially the kitchen.</li> </ul>	
Threshold 	Supporting everyday practices	<ul style="list-style-type: none"> <li>Support more efficient utilization of shallow balconies.*</li> </ul>	
	Privacy	<ul style="list-style-type: none"> <li>Improve the sense of privacy on open balconies.<sup>G</sup></li> </ul>	<ul style="list-style-type: none"> <li>Improve privacy on the balconies.</li> </ul>
	Social interaction	<ul style="list-style-type: none"> <li>Support varying degrees of social interaction.<sup>T</sup></li> </ul>	
Facade 	Expression	<ul style="list-style-type: none"> <li>Waste management.*</li> <li>Pay attention to the user's negative perception of the buildings' expression (in Toveshøj and Gellerupparken)<sup>T,G</sup> - through physical alteration and/or communication of the value of the existing.</li> </ul>	<ul style="list-style-type: none"> <li>Be attentive to the residents' perception of the expression of the buildings.</li> </ul>
	Uncertainties and concerns related to the process*	<ul style="list-style-type: none"> <li>Address uncertainties related to the renovation process.*</li> </ul>	

\*No quantitative data; Identified solely through interviews in Toveshøj and Gellerupparken.



**Table 8** Themes related to the thermal indoor climate where more than 33% express dissatisfaction (Listed under Experience and satisfaction). Themes where more than 33% of the group of participants who experience 'less good' or 'poor' health also express dissatisfaction (Listed under Health). Results > 33% are displayed in bold. T= Toveshøj, S= Søvungen and G=Gellerupparken. All values are shown as n (%).

Identified theme	Variable description "People who..."	Esperience and satisfaction				Health
		No. (%) All (N=121)	No. (%) T (n=15)	No. (%) S (n=47)	No. (%) G (n=59)	No. (%) Less good/poor health (n=20)
<b>Temp.</b>	<i>...find it 'cold' or 'too cold' during winter:</i>					
Too cold winter	• Living room	<b>76 (63%)<sup>6</sup></b>	<b>10 (67%)</b>	<b>28 (60%)</b>	<b>38 (64%)<sup>6</sup></b>	6 (30%)
	• Bedroom	<b>71 (59%)<sup>6</sup></b>	<b>8 (53%)</b>	<b>26 (55%)<sup>6</sup></b>	<b>37 (63%)<sup>6</sup></b>	<b>8 (40%)</b>
	• Children's Rooms/spare rooms*	<b>67 (55%)<sup>3</sup></b>	<b>7 (47%)<sup>6</sup></b>	<b>22 (47%)<sup>5</sup></b>	<b>38 (64%)<sup>6</sup></b>	<b>9 (45%)</b>
	• Kitchen	<b>69 (57%)<sup>6</sup></b>	<b>7 (47%)</b>	<b>28 (60%)</b>	<b>34 (58%)<sup>6</sup></b>	<b>9 (45%)</b>
	• Hallway	<b>64 (53%)<sup>6</sup></b>	<b>9 (60%)</b>	<b>23 (49%)</b>	<b>32 (54%)<sup>6</sup></b>	<b>9 (45%)</b>
	• Bath	<b>57 (47%)<sup>6</sup></b>	<b>8 (53%)</b>	<b>23 (49%)</b>	<b>26 (44%)<sup>6</sup></b>	<b>10 (50%)</b>
	<i>...find it 'hot' or 'too hot' during summer:</i>					
Too warm summer	• Living room	<b>53 (44%)<sup>2</sup></b>	<b>5 (33%)<sup>6</sup></b>	<b>21 (45%)<sup>6</sup></b>	<b>27 (46%)<sup>6</sup></b>	<b>11 (55%)</b>
	• Bedroom	<b>50 (41%)<sup>2</sup></b>	<b>5 (33%)<sup>6</sup></b>	13 (28%) <sup>6</sup>	<b>32 (54%)<sup>6</sup></b>	<b>9 (45%)</b>
	• Children's room/ spare rooms*	<b>43 (36%)<sup>4</sup></b>	<b>5 (33%)<sup>5</sup></b>	10 (21%) <sup>5</sup>	<b>28 (47%)<sup>6</sup></b>	<b>8 (40%)</b>
	• Kitchen	38 (31%) <sup>2</sup>	<b>5 (33%)<sup>6</sup></b>	10 (21%) <sup>6</sup>	<b>23 (39%)<sup>6</sup></b>	<b>9 (45%)</b>
<b>Air circulation</b>	<i>...find that there is a 'little' or 'a lot of draught:</i>					
Draught		<b>77 (64%)<sup>6</sup></b>	<b>9 (60%)</b>	<b>29 (62%)</b>	<b>39 (66%)<sup>6</sup></b>	<b>12 (60%)</b>
<b>Ability to influence temp.</b>	<i>...find the ability to influence the temp. 'unsatisfactory' or 'very unsatisfactory.'</i>	<b>50 (41%)</b>	<b>8 (53%)</b>	<b>26 (55%)</b>	16 (27%)	<b>8 (40%)</b>
<b>Ability to influence air circulation</b>	<i>...find the ability to influence the air circulation 'unsatisfactory' or 'very unsatisfactory.'</i>	<b>51 (42%)</b>	<5	<b>20 (43%)</b>	<b>27 (46%)</b>	<b>10 (50%)</b>

<sup>2</sup> 6-10 % missing responses. <sup>3</sup> 11-15 % missing responses. <sup>4</sup> 16-20% missing responses. <sup>5</sup> > 20 % missing responses.

<sup>6</sup> The number of missing responses is less than 5, which is a threshold defined by the Danish Health Data Authority to protect personal data. Therefore, the percentage of missing responses relative to the sample is not displayed.

\*There is a relatively high number of missing responses in relation to individual questions, e.g., related to the children's room/spare room. This may be caused by ambiguity in the question or the fact that some smaller apartments do not have these additional spaces. These responses are naturally depicted as missing as it was not possible to check a box with "not relevant."

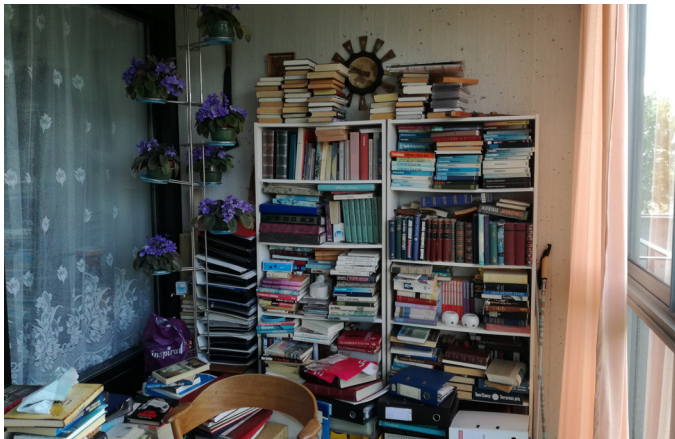


**Table 9** Themes related to the level of privacy/openness, where more than 33% express dissatisfaction (Listed under Experience and satisfaction). Themes where more than 33% of the group of participants who experience 'less good' or 'poor' health also express dissatisfaction (Listed under Health). Results > 33% are displayed in bold. T= Toveshøj, S= Søvangen and G=Gellerupparken. All values are shown as n (%).

Identified theme	Variable description "People who..."	Esperience and satisfaction				Health
		No. (%) All (N=121)	No. (%) T (n=15)	No. (%) S (n=47)	No. (%) G (n=59)	No. (%) Less good/poor health (n=20)
<b>Too public/ private outdoor spaces</b>	<i>...find the apartment "too public" in relation to the surroundings:</i> • The open balcony*	28 (23%) <sup>1</sup>	<5	<5 <sup>6</sup>	<b>22 (37%)<sup>6</sup></b>	<b>7 (35%)</b>

<sup>1</sup>1-5 % missing responses.<sup>6</sup>The number of missing responses is less than 5, which is a threshold defined by the Danish Health Data Authority to protect personal data. Therefore, the percentage of missing responses relative to the sample is not displayed.

\*Note: Potential misclassification as some people in G and T have replied "not relevant" even if all apartments in these housing areas have at least a shallow, open balcony.



**Figure 62** Example of glazed deep balcony (Toveshøj).



**Figure 61** Example of open deep balcony (Gellerupparken).



**Figure 63** Single-room apartment with shallow balcony (Toveshøj).

The quantitative findings show a tendency that the residents felt too hot during summertime in their living rooms in all three housing areas (33% in Toveshøj, 45% in Søvangen, and 46% in Gellerupparken). In Toveshøj and Gellerupparken, the residents also expressed that they feel hot or too hot in their bedroom, the children's room/spare rooms, and the kitchen (Table 8). The interview findings from Toveshøj and Gellerupparken support the tendency of a sense of overheating in some spaces.

More than half of the residents in Toveshøj (53%) and Søvangen (55%) find the ability to influence the temperature unsatisfactory or very unsatisfactory, whereas the prevalence is lower in Gellerupparken (27%). In Søvangen and Gellerupparken, the residents express dissatisfaction with the ability to influence the air circulation (43% and 46%, respectively). The level of dissatisfaction in Toveshøj falls just below the established threshold (Table 8).

The qualitative findings indicate that the residents try to adjust to the heat by spending more time in a different part of the apartment or by creating through draught during hot days:

*“When it is really hot, it is impossible to sit in the kitchen. Then we go out here [the balcony].” [...] “In the afternoon, it is unbearable on the balcony [...] Then we go to the living room and make draught through, regulate the temperature”* (Female resident, Toveshøj).

The study also indicates a potential for related health effects (Table 8). More than one-third of residents experiencing poor or less good health (30-50%) also experienced the spaces in their dwelling to be too cold or cold during the heating season in all rooms except in the living room (which is just below the threshold, 30%) and most pronounced in the bathroom (50%). During the non-heating season, the group of participants experiencing poor or less good health experience that all spaces except for the bathroom (which is just below the threshold, 30% (Appendix E)) are hot or too hot, opposite from what was shown during the heating season. More than half of the participants with poor or less good health (60%) experienced draught or too much draught.

In summary, there is an identified potential for improving the residents' thermal comfort within the dwellings. Further, there is an indication that improving the residents' thermal comfort through, e.g., façade renovation, may represent a potential health effect.

### Example 2: use and privacy of balconies (threshold)

The questionnaire responses show a tendency that residents in Gellerupparken find the open balconies to be too public (37%) (Table 9) (Figure 61 on page 119).

Generally, the participants are satisfied with the ability to influence the degree of openness towards the surroundings. However, the highest number of unsatisfied or very unsatisfied residents was found in Gellerupparken (17%) (Appendix E). Unfortunately, this theme has not been addressed as part of the qualitative interviews.

The qualitative interviews revealed that the balconies' openness and layout are highly influential to the residents' experience and use of these exterior or semi-exterior spaces. The closed balconies in Toveshøj (Figure 62 on page 119) are used as a sort of extension of the interior spaces. The deep, open balconies in Gellerupparken (Figure 61 on page 119) are used as multipurpose exterior spaces for both storage and stay. However, two of the residents in Gellerupparken mention that they seldom sit on the balcony because it is too windy:

*“It is too windy because I live in the gable”* (Female resident in Gellerupparken).

Two participants who live in single-room apartments facing East or West (Toveshøj and Gellerupparken) only have shallow balconies (Figure 63 on page 119) and state that it is challenging to make use of these spaces.

*“The balconies are small. Too narrow to be useful.” [...] “But it means that I cannot use it a lot. However, I am pleased to have it.” [...] “Couldn't they just have given it 20 cm more? Then one could pass the chair. Or make a bigger opening from within the apartment”* (Male resident, Gellerupparken).

In summary, there is an identified potential for improving residents' satisfaction with the use and privacy of the open balconies. This potential can be addressed as a part of façade renovation.

The descriptive analysis has also indicated a potential health effect of improving the balconies' privacy: one-third of the participants, who experienced poor or less good health, also perceived the open balcony as too public (35%). This should be addressed in more depth in future studies.



**Table 10** Results of the residents' satisfaction with the building's expression (Listed under Experience and satisfaction). Under Health is listed how many of the group of participants who experienced 'less good' or 'poor' health also expressed dissatisfaction with the building's expression. All values are shown as n (%). Results > 33% are displayed in bold. T= Toveshøj, S= Søvangen and G=Gellerupparken.

Identified theme	Variable description "People who..."	Esperience and satisfaction				Health
		No. (%) All (N=121)	No. (%) T (n=15)	No. (%) S (n=47)	No. (%) G (n=59)	No. (%) Less good/poor health (n=20)
<b>Expression</b>	<i>... find the expression of the building block "unappealing" or "very unappealing"</i>	48 (40%)	<b>12 (80%)</b>	5 (11%)	<b>31 (53%)</b>	<b>7 (35%)</b>



**Figure 64** West facade - Søvangen.



**Figure 66** West facade - Toveshøj.



**Figure 65** West facade - Gellerupparken.



**Figure 67** Example of waste on canopy roofs. Figure 67 was not part of the original published paper.

### Example 3: the expression of the buildings (façade)

The quantitative studies show a tendency that the residents in Søvangen are notably more pleased with the expression of the building from the exterior than the residents in Toveshøj and Gellerupparken, where 80% and 53%, respectively, find the expression unappealing or very unappealing (Table 10 and Figure 64 on page 121).

Søvangen has different physical characteristics, e.g., in terms of materials and varying building types (Table 6 on page 115) (Figure 64 on page 121). The results may indicate a preference for these characteristics over the large-scale repetitive concrete prefabricated constructions in Toveshøj and Gellerupparken (Table 6) (Figure 65 and Figure 66).

Such preferences may be influenced by external voices, as the prefab constructions of the '60s have been a much-criticized typology over the years (Bech-Danielsen 2012). Examples of statements about the expression are:

*"It is, like, very standard. Not so nice. However, if it had been first class, then they probably could not afford to live here"*

(Male resident in Toveshøj via interpreter).

*"The images on the gables look nice; however, the 'grey-in-grey' is rather boring to look at"*

(Female resident, Gellerupparken).

When discussing the building's expression during the qualitative interviews, it was also revealed that waste is an issue (Figure 67). When discussing downsides to the apartment, a female resident in Toveshøj replied:

*"Besides neighbours who make a mess on the roof?"*

(Female resident, Toveshøj).

Another resident mentioned issues with people leaving waste and wet cardboard boxes on the stairs, so they get all blocked. *"I don't know why it was there, but now it has been removed"* (Male resident, Toveshøj). He expressed that he was happy that the housing association prioritizes coming to fix and clean things. *"If something doesn't work, then I just call someone to come and fix it"* (Male resident, Toveshøj).

The interviews in Toveshøj and Gellerupparken indicate that the residents experience that the areas have a negative reputation. This bothers them, as it does not reflect their own experience of the area.

*"Generally, only the negative things take up space, but that's not what I know. So many sweet and nice people live out here. We get along, and it doesn't matter if it is Somalis, Iranians, Danes – the people I know out here are lovely people. Then there are a few scamps, but they can be found everywhere. And they ruin it for the others"* (Female resident, Gellerupparken).

This theme is not directly related to the physical characteristics of the area. Yet, historically, the negative narrative has also been associated with the image of the large-scale concrete prefab housing blocks of the '60s and '70s (Bech-Danielsen and Stender 2017; Bech-Danielsen 2012). Today, there is a dawning recognition of qualities in the concrete prefab housing blocks of the postwar era within the architectural field (addressed in the work of, e.g., Martens Gudmand-Høyer 2018; Bech-Danielsen and Stender 2017). This, in addition to positive stories from the residents themselves, could serve as a basis for supporting future renovations with positive "branding"/"storytelling" of existing and added values, externally as well as internally, to help promote the attractiveness of the area as well as the resident's sense of identity in the area.

The descriptive analysis related to health shows that the building's expression was perceived as unappealing or very unappealing by 35% of the group experiencing poor or less good health. This should be addressed in more depth by looking into the perceived state of health in the individual housing areas.

### SUMMARY AND DISCUSSION

The study has demonstrated potentials for promoting the residents' well-being as part of a sustainable renovation. This has been examined through attention to the residents' 'satisfaction' with gestures in the existing built environment and their experienced 'health'. The analysis has revealed potentials for increasing the residents' well-being in terms of satisfaction, e.g., improving the perceived thermal comfort, air quality, sound/acoustics, accessibility, and contributing to a more positive perception of the buildings' expression (Table 7, middle). Further, the findings indicate that carefully altering physical elements in the built environment to realize these potentials may, in some cases, not "only" serve to increase the resident's level of satisfaction but also improve their health (Table 7, right). The list of potentials is not exhaustive. Rather, it should be considered a screening to be elaborated and extended. The screening (Table 7) and subsequent exemplification

of potentials contribute to visualizing potentials for increased physiological and psychological well-being more explicitly than what is common in today's MSH renovation practice. By articulating such well-being potentials more explicitly, we hope to contribute to increased attention to well-being when different energy renovation measures are discussed and weighed during the design process. The following section provides a discussion of the applied approach as well as perspectives for further studies.

#### **'Satisfaction' and 'health' as indicators for potentials for increased well-being**

The overall research design revolved around engaging in dialogue with the current residents before the renovation, identifying themes with which they expressed dissatisfaction, and combining this with understanding how they perceived their health. The assumption is that by identifying such themes, it is possible to reveal potentials for improvements of the residents' well-being when performing the renovation. The focus on 'satisfaction' and 'health' has proven valuable in getting peoples' voices heard. Nevertheless, there are naturally other ways to examine the subject of potentials for increased resident well-being in the energy renovation of MSH. For instance, there may be needs and potentials that the residents themselves did not express explicitly. As mentioned in relation to Objective 1, Spradley (1980) distinguishes between explicit vs. tacit knowledge in a population. As such, the list of potentials identified in this study could be further extended through careful attention to tacit knowledge embedded in the residents' practices.

Even if the participants expressed satisfaction with a given theme, there might still be room for improvement. For instance, many residents across housing areas expressed that they feel 'safe' or 'very safe' when arriving at their building block (53% in Toveshøj, 83% in Søvangen, and 68% in Gellerupparken) (Appendix E). However, national studies on safety reveal that the general level of safety in, e.g., Gellerupparken lies below the national average (Rigspolitiet 2018), suggesting a potential for improvements, e.g., through upgrades of the built environment (Det Kriminalpræventive råd 2010).

Lastly, it is essential not to forget existing qualities when focusing on potentials for added value through renovation. The data also revealed themes with which the residents

are generally satisfied or very satisfied. For instance, the residents are generally satisfied with the daylight conditions, e.g., 47% in Toveshøj, 89% in Søvangen, and 81% in Gellerupparken are 'satisfied' or 'very satisfied' with the daylight conditions in their living room (Appendix E). Further, several of the participants in the interviews expressed that they were pleased with the view overlooking trees (which also contributes to the sense of privacy) and overlooking the city of Aarhus and Lake Brabrand. As such, these themes represent values worth preserving or accentuating when performing renovation, as the scheduled transformation process in Toveshøj and Gellerupparken includes densification of the areas between the building blocks (Pluskontoret Arkitekter and Rambøll Danmark A/S 2017; Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a).

In terms of 'health,' the idea that energy renovation of dwellings can contribute to residents staying healthy holds an interesting socio-economic perspective (also addressed by, e.g., Volf et al. 2019; Ortiz et al. 2019), which can be further explored to include an economic valuation of the otherwise 'soft' values. In this regard, the present study is based solely on the residents' self-reported general health. Further studies could include the analysis of objective measurements to supplement the subjective statements.

#### **Mixed-methods approach**

The study of potentials for increased well-being in terms of 'satisfaction' and 'health' has been carried out using a mixed-methods approach, combining quantitative questionnaires with qualitative interviews. The questionnaire format allows for an insight into a larger sample. However, the chosen closed-ended questions format and its inherent rigidity are a potential shortcoming. For example, the wording of the question "the ability to arrange/furnish the apartment" has proven to be somewhat limiting at the same time as imposing a double question in terms of "arrange" and "furnish." The interviews, on the other hand, have allowed for deeper insights into potentials, e.g., adding value by better supporting the everyday practices of the residents through the layout of the apartment. Preferably, the quantitative and qualitative data would have been collected during the same season; however, this was not possible due to administrative circumstances. Despite this, the mixed methods approach has served to qualify and nuance the results and is recommended for future studies.



### Assumptions for data analysis

The study has introduced a threshold of 33% for assessing potentials for added value based on the empirical data. Themes with a lower degree of dissatisfaction and poor/less good health naturally also represent a potential for improvement. However, as established in the methods section, the threshold is introduced to ensure a certain volume behind the identified potentials, ensure a systematic and transparent approach, and at the same time retain a maximum level of data protection. Lowering the threshold could result in more identified potentials; for instance, the theme of access to private outdoor spaces is close to the established threshold in Søvangen and Gellerupparken (Appendix E).

Responses that could be seen as an expression of dissatisfaction have been grouped. For example, the responses “unsatisfactory” and “very unsatisfactory” are grouped as an expression of dissatisfaction with a given theme. Given the relatively low sample size (especially in Toveshøj (n = 15)), an overview of the residents’ attitude is considered more valuable than the detailed variation. Only the answers related to openness remain ungrouped, as the responses “private” and “public” are ambiguous and do not necessarily reveal a negatively loaded attitude. Given that the full questionnaire has not been validated in previous studies, the applied grouping could be a subject of further discussion.

### Understanding of well-being

The identified potentials for increased well-being exemplify both physiological and psychological aspects. The former, e.g., in terms of thermal comfort, and the latter, e.g., improving the sense of privacy in balconies. Nevertheless, the results reflect the focus in the original questionnaire (developed for a different project) on indoor environmental quality, targeting physiological well-being aspects. As such, further studies should further examine mental well-being aspects in the context of sustainable renovation. Further, the empirical studies focused on themes with which the residents expressed dissatisfaction. Future studies should include more thorough attention to preserving, accentuating, or adding positive stimuli.

### Identification of gestures in the interior, threshold, and façade

The results of the data analysis – the identified potentials for increased well-being – have been reported relative to where the related physical gestures may be experienced from: in the interior, the threshold, or in the façade. Table 7 on page 117 shows that more potentials have been identified in the interior than in the threshold and the façade. The results reflect that questions about the interior have dominated the questionnaire and question guide, as the interdisciplinary team had this theme as a common starting point. Nevertheless, using the three themes to structure Table 7 and the subsequent exemplification has served to visualize that one energy renovation strategy may hold several potentials for increasing (or decreasing) residents’ well-being across scales, depending on the specific implementation in the given project. The approach is considered valuable for promoting a more holistic approach to sustainable renovation and could be further unfolded as part of future research designs.

### Perspectives for further studies

In the light of the above reflections, the present study should be considered an initial screening of potentials for added value in sustainable renovation in terms of increased resident well-being. The next step would be to move beyond the screening of potentials and statistically analyze the identified potentials in more depth. Further, to more closely examine the relationship between the individual well-being themes in alternative renovation scenarios.

The immediate perspective of the empirical study presented in this section is to follow up on the cross-sectional study through a longitudinal study, comparing the findings of this study with post-occupancy evaluation and thus pointing to delivered synergies between energy savings and increased resident well-being (lived gestures).

Based on the empirical study reported in this section, there is a potential for using the described methodological approach in the initial stages of any larger renovation design process to gather and visualize new types of insights on project-specific potentials for increased well-being. Such insights could help inform and qualify design decisions. The use of the approach for this purpose should be tested in ongoing design projects.





The section is based on the paper “Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation” (Jensen et al. 2020). The text and summarizing table have been edited to form a coherent part of the thesis. Further, references have been added to the original review.

# Value creation identified through literature study

This section is devoted to presenting the findings of a literature review previously published in the paper “Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation” presented at the World Sustainable Built Environment conference in Chalmers 2020 (Jensen et al. 2020). The text and summarizing table (Table 11) has been edited to form a coherent part of the thesis. Further, references have been added since the original review. This is accounted for in the sub-section ‘Addition to the original study.’

The purpose of the review has been to gather examples of existing impact studies of resident well-being in multi-family housing renovation. The study has been performed as a database search in Science Direct. The search strategy is accounted for in more depth in ‘Part 2: Methodology’.

The literature study is based on the conceptual framework developed as part of Objective 1 (Phase B). The proposed framework combines architectural theory and a realist evaluation approach, emphasizing the contextual dependency of the outcome of alteration measures. The conceptual framework serves as an underlying lens; however, the study is not limited to references that reflect a realist evaluation approach. Rather, since the subject of synergies between resident well-being and energy optimization is interdisciplinary, the study has included explanatory research findings from different disciplines based on varying methodological foundations. Available information on contextual factors, which the given reference mentions as relevant to the outcome, is summarised in the annotated bibliography in Appendix D.

Table 11 on page 128 presents a synthesis of identified relations between alteration measures (horizontally) and social outcomes in terms of increased resident well-being (vertically).

The account of alteration measures (horizontally) is organized in a manner inspired by Brand’s “Shearing layers of change” (Brand 1995) in the top, followed by a more detailed account of the alteration measures. The list of alterations is derived using the wording of the identified references, and, as Table 11 shows, it varies whether the reviewed studies describe alteration measures in isolation or as part of a larger ‘package.’ The majority of the references focus on alterations to the building envelope and ventilation system.

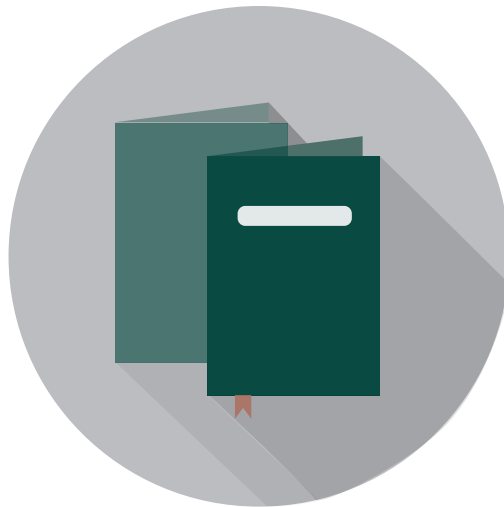
The identified related social outcomes in terms of resident well-being (vertically) are grouped in themes by the author. They subsequently reflect some degree of subjective interpretation. The identified themes are Thermal comfort, Visual comfort, Perceived air quality, Stimulating experiences, Financial safety, Safety, Pride/positive identity, Social relations, Control, Inclusion, and Health-related impacts.

Table 11 shows that the majority of the reviewed studies focus on perceived indoor climate, especially thermal comfort (e.g., Haverinen-Shaughnessy et al. 2018; Byrne et al. 2016; Almeida and Ferreira 2017; Abdul Hamid et al. 2019; Liu et al. 2015; Thomsen et al. 2016). These studies generally focus on the physiological well-being of residents. However, a few of the included studies touch upon the psychological well-being 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 (Almeida and Ferreira 2017; Juntti and Lundy 2017). Some included studies span both physiological and psychological concerns – most notably studies related to the so-called “EBC Annex 56 project” (Rose et al. 2019; Mørck et al. 2016; Almeida and Ferreira 2017; Thomsen et al. 2016).

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) (Almeida and Ferreira 2017; Haverinen-Shaughnessy et al. 2018; Liu et al. 2015) or loss of existing experiential qualities, such as trees, as a consequence of densification (Kasemets et al. 2019).

As mentioned previously, the methodological outset for the identified 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 (Abdul Hamid et al. 2019) or the impact of inner wall constructions on the satisfaction with sound insulation (Hongisto et al. 2015). 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,

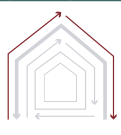

► Continued on page 130.



**Figure 68** Exploration of potentials for added social value based on literature review.

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**Table 11** Diagram depicting Alterations of the construction horizontally and Outcome vertically. “+” signals positive associations, and “-” signals negative associations. Orange references signal references which are added after the original, published study.




		ALTERATION MEASURE																
		 Skin													 Layout			
		Adding insulation	Insulation of entire building envelope	Facade insulation (general)	Facade insulation (exterior)	Facade insulation (cavity)	Facade insulation (internal)	Roof insulation	Ground floor insulation	Cellar ceiling insulation	Airtightness/reduced thermal bridges	Windows replacement	Larger window areas	Roof light or sun pipes	External shading	Balconies and loggias	Internal wall construction (heavy/light)	
<b>SOCIAL OUTCOME</b> in terms of increased resident well-being	Thermal comfort	+(1)	+(2)	+(3)	+(2, 4)	(4)	+(2) ÷(2)	+(2)	+(2)	+(2)	+(3)	+(2, 3)	÷(2)		+(2)	+(2) ÷(2)		
	Visual comfort		÷(2)		÷(2)		÷(2)						+(2)	+(2)		-(2)		
	Perceived air quality				+(2)			+(2)										
	Acoustic comfort	+(1)	+(2) ÷(2)		+(2) ÷(2)		+(2) ÷(2)	+(2) ÷(2)			+(1)	+(2, 5) ÷(2)			+(2)	+(2)	+/÷ (8)	
	Stimulating exper.																	
	Use				+(2)		÷(2)	+(2)								+(2)		
	Financial safety		+(2)		+(2)		+(2)	+(2)	+(2)	+(2)		+(2)		+(2)	+(2)			
	Safety											+(2)	+(14)			+(14)		
	Pride/ positive identity		+(2)		+(2)		+(2)	+(2)	+(2)	+(2)		+(2)						
	Social relations/integration in city															+(14)		
	Control																	
	Inclusion																	
	Health impacts																	+/÷ (8)
	Financial impact																	
Environmental impact	(1)	(2)		(2, 4)	(4)	(2)	(2)	(2)	(2)	(1)	(2, 5)	(2)	(2)	(2)	(2)			

**References:**

(1) (Haverinen-Shaughnessy 2018)  
 (2) (Almeida & Ferreira 2017)  
 (3) (Liu et al. 2015)  
 (4) (Byrne et al. 2016)  
 (5) (Mørck et al. 2016)  
 (6) (Abdul Hamid et al. 2019)

(7) (Thomsen et al. 2016)  
 (8) (Hongisto et al. 2015)  
 (9) (Juntti & Lundy 2017)  
 (10) (Kasemets et al. 2019)  
 (11) (Darby 2017)  
 (12) (Weber & Wolff 2018)  
 (13) (Rose et al. 2019)

ALTERATION MEASURE

 installations							 Site							 Packages						
Heat pump for heating	Biomass heating system	Efficient DHW system	Automatic control systems	Air renewal systems	MVHR systems	Solar thermal systems	Parks and gardens	Pathways through the neighborhood	Pathways, lighting, and cutting trees and bushes	Water pond	Removing existing trees as part of densification of housing area	Adding new public functions within an area	Renovation including facade transformation	Energy efficiency retrofits (unspecified).	Insulation. Replacing windows.	Replacing windows. Installing heat recovery. Insulation (walls, roofs). Glazing balconies.	Insulation (exterior walls, roof). New brick facade. 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. From brick to rendered facade. Windows replaced. MVHR.	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.
				+(2)	+(2, 3, 6) ÷(7)									+(11)		+(1)	+(7, 13) ÷(7)	+(3)		+(5)
				+(2)	+(2, 6) ÷(2)												+(7, 13)	+(3)		
				÷(2)	÷(1-3)											+(1) ÷(1)	+(7, 13)	+(3) ÷(3)		
											÷(10)									
			+(2)	÷(2)											+(13)		(13)			
+(2)	+(2)	+(2)		+(2)	+(2)	+(2)								+(11, 12) ÷(12)			(13)			
									+(14)			+(15)								(+) (9)
		+(2)			+(2)	+(2)		+(9)					+(14)							
							+(9)	+(9)		+(10)		+(15)								(+) (10)
					+(6) ÷(7)												÷(7)			
																				÷(9) ÷/(15)
																+(1)		+(3)		
														(11, 12)	(13)		(13)			
(2)	(2)	(2)	(2)	(2)	(1, 2, 6, 7)	(2)	(9)			(10)				(12)	(13)	(1)	(7, 13)	(3)	(9)	(5)

Added references:

- (14) (Nørgaard & Rudå 2021)
- (15) (Stender & Bech-Danielsen 2019)

mixed-methods approaches are used to identify and qualify relations (e.g., Thomsen et al. 2016). On the other end of the methodological scale, qualitative studies form the basis for capturing personal narratives (e.g., Darby 2017), which are interpreted and contextualized based on relevant theory.

The two last rows in Table 11 signify if the studies explicate the related financial and/or environmental impacts of the social value creation. Several references include attention to environmental value creation – these studies focus primarily on reduced operational energy and are generally linked to social value creation in terms of improved perceived indoor comfort (e.g., Haverinen-Shaughnessy et al. 2018; Abdul Hamid et al. 2019; Liu et al. 2015; Thomsen et al. 2016), with few references demonstrating a broader range of ‘co-benefits’ (e.g., Almeida and Ferreira 2017). There are only a few references that address the financial potential of social value creation (e.g., Rose et al. 2019). This is addressed in more depth in ‘Part 5: Communication.’ 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 (Darby 2017) and reduced exposure to energy price fluctuations (Almeida and Ferreira 2017). However, renovation may have the opposite effect for residents, who already keep their heating expenses at a minimum and are vulnerable to rent increases prompted by the renovation (Weber and Wolff 2018).

#### **ADDITION TO THE ORIGINAL STUDY**

As mentioned, Table 11 shows that most of the reviewed studies focus on the perceived indoor climate. In order to nuance the findings, Table 11 includes two examples of references that have a “softer”/“more qualitative” outset but fell outside the original search criteria of the initial structured study. The added references (which did not form part of the published study) are included in Table 11 in orange writing. The added references include follow-up studies in multi-family housing after renovation. They are, thus, assessed to respect the search criteria related to establishing actual “lived” gestures after alteration measures have been implemented.

They supplement the original findings in the sense that they focus on traditionally more soft values such as sense of safety and sense of pride. However, they do not include explicit attention to energy savings.

#### **SUMMARY AND DISCUSSION**

This section has presented the results of a literature review of existing studies on the relationship between material transformations and social value creation in terms of increased resident well-being. In this section, the potentials and limitations of the findings – and the perspectives for further development – are discussed.

#### **Methodological limitations and perspectives for further development**

The listed alteration measures and well-being themes (Table 11) are derived from the literature review. As such, Table 11 does not make up an exhaustive list of potential relations. Use of alternative search strategies, search 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 not yet been addressed in existing research today. As such, this literature review may serve as inspiration for future research.

#### **Mapping and displaying joint environmental and social impacts**

The review itself has focused on identifying studies with an explicit account of relations between alterations of the existing construction of multi-family housing and their influence on the well-being of the residents. Where references include an explicit account of environmental impacts, this has been noted in Table 11. In future developments of the approach, it would be natural to examine in more depth how alterations of the construction may be best implemented to ensure synergies between resident well-being and energy savings.

#### **Perspectives for capitalizing the social value creation**

Rose et al. (2019) state that “*It is difficult to monetize the co-benefits*” (Rose et al. 2019, p. 2). The low number of identified studies, including capitalization of social value creation, seems to underline this statement. Rose et al. 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 m<sup>2</sup> for an average-sized Danish apartment, and with a typical rent of 160 €/m<sup>2</sup>/year, the co-benefit is worth approximately €1,440 per year per apartment”* (Rose et al. 2019, p. 2). Haverinen-Shaughnessy et al. (2018) link renovation initiatives to lower odds for reporting respiratory symptoms as well as not missing school or work due to respiratory infections (Haverinen-Shaughnessy et al. 2018). Though not linked directly to isolated renovation measures, this makes for interesting socio-economic perspectives. Almeida and Ferreira (2017) 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 (Almeida and Ferreira 2017). The references make for interesting examples of how social value creation may be monetized and thereby become more visible in economic prioritizations. This aspect is addressed in more depth in ‘Part 5: Communication’.

### **Contextual dependency**

As stated previously, each study’s research approach and contextual conditions vary. Contextual factors of relevance for the outcome should be closely examined when applying the relevant renovation measures in new projects (see also the research related to Objective 1, Phase B). The renovation of MSH is a complex matter for which no generalizable “one size fits all”-solution is available (Mørck et al. 2016; Darby 2017). 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. By also conveying methodological and contextual factors of the studies in a framework intended for informing the process (Objective 3), the aim would be to allow critical interpretation and to qualify the use of the framework in similar contexts and/or adapt the findings to the new context in a holistic manner.

In summary, this section has presented the results of a review of existing impact studies of increased well-being in housing renovation. The study has demonstrated that there are indeed potentials for increased well-being, which can be linked to environmental upgrades. In a few cases, the documented increased well-being has also been capitalized financially.

However, the knowledge base for joint energy savings and increased well-being in housing renovation is still limited and focuses primarily on physiological well-being themes related to perceived indoor climate.

# Identifying potentials for value creation - synthesis

The following section is devoted to synthesizing the findings of the chapter in relation to Objective 2:

2a. To identify examples that renovation measures can impact resident well-being in a broad understanding.

2b. To identify examples for synergies between increased well-being and energy savings.

To answer Objective 2a, the identified examples from the *architectural analysis* of completed cases, the *empirical studies*, and the *literature review* are summarized in Figure 70 as “well-being themes.”

Figure 70 is not exhaustive. It is intended as a starting point, a sort of skeleton, with examples of themes, for which a *documented* relation between renovation measures and increased resident well-being has been identified under certain contextual conditions.

The identified themes are “The sensuous space,” “The safe space,” “The social space,” “‘My’ space,” “The including space,” and “The functional space.”

The well-being themes are presented as, e.g., “The safe space” rather than “Safety” to signal that the specific way of altering the construction leads to spatial gestures that may inhibit or promote a sense of safety. By using personification as a linguistic instrument, the thesis points to the capabilities of the building – what the building potentially *does* when experienced by a resident under certain contextual conditions. This is *not* to suggest that a building holds objective capabilities independently of an experiencing subject.

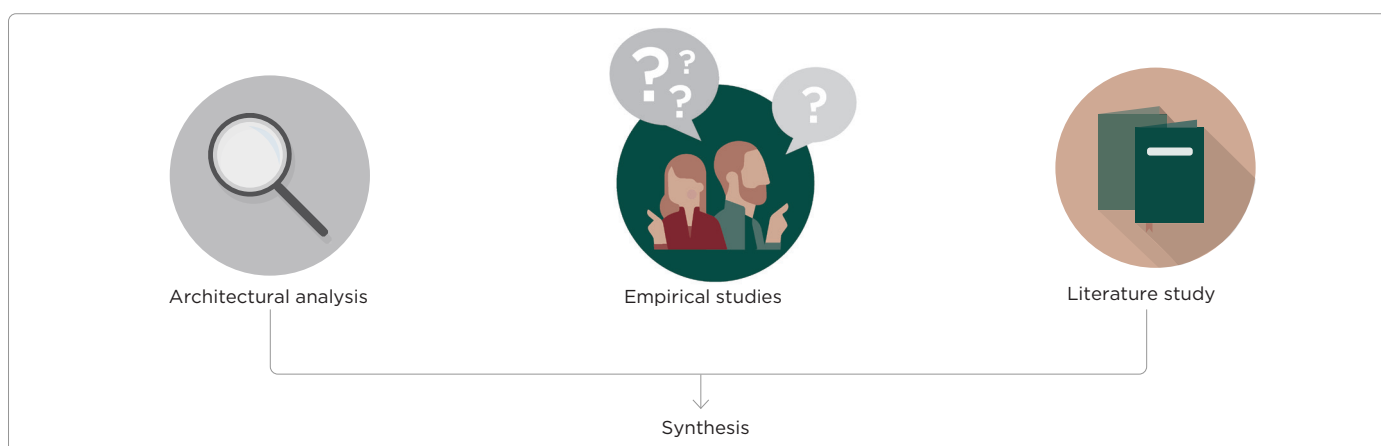
The focus is on *documented* relations between alteration

of the construction and increased well-being due to accentuated or added spatial gestures. Therefore, the synthesis is based primarily on the explanatory references identified in the *literature review*. The identified well-being themes were subsequently substantiated with examples from the *architectural analysis* and *empirical studies*.

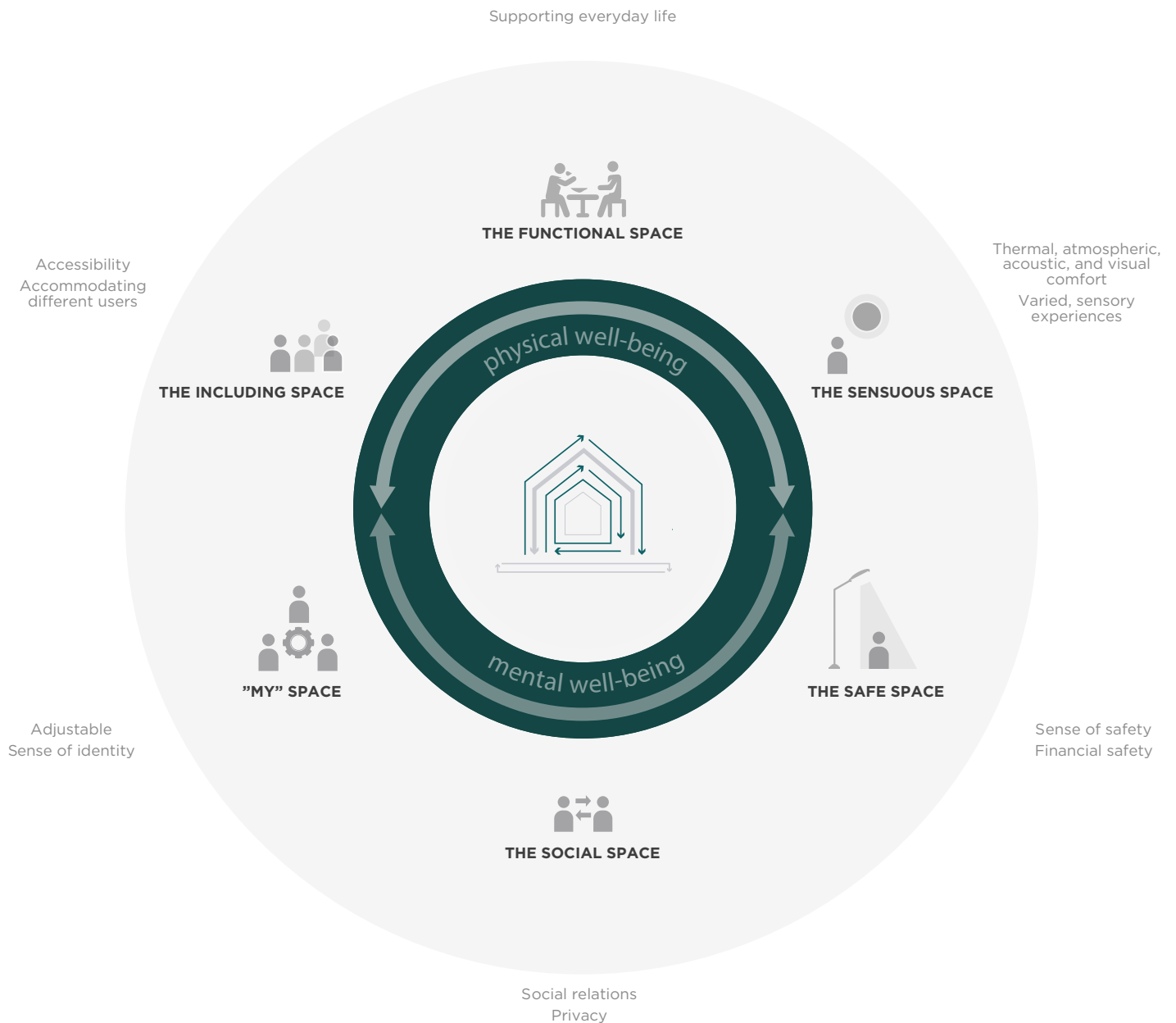
In the following, each of the well-being themes of Figure 70 is explained based on findings from the *architectural analysis of completed cases*, the *empirical studies*, and the *literature review*. As part of the synthesis, the relevance of each well-being theme is established relative to the specific context of social housing renovation. This is done with reference to publications from the Danish National Building Foundation.

In order to answer Objective 2b, the synthesis includes an account of how each well-being theme could form synergies with energy-saving efforts. This is done with reference to Figure 41 on page 86 (“Examples of typical strategies for implementing energy savings”).

While the well-being themes are described separately, it is important to note that they are closely related. For instance, mechanical ventilation may contribute positively to the atmospheric comfort of a dwelling. However, it may be problematic in terms of noise nuisances and installations taking up space within the dwelling. In addition, positive sensory stimuli may be both an objective in its own right and a means to reach the objectives of, e.g., a sense of safety.



**Figure 69** This section is devoted to a synthesis of the findings of the chapter.



**Figure 70** Well-being themes identified through the three sub-studies. Alterations to the built environment are likely to influence other dimensions of resident well-being. As such, the figure should be seen as a starting point for gathering examples of documented relations.

## POTENTIALS FOR IMPROVING RESIDENT WELL-BEING THROUGH RENOVATION

### The sensuous space



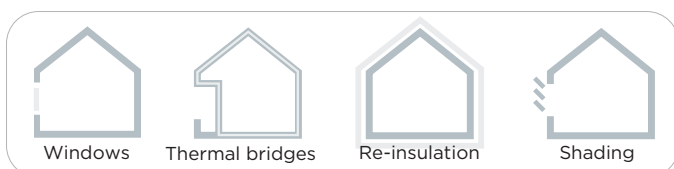
The sensuous space refers to the ability of the built environment to offer sensory stimuli to the resident. The theme includes attention to limiting negative stimuli *and* promoting positive stimuli.

#### *Thermal well-being*

Much reviewed literature in the *literature review* centered on securing thermal comfort by eliminating nuisances from draught and reducing the heat loss through the façade during cold months (Haverinen-Shaughnessy et al. 2018; Byrne et al. 2016; Almeida and Ferreira 2017; Abdul Hamid et al. 2019; Liu et al. 2015; Thomsen et al. 2016). The *empirical studies* supported the potential for improving the resident's thermal comfort through a renovation in the investigated housing areas. The *empirical studies* further indicated a potential for improving residents' health by improving thermal comfort. This relation was also identified in the literature review (e.g., in the work of Haverinen-Shaughnessy et al. 2018).

The *architectural analysis* of all six completed cases points to alterations that are likely to improve thermal comfort, such as upgrading the thermal performance of the building envelope.

The National Building Foundation mentions thermal bridges and a need to re-insulate facades and roofs as a recurring issue in multi-family housing (Landsbyggefonden 2014). Improved thermal comfort is often a 'low-hanging fruit' in relation to energy saving efforts, as the thermal comfort of a dwelling is closely related to the operational energy used for heating it. Efforts to improve thermal comfort can thus be implemented by improving thermal insulation and airtightness, e.g., by replacing windows with thermally efficient ones and adding exterior insulation. As seen in the *architectural analysis* of completed



**Figure 71** Typical energy-related alteration measures relevant to "The stimulating space" in terms of thermal comfort.

cases, the latter approach can cause radical changes to the existing building. The *architectural analysis* of cases exemplified that efforts to improve thermal performance can be executed differently, preserving, accentuating existing gestures, or adding new ones. As such, efforts to reduce heat loss and improve thermal comfort prescribe a thorough analysis of existing qualities.

The *empirical studies* have pointed to a potential for easing overheating during summertime. This should be addressed as part of the future façade renovation, e.g., through the addition of shading devices. Further, the *architectural analysis* of cases, e.g., of Kleiburg in the Netherlands, has pointed to a potential need for shading in the new dwellings on the ground floor which does not have the same overhang as the original dwellings from the second floor and upwards.

#### *Visual well-being*

The identified relations in terms of visual well-being center on daylight and views.

Visual well-being is not articulated explicitly by The National Building Foundation. Yet, the *literature review* and the *architectural analysis* of cases have pointed out that, e.g., exterior re-insulation, may compromise daylight access (Almeida and Ferreira 2017). As mentioned in the introduction, many postwar social housing dwellings are characterized by good daylight conditions. The *empirical studies* support that the residents are generally satisfied with the access to daylight. As such, this represents a value in risk of being compromised when altering the building and its surroundings.

The *empirical studies* do, however, also indicate an excess of light in the sleeping rooms during summertime.

The *empirical studies* have pointed to the risk of losing views to large trees in the proximity of the building due to the densification of the area. The risk of losing experiential qualities associated with trees and greenery has also been identified in the *literature review* (Kasemets et al. 2019).



**Figure 72** Typical energy-related alteration measures relevant to "The stimulating space" in terms of visual comfort.

### Acoustic well-being

Acoustic well-being refers to experienced acoustic conditions in a dwelling, between dwellings, and from the exterior.

The *literature review* pointed to potentials for synergies between improvements of the thermal performance of the envelope and efforts to improve sound insulation from the exterior, e.g., re-insulation and new windows (Almeida and Ferreira 2017; Haverinen-Shaughnessy et al. 2018; Mørck et al. 2016).

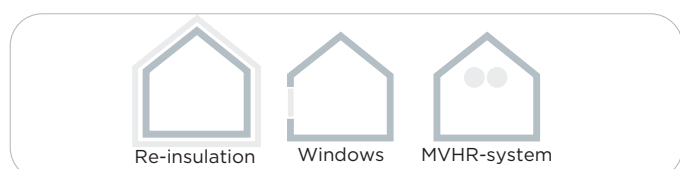
The National Building Foundation specifically mentions noise-related issues between dwellings and from the exterior (Landsbyggefonden 2014). The *empirical studies* also found a potential for improving the residents' well-being by improving the sound insulation between dwellings and from the exterior as part of a renovation. The *literature review* revealed that the introduction of, e.g., MVHR-systems (mechanical ventilation with heat recovery), may introduce new noise nuisances (Almeida and Ferreira 2017; Haverinen-Shaughnessy et al. 2018; Liu et al. 2015).

### Atmospheric well-being

Atmospheric well-being refers to perceived air quality, such as smells. Further, it refers to more passively polluting particles.

The National Building Foundation includes the risk of xenobiotics in their account of general challenges in blocks of flats from the 1945-1959 and 1960s-1974 (Landsbyggefonden 2014). The *literature review* pointed to potentials for improving the perceived air quality by introducing new/more ventilation (Almeida and Ferreira 2017; Abdul Hamid et al. 2019). This may be combined with heat recovery (MVHR) to reduce the energy consumption of the building (Abdul Hamid et al. 2019). On the other hand, it is important to ensure that new issues do not arise in the wake of the renovation in terms of degasification from new building materials (Videnscenter for Energibesparelser i bygninger 2020).

The *empirical studies* illustrated a need for updating



**Figure 73** Typical energy-related alteration measures relevant to “The stimulating space” in terms of acoustic comfort.

exhaust from the kitchen and bathrooms. Further, the *empirical studies* pointed to potentials for reducing stuffy smells and tobacco and cooking smells from neighbors and to better influence the dampness of the dwelling.

The *architectural analysis* of completed renovation cases pointed to existing spaces being “seized” for ventilation purposes, aiming to improve the perceived indoor climate. This points to the importance of considering the best possible implementation in a specific project (e.g., in the ceiling, optimal placement of pipes, etc.) as well as continuous dialogue with the residents.

### Tactile well-being

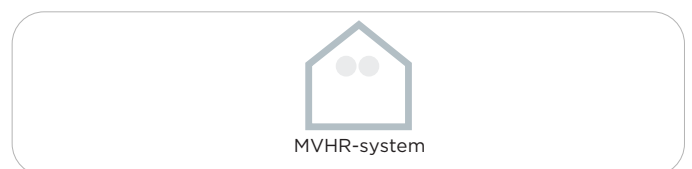
The *architectural analysis* pointed to the addition of wooden handrails in Kleiburg and wooden panels in Park Hill. With reference to architectural theorists such as Pallasmaa and Frascari (Pallasmaa 2012; Frascari 1996), these elements can be seen as a possible way to add tactile qualities in a scale close to the body in largescale buildings otherwise dominated by concrete. Tactile qualities should be remembered as part of all efforts to save energy. The subtheme was not identified through the explanatory references of the literature review. It is, therefore, only included here to nuance the understanding of “the sensuous space” and to draw attention to the subject as a basis for future studies.

### The functional space



The functional space refers to the ability of the built environment to provide functional spaces which support the behavior of the residents.

The *literature review* pointed to potentials for improving the effective usable floor area of the dwelling when the façade becomes ‘warmer’ and allows for better usage of the square meters (Rose et al. 2019). As such, this is directly related to improvements in the thermal performance of the façade. The *empirical studies* supported that



**Figure 74** Typical energy-related alteration measures relevant to “The stimulating space” in terms of atmospheric comfort.

this represents a potential also in the three investigated housing departments, where regulation of temperature and prevention of draught represents a potential for increased well-being.

The National Building Foundation points to outdated bathrooms and kitchens in the postwar social housing stock (Landsbyggefonden 2014). This is reflected in the *empirical studies*. The studies identified potentials for improving the functionality of the dwellings by allowing space for (and water/electricity connection to) a washing machine and a tumble dryer. Further, the *empirical studies* identified a potential for improving accessibility in the bathroom layout (see also “The including space”). Attention to the bathroom layout may not be directly linked to energy savings. Yet, it is closely related to updating the installations of the dwelling, which is part of many larger renovations.

The *empirical studies* have further pointed to potentials for supporting more efficient utilization of the shallow balconies in Toveshøj and Gellerupparken. This could be improved by, e.g., creating a larger opening as part of the façade renovation.

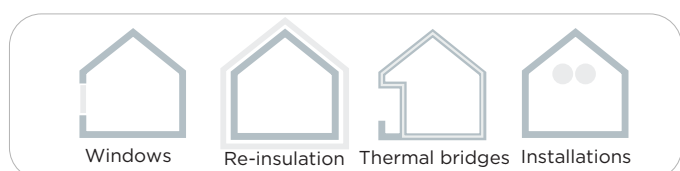
### The safe space



The safe space refers to financial safety and a sense of safety in the built environment.

#### Financial safety

The *literature review* illustrated that renovation might directly benefit the residents, e.g., through reduced household expenses for heating and reduced exposure to energy price fluctuations (Darby 2017; Almeida and Ferreira 2017). However, renovation may have the opposite effect for households, who already keep their heating expenses at a minimum and are vulnerable to rent increases prompted by the renovation (Weber and Wolff 2018).



**Figure 75** Typical energy-related alteration measures relevant to “The functional space”.



**Figure 76** Typical energy-related alteration measures relevant to “The safe space” in terms of financial safety.

#### Sense of safety in the built environment

The *literature review* has pointed to a potential for an improved sense of safety in the renovated areas. This is linked to alterations in the exterior, such as pathways through the neighborhood, increased lighting, and cutting trees and bushes (Nørgaard and Rudå 2021). Such alterations may be implemented in synergy with changes to the overall layout of the area, as part of implementing more energy-effective lighting systems, or as part of LAR strategies (local handling of rainwater). In addition, adding windows in closed parts of a building is also mentioned as an alteration measure that can be linked to an increased sense of safety (Nørgaard and Rudå 2021). Such alteration measures can be combined with general façade renovation to promote both energy savings and increased well-being. This was the case in the Rosenhøj project, referred to as part of the *literature review* and analyzed as part of the *architectural analysis* of completed cases.

Sense of safety is a recurring theme in The National Building Foundation’s account of contemporary challenges (Landsbyggefonden 2014).



**Figure 77** Typical energy-related alteration measures relevant to “The safe space” in terms of a sense of safety in the built environment. (NB: alterations to the exterior lie outside the scope of the thesis).



## “My” space



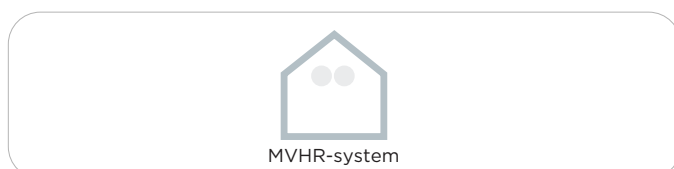
“My” space refers to the ability of the residents to influence conditions in the built environment and the ability of the built environment to contribute to a positive narrative in the area which can contribute to a sense of pride and identity.

### *Ability to influence conditions*

The *literature review* pointed to potentials for promoting a sense of control by allowing the residents to adjust conditions in the built environment. Specifically, Abdul Hamid et al. (2019) pointed out that residents feel more in control over their ventilation after implementing a decentralized MVHR-system (Abdul Hamid et al. 2019). The *empirical studies* demonstrated a potential for improving the residents’ ability to regulate sound/acoustic conditions, temperature, air circulation, and dampness. However, the *architectural analysis* of Ellebo exemplified that the implementation of an MVHR-system may come at the expense of other qualities, as the equipment takes up considerable space in the apartment. This calls for careful attention and user dialogue in the planning phase and consideration of the best aggregate type for the specific project – e.g., implemented in the ceiling, in niches, etc.

### *Sense of pride and identity*

The National Building Foundation mentions that many postwar MSH areas today have a physical appearance which has a negative impact on the residents’ sense of identity: “Roof and facades are worn and/or unsightly, uninspiring, negatively impacting a sense of identity” (Landsbyggefonden 2014, p. 52, translation by author). The *literature review* pointed to potentials for contributing to a sense of pride and identity when renovating a housing area and when implementing new attractive garden elements and pathways which allow visitors to pass through the area (Juntti and Lundy 2017; Nørgaard and Rudå 2021). Nørgaard and Rudå (2021) presented to



**Figure 78** Typical energy-related alteration measures relevant to “My’ space” in terms of ability to influence conditions.

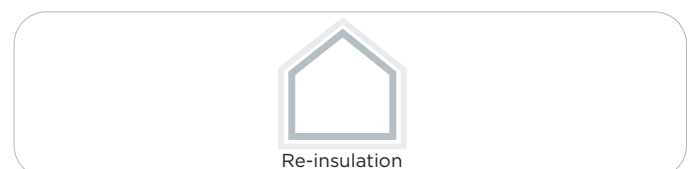
a study in Rosenhøj where a large proportion of residents now feel proud of living in the area. Efforts to renovate Rosenhøj included renovation of the façades, also resulting in energy savings.

Renovation efforts focusing on the exterior spaces, e.g., new pathways, may be linked to the implementation of LAR strategies.

As part of the *architectural analysis* of completed cases, it was exemplified how different approaches to improving the envelope’s thermal performance may be used to ‘re-brand’ the housing area; in Rosenhøj by combining exterior re-insulation with the introduction of new materials, which create an altogether renewed expression, and in Park Hill by rethinking the non-loadbearing elements within the preserved grid-structure. Efforts to increase the residents’ sense of pride and identity prescribes a thorough analysis of existing values in a building to determine the level of preservation vs. renewal and how to weigh this up against the technical goal of energy savings.

The *empirical studies* revealed that residents in Søvangen are notably more pleased with the expression of the building from the exterior than the residents in Toveshøj and Gellerupparken. It was discussed how this might reflect the different characteristics of the buildings – and that it represents a potential for improvements through renewal as part of the physical alterations in Gellerupparken and Toveshøj. However, it was also suggested that future renovation efforts (if focusing on preservation and accentuation of values) could be complemented with positive “branding”/“storytelling” of existing and added values externally as well as internally. This may help promote the attractiveness of the area as well as the resident’s sense of identity in the area.

The *empirical studies* further pointed to the importance of waste management in retaining a positive image and a potential for ‘lifting’ the image amongst residents through a general renovation of the apartments now considered worn.



**Figure 79** Typical energy-related alteration measures relevant to “My’ space” in terms of adding to the residents’ sense of pride and identity.

## The social space



The social space refers to the ability of the built environment to promote different degrees of social interactions and allow for privacy.

### Social interaction

The *literature review* included a reference indicating that new balconies might contribute to more encounters between residents (Nørgaard and Rudå 2021). This renovation measure may be combined with energy optimization of the façade. The *literature review* further pointed to the potential to create places for social encounters through alterations to the exterior spaces. This may be combined with environmental efforts to handle rainwater (Kasemets et al. 2019), which The National Building Foundation mentions as a focus (Landsbyggefonden 2014).

The *empirical studies* illustrated that people have varying needs and wishes for social interaction. Some residents value the casual meetings in the stairway, whereas others participate in, e.g., communal eating and volunteer in various activities. In this connection, the National Building Foundation points to the need to address the worn or altogether missing common facilities in many housing departments (Landsbyggefonden 2014). The *architectural analysis* of completed cases exemplified that, e.g., Fittja People's Palace and Kleiburg, included reprogramming the lower floors. Reprogramming existing spaces for common facilities may be seen as a way to utilize existing spaces better, which can be considered an energy-optimizing strategy in its own right.

The *literature review* pointed to potentials for better integrating housing areas in the surrounding city through alterations in the built environment (Stender and Bech-Danielsen 2019; Juntti and Lundy 2017). One strategy is to include public functions in the layout of the housing area and, in continuation hereof, to make it easy and attractive

for 'externals' to use pathways and green spaces within the housing area. In this regard, the study has pointed to the importance that existing residents do not feel excluded (feel that they are not the target group of the regeneration) (Juntti and Lundy 2017). Further, the study points to the fact that "...*spatial proximity does not necessarily reduce social distance*" (Stender and Bech-Danielsen 2019, p. 53).

### Privacy

When living close to one another, it is crucial also to ensure people's sense of privacy.

The theme was not identified explicitly as part of the *literature review*. However, as mentioned, The National Building Foundation explicitly mentions noise-related issues between dwellings and from the exterior in their account of general challenges in the postwar MSH building stock (Landsbyggefonden 2014). The relevance of addressing the *acoustic privacy* of the residents was also identified through the *empirical studies* (see "the sensuous space"). Renovation may represent an opportunity to improve acoustic privacy while improving the thermal performance of the building envelope.

The *empirical studies* have further pointed to a potential for promoting a sense of visual privacy on the open balconies in the studied buildings.

As densification forms part of many renovations of MSH (and can be considered a strategy for optimizing the energy use in an area), it is also important to ensure that residents' sense of privacy is not compromised due to adding new building volumes or cutting trees which today help block views. This point was identified through the *empirical studies*.



**Figure 80** Typical energy-related alteration measures relevant to "The social space" in terms of promoting social interaction. (NB: alterations to the exterior lie outside the scope of the thesis).



**Figure 81** Typical energy-related alteration measures relevant to "The social space" in terms of securing privacy.

## The including space



The including space refers to the ability of the built environment to promote accessibility for people with special needs and to embrace different groups of residents.

### Accessibility

The National Building Foundation has formulated ‘improved accessibility’ as part of the core issues to be addressed in the postwar social housing stock (Landsbyggefonden 2014). They point to issues in the bathrooms (see also “The functional space”) and access to the building and dwellings. Further, they point to a general lack of maneuver freedom in the dwellings. This theme was not identified explicitly through the *literature review*. Yet, evaluations, by e.g., Bech-Danielsen and Stender (2020) and Bech-Danielsen and Mechlenborg (2017), point to examples of increased accessibility after renovation of MSH (Bech-Danielsen and Mechlenborg 2017; Bech-Danielsen and Stender 2020).

The *empirical studies* in this thesis support the potential to improve accessibility in the bathrooms and the entrance situation by implementing elevators. These issues may be addressed in synergy with energy-related concerns, e.g., when renovating the façade and when updating installations within the dwelling.

### Embrace different groups of residents

In addition to the accessibility concerns, “the including space” also relates to providing spaces that meet the needs of different demographic groups.

The *literature review* directed attention to potentials for targeting different (and new) user groups through new ownership and dwellings types. This strategy was applied in, e.g., the Woodberry Down Estate, UK, described by Juntti and Lundy (2017) and Finlandsparken in Denmark, described by Stender and Bech-Danielsen (2019). Securing different dwelling types may be considered a positive

thing in many instances as, for instance, it allows residents to “...climb up the ladder of the housing career without leaving the area” (Stender and Bech-Danielsen 2019, p. 51) and may form part of strategies to “open up” an area to the remaining city (Stender and Bech-Danielsen 2019). However, it may not *necessarily* contribute to the interaction between different groups of residents. Further, Stender and Bech-Danielsen point to the fact that “...refurbishment of social housing estates is often also used strategically to change the composition of tenants and push out particularly marginalized tenants by merging one room flats etc.” (Stender and Bech-Danielsen 2019, p. 50). As such, embracing different groups of residents is a delicate subject that requires a high level of contextual awareness.

The National Building Foundation mentions issues related to renting out certain apartment types (“tomgang”). This is a highly context-dependent issue that is most widespread in peripheral regions (Landsbyggefonden 2014). Further, The National Building Foundation mentions issues related to too many small apartments and a subsequent strategy for merging smaller apartments (under 60 m<sup>2</sup>) (Landsbyggefonden 2014). Not least, they mention that kitchens are generally outdated and should be rethought as part of the renovation to accommodate contemporary living. Reprogramming may be considered in combination with energy-related optimization of the utilization of the existing building mass.



**Figure 82** Typical energy-related alteration measures relevant to “The including space” in terms of accessibility.



**Figure 83** Typical energy-related alteration measures relevant to “The including space” in terms of embracing different users.

# Summary

This chapter has applied three different methodological ‘lenses’ for identifying examples of increased well-being in renovation and how this may be combined with energy savings: architectural analysis of completed cases, empirical studies, and a literature review. In the previous section, the findings were synthesized as what is referred to as “well-being themes”, identified aspects of resident well-being that can be influenced when performing the renovation. The identified themes are: The sensuous space, The functional space, The safe space, “My” space, The social space, and The including space. As part of the synthesis, it has been illustrated how spatial gestures in the built environment may be combined with attention to energy savings.

Some of the identified themes are regulated through the national building regulations and some through the subsidy scheme of The National Building Foundation. As an example of the former, the national building regulations put forward minimum requirements for acoustic performance (Ministry of Transport Building and Housing 2018); However, for instance, sound regulation between dwellings is only mandatory if the specific wall is affected by the renovation. Similarly, only ‘affected’ components need to comply with the building regulations regarding energy performance.

The National Building Foundation promotes certain themes through its subsidy scheme, which is the case for, e.g., accessibility and improvements of common facilities (Landsbyggefonden 2021) – and more recently through an increased focus on the green transition (Landsbyggefonden n.d.-c).

Beyond this, it is a task for the involved stakeholders (in collaboration with The National Building Foundation) to promote synergies between energy savings and well-being in the built environment. As addressed in the introduction to the thesis, especially the “softer” well-being themes are difficult to articulate and implement as part of contemporary sustainable renovation processes. As such, traditionally qualitative, “softer” themes form center stage in the following chapter, focusing on using the identified examples as a basis for informing the interdisciplinary renovation process (Objective 3).



# Part 5 : Communication - informing practice







# Informing practice

The previous section was devoted to identifying examples that renovation measures can impact resident well-being and how this may form synergies with energy savings. This chapter is devoted to Objective 3, which focuses on how to bring the identified insights “into play” in future renovation projects as a strategy for supporting the architect’s role as a promoter of resident well-being in the early design phases of sustainable renovation processes.

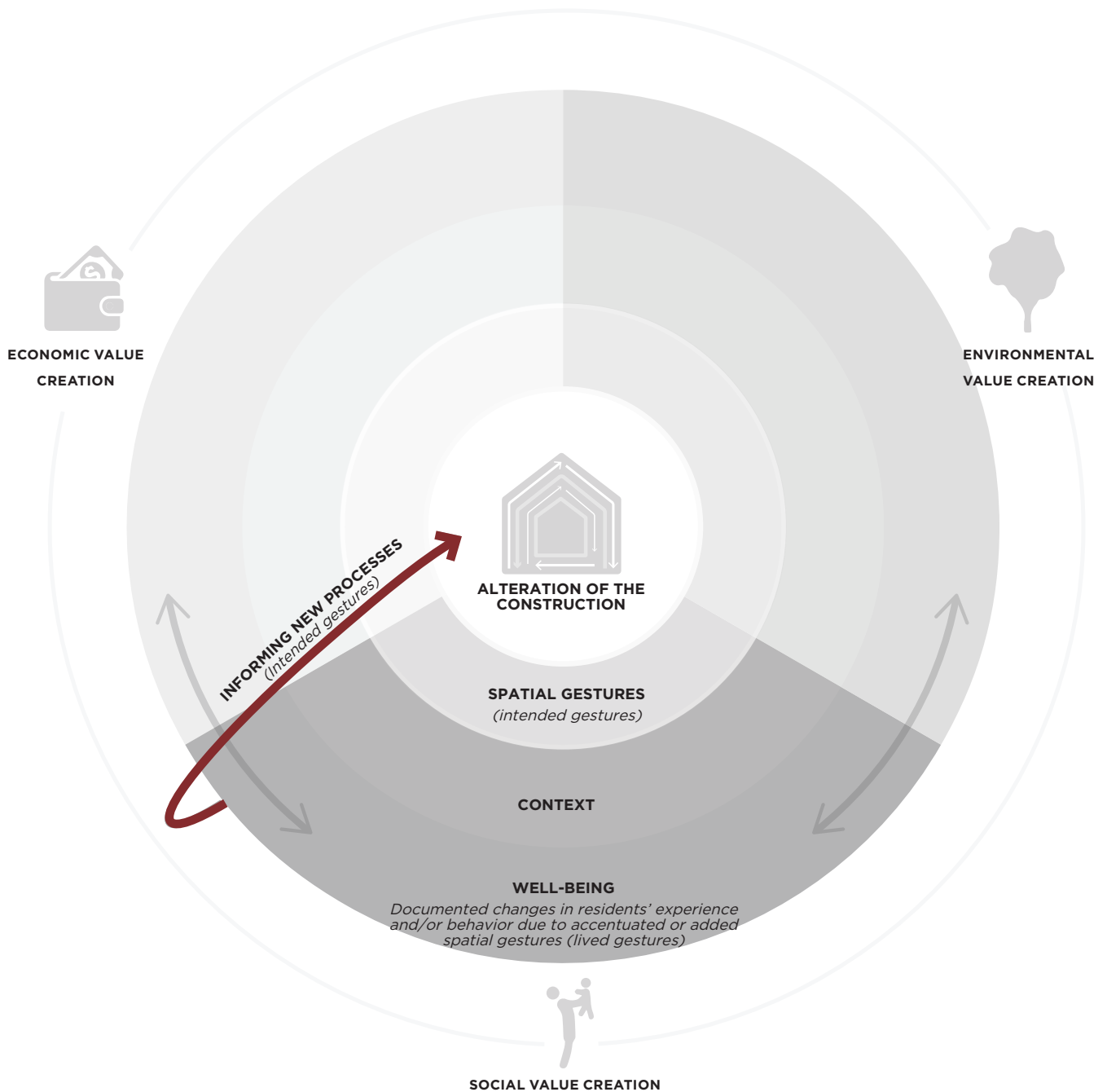
To use the terminology developed in Objective 1, the knowledge about “lived gestures” derived from previous projects is used to lay the grounds for “intended gestures” in future projects (Figure 84). To recap, Objective 3 consists of the two following sub-objectives:

*3a. To describe typical characteristics of the early stages of renovation of multi-family social housing.*

*3b. To exemplify how a framework could be developed to visualize potentials for synergies between energy savings and improved resident well-being in a manner where traditionally “soft,” qualitative aspects are treated on equal terms as “hard,” quantitative aspects (to be used by architects when engaging in dialogue with other stakeholders in the early design process).*

Objective 3a was addressed in part in the introduction to this thesis, which included a brief overview of the typical renovation process and the typical stakeholders involved when performing renovation of MSH in a Danish context. This chapter reports on the findings of a research through design study (RtD study) used to exemplify the general process and point to key learning points relevant to informing the decision process. Subsequently, the RtD study was used to explore the creative interdisciplinary process in more depth by zooming in on three downstrokes into the decision process and discussing how insights into potential synergies between resident well-being through spatial gestures and energy-saving might have supported the process in these situations.

Findings in relation to Objective 3b are reported in the subsequent sections. First, different approaches within the architectural field for informing the early design stages were discussed. After that, three proposals for frameworks were introduced to inform the early stages with insights on potential synergies between resident well-being and energy savings. A focus group interview as well as the RtD study were used as a basis for discussing the first concept and proposing two additional concepts. These additional concepts were also discussed relative to the findings of the RtD study, and the study was concluded by a joint summary pointing to further perspectives for the research.



**Figure 84** The previous section was devoted to identifying examples that renovation measures can impact resident well-being and how this may form synergies with energy savings. This chapter is devoted to Objective 3, which focuses on how to bring the identified insights “into play” in new projects.

# Exploring the renovation design process

## EXPLORING THE CONTEMPORARY INTERDISCIPLINARY RENOVATION DESIGN PROCESS FROM THE PERSPECTIVE OF THE ARCHITECT

A research through design study (RtD study) has been carried out in the architectural studio of AART architects in Aarhus, Denmark in the winter 2016/17. The case project was a competition entry for renovation of a housing block in Gellerup, Denmark, called B4. As described in 'Part 2: Methodology', the overall aim of the RtD study was to gain background knowledge about the field and, more specifically, to investigate how practicing architects work to promote the well-being of residents and energy savings in the early design phases.

The case building block has also been described in relation to the empirical study. Whereas the empirical study focused on the residents' perception of the building before the renovation, the present chapter focuses on the architectural and interdisciplinary process of developing and evaluating different design alternatives in the early stages of the renovation process (Figure 92 on page 149).

In brief, the existing building is an eight-story building block, built from 1968-72. The building block is a prefabricated construction, built from concrete slabs and bearing walls. In the following, the case is first described relative to the general description of the process and stakeholders in the introduction.

After that follows an account of key learning points concerning the decision 'dynamics' in the process. These findings are related to theory on architectural design processes in order to demonstrate the broader relevance of these learning points beyond the single case.

Lastly, the RtD study is used as a basis for a retrospective analysis, based on the architectural conceptual framework developed in relation to Objective 1. This analysis exemplifies situations where documented insights might have informed the interdisciplinary process on potentials for joint social and environmental value creation.

## THE RENOVATION DESIGN PROCESS EXEMPLIFIED - B4 IN GELLERUPPARKEN

The renovation of the building block B4 was one of three "pilot projects," which marked the first stage of the realization of a large overall plan for Gellerupparken and Toveshøj in Aarhus (Figure 85 and Figure 86). An engineering company (Rambøll) and an architectural studio (Pluskontoret arkitekter) had been involved as client consultants from earlier stages. Together with a schema A to the National Building Foundation, an overall plan formed the basis for a turnkey contract tender and associated competition.

The competition included (Figure 87-Figure 90):

- A penetration project: penetrating the building to allow for a road to cut through the area.
  - A renovation project including renovation of the building envelope and staircases and a so-called basis renovation of the dwellings, including new bathrooms and ventilation system and optional renovation of kitchens.
  - A transformation project: transforming the ground and first floors into new so-called 'town-houses'.
  - An infill project: establishing new dwellings above a new road cutting 'through' the building.
  - Suggesting densification of the site.
- (Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a; Pluskontoret Arkitekter and Rambøll Danmark A/S 2016b)

In terms of energy, the target was to meet the Danish building regulation BR15 by securing that altered/replaced components comply with the national standards (Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a; Pluskontoret Arkitekter and Rambøll Danmark A/S 2016b). When the competition was launched, the residents had already voted in favor of the renovation based on sketches presented by the client consultants. As such, a relatively high number of boundary conditions had been set up before the launch of the competition call, including, for instance, the layout of the dwellings.

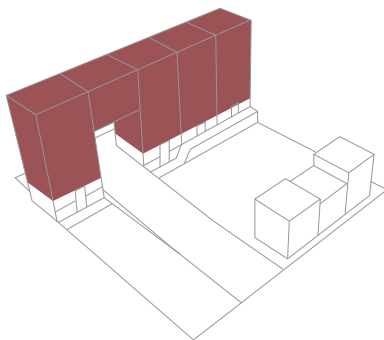
The competition was initiated to get proposals as to how to synthesize the intentions of the previous phase into specific design scenarios within the financial framework (target budget: 92 million Danish Kroner) and to pick a turnkey contractor to manage the renovation.



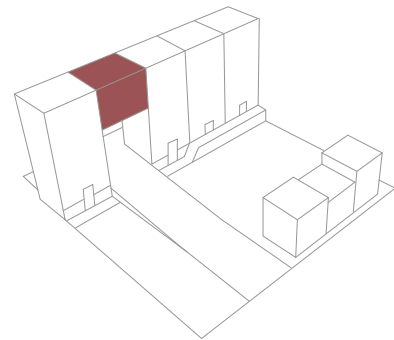
**Figure 85** Building block B4 in Gellerup.



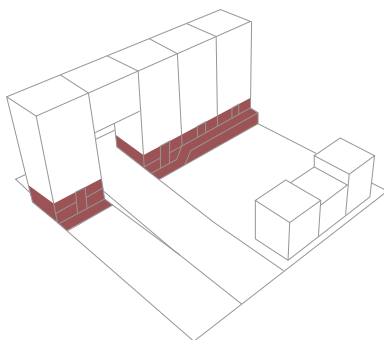
**Figure 86** Building block B4 in Gellerup.



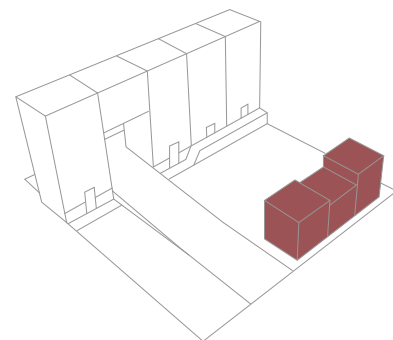
**Figure 87** The planned changes to the building described diagrammatically. Renovation. (Based on Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a, p. 13).



**Figure 88** The planned changes to the building described diagrammatically. Demolishing a staircase and creating an infill structure. (Based on Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a, p. 13).



**Figure 90** The planned changes to the building described diagrammatically. Transformation of ground and first floors. (Based on Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a, p. 13).



**Figure 89** The planned changes to the building described diagrammatically. Densification. (Based on Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a, p. 13).

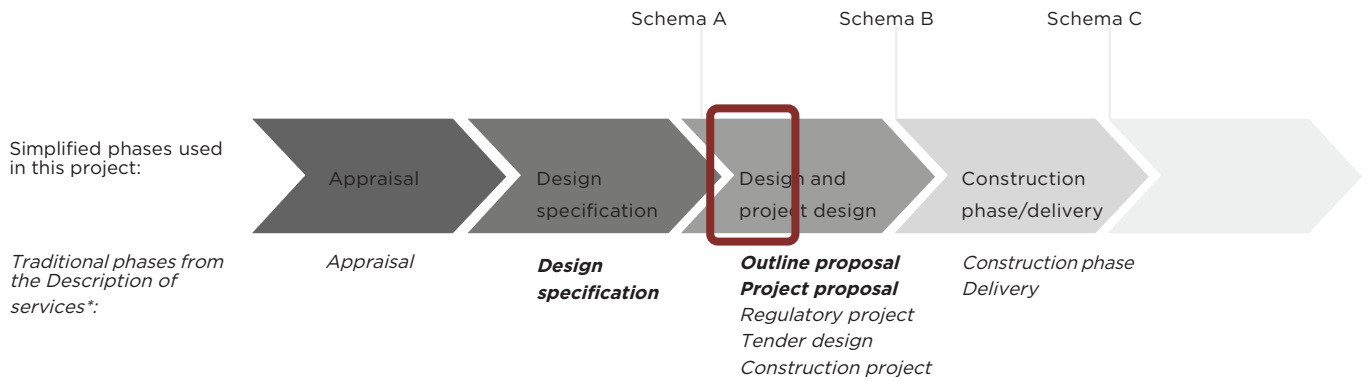
Figure 92 indicates when the competition was carried out relative to the general process description from the introduction to the thesis.

The competition was organized as a turnkey tender. A turnkey contract prescribes that a turnkey contractor manages the project design and construction, possibly in collaboration with consultants (Rambøll 2018). The primary stakeholders involved in the development of the B4 competition-entry were: the turnkey contractor (Enemærke + Petersen) with an engineering company (Viggo Madsen) and an architectural company (AART architects) as sub-contractors. The author formed part of the team of architects. The contractor had an ongoing dialogue with potential craftsmen about the pricing of the proposed alterations (Figure 91).

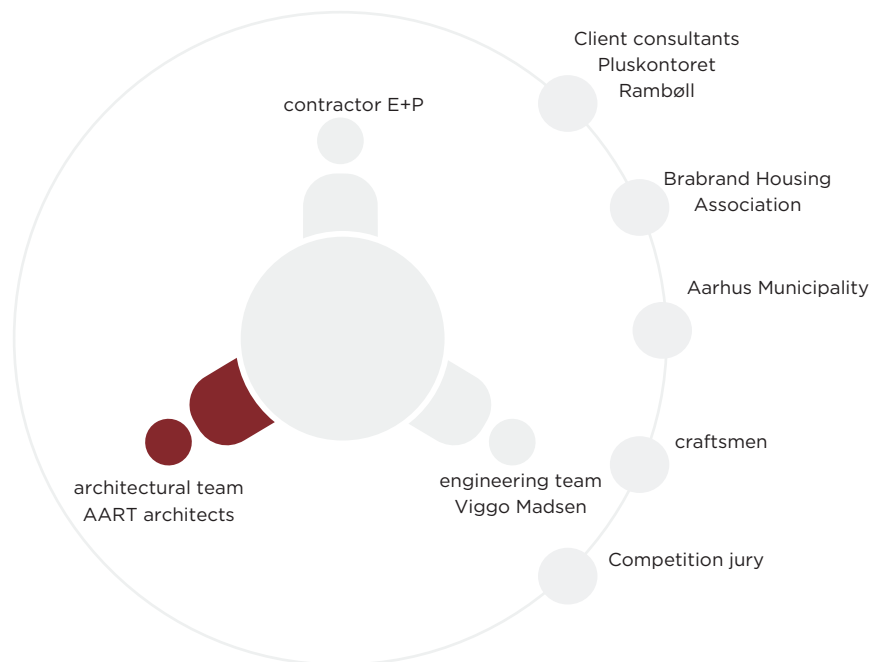
Figure 93 on page 150 is a principle diagram showing the meeting structure in the B4 competition project (can be understood as an elaboration of the excerpt in Figure 92). The diagram depicts the iterative process within the design team at AART architects (red, top). The interdisciplinary project team of architects, engineers, and contractors would meet on a weekly basis to discuss the development of the project (red, bottom). The competing team had an opportunity to interact with the client and client consultants in an initial information meeting and two so-called 'dialogue meetings', where the project was presented and discussed following the tender format: "udbud med forhandling" [procurement with negotiation] (green). Based on these 'dialogue meetings', and the alteration measures discussed in these meetings, the client consultants would send out corrections to the competition brief to all competing teams afterwards. Therefore, the teams would indirectly influence each other through this 'channel' (blue).

Following this brief account of the process in relation to the B4 competition process, the RtD-study is used to identify some overall patterns related to the decision process, with relevance when aiming to inform the early stage renovation process.

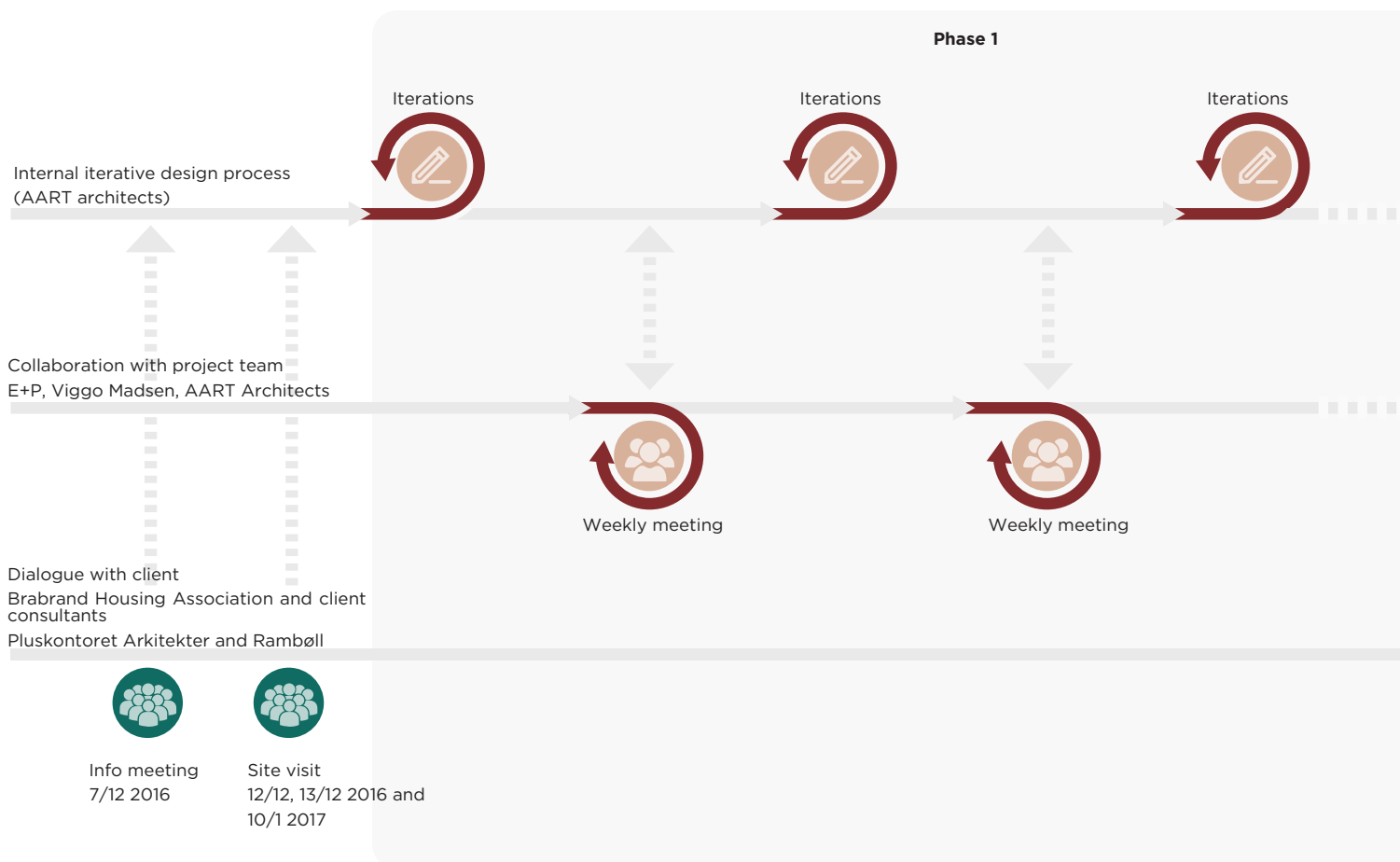




**Figure 92** Diagrammatic representation of when the competition entry was developed (marked with a red square) relative to a simplified, “typical” process, described in the introduction to this thesis.



**Figure 91** Diagrammatic overview of the primary stakeholders in the competition team.



**Figure 93** Principle diagram showing the process in in the B4 competition. Elaboration of the excerpt of Figure 92 on page 149. The diagram depicts the iterative process within the design team at AART architects and how interaction with the project team and client influenced the process. Prior to this process lies a prequalification process.

#### OVERALL PATTERNS RELATED TO THE DECISION PROCESS

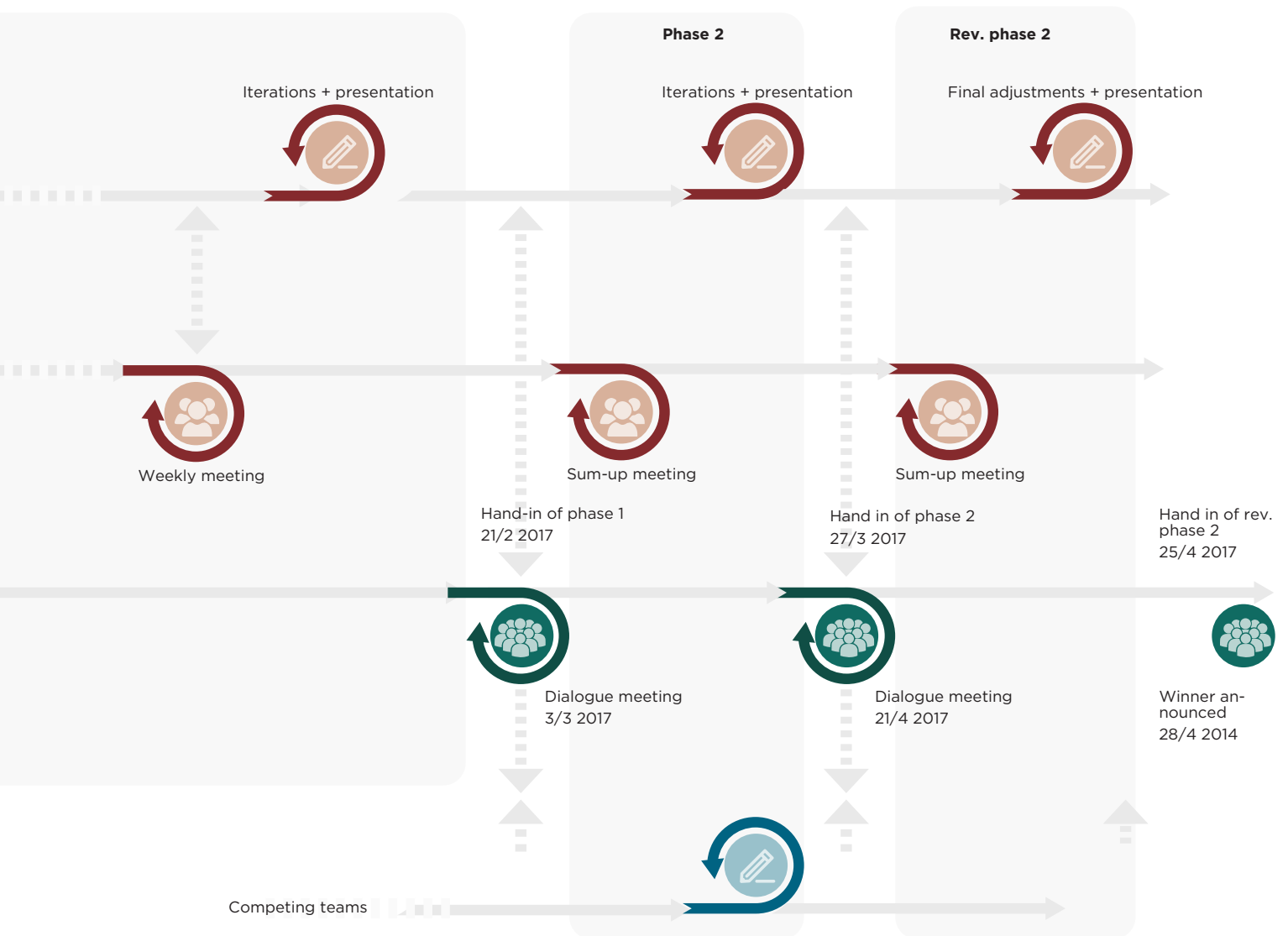
In the following, some key learning points from the RtD-study are accounted for. The learning points are related to theory on architectural design processes to demonstrate that the learning point is not “only” relevant for the specific case. The learning points are summarized in Figure 102 on page 157.

#### Internal and external decision process

In the B4 process, an integrated design process was pursued through a high involvement of all stakeholders (Larsen and Birgisdóttir 2013). From the process in B4 it was evident that there may be a potential for informing both the “internal” process of the architects within the architectural studio and the “external” process, where the stakeholders (architects, engineers, and contractor)

get together.

Internally, it would be a matter of “supplying” insights in the right format and time to the individual architect or a group of architects. Researchers have addressed the subject from various perspectives. For instance, Purup and Petersen, who – based on a series of interviews with practitioners – identified 31 different ‘design activities’ categorized into ‘research activities’, ‘modelling activities’ and ‘meeting activities’. The motivation was to understand how “...tools for indoor climate and energy performance simulation (BPS) [can] be conformed to fit architectural design practice” (Purup and Petersen 2020, p. 1). The RtD-study, as well as the study by Purup and Petersen, suggests that within the architectural studio, there are individual activities as well as group activities which include



design decisions. Further, design decisions may be more or less explicitly articulated, as the designer also makes a series of individual choices whilst sketching.

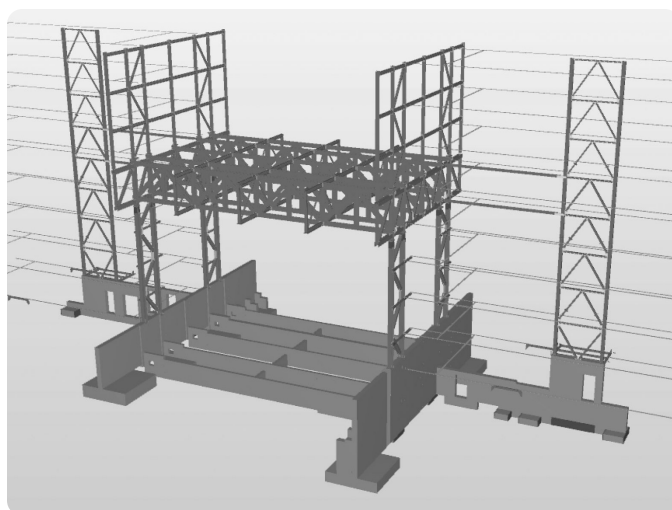
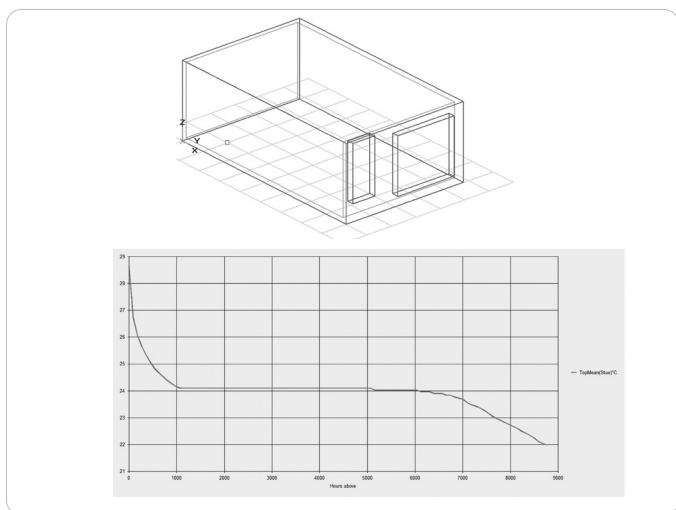
Looking closer at the 'external' process, typically, the members of the interdisciplinary team would meet physically once a week to discuss the project. Purup and Petersen (2020) referred to this meeting activity as "argumentative consolidation", in which "Project stakeholders and/or design team meet to discuss possible solutions and make final consolidated decisions about the design" (Purup and Petersen 2020, p. 11). In general, the themes defined in the building program (penetration, renovation, infill, and densification) served as organizing themes for the meetings and the dialogue with the client. Between

meetings, there was also the informal dialogue between the contractor, engineers, and architects via phone or e-mail.

The PhD project focuses on informing the 'external' process. From the process in B4, it appears valuable to equip the architects with arguments for the potentials for synergies between increased well-being and energy savings concerning traditionally "softer" well-being themes:

- when discussing and weighing alternatives in the weekly project group meetings.
- which could also be implemented as part of the argumentation towards the client.

This is in line with, e.g., Beim and Stylsvig Madsen (2015), who pointed to the need for visualizing soft values alongside hard values to promote an equal weighing.



**Figure 94** Examples of argumentation for complying with “hard” values through (left) BSim simulation of the thermal indoor climate and (right) finite element analysis of the static system. From the hand-in of phase 1 in the competition (21/2 2017). Pictures made grayscale for this thesis.

### Different “languages”

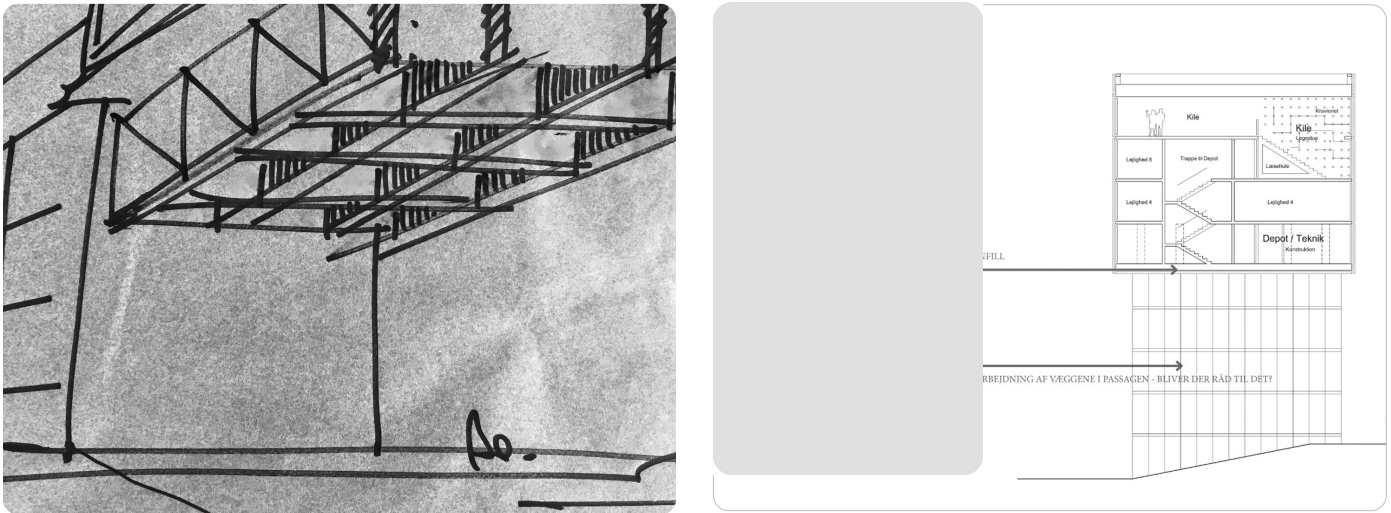
The RtD-study showed a tendency that often the architect would argue based on professional intuition and examples from other completed building or renovation cases (Figure 95). Figure 95 includes the sentence “*Idea: view from the entrance/sitting niche/stringency*” (Figure 95 – translation by the author), which reflects the architects’ intention to add spatial gestures in the exterior and interior (without using the term “gestures”). In contrast, the argumentation of the engineers would be based on quantitative data, e.g., prices based on previous experience or estimates by craftsmen or calculations or simulations of the performance of the building. Figure 94 shows two examples of the latter; to the left: simulation of the thermal performance of a living room, and to the right: finite element analysis of the loadbearing system. However, as will be further addressed in later sections, simulations of thermal indoor climate were not used as part of the iterative process – only to verify the final result.

The identified difference in “language” relates to the findings by, e.g., Beim and Stylsvig Madsen (2015), that there is a difference in the way quantitative and qualitative values are addressed as part of contemporary renovation practice (Beim and Stylsvig Madsen 2015).



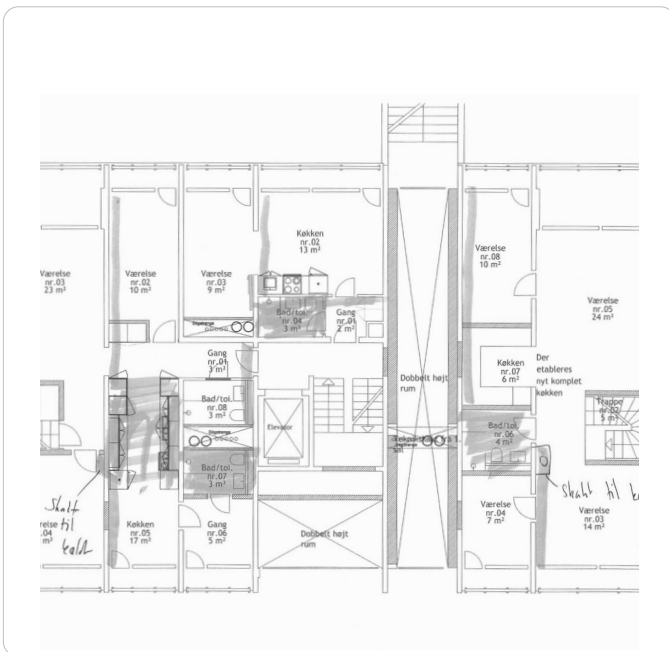
**Figure 95** Example of argumentation for “soft” values through the use of drawings/sketches and reference images. Project group meeting (19/12 2016). Image credits for reference image in upper right corner: Tegnestuen Lorenzen (Lorentzen n.d.).

The reference image has been hidden in the published version of the thesis due to copyright issues.



**Figure 96** Examples of different sketching tools used interchangeably throughout the process. Left: handsketch (17/3 2017) and right: AutoCad drawing and reference pictures (13/1 2017). Pictures made grayscale for this thesis. Image credit for reference images in the middle: see list of Figures.

Reference images have been hidden in the published version of the thesis due to copyright issues.



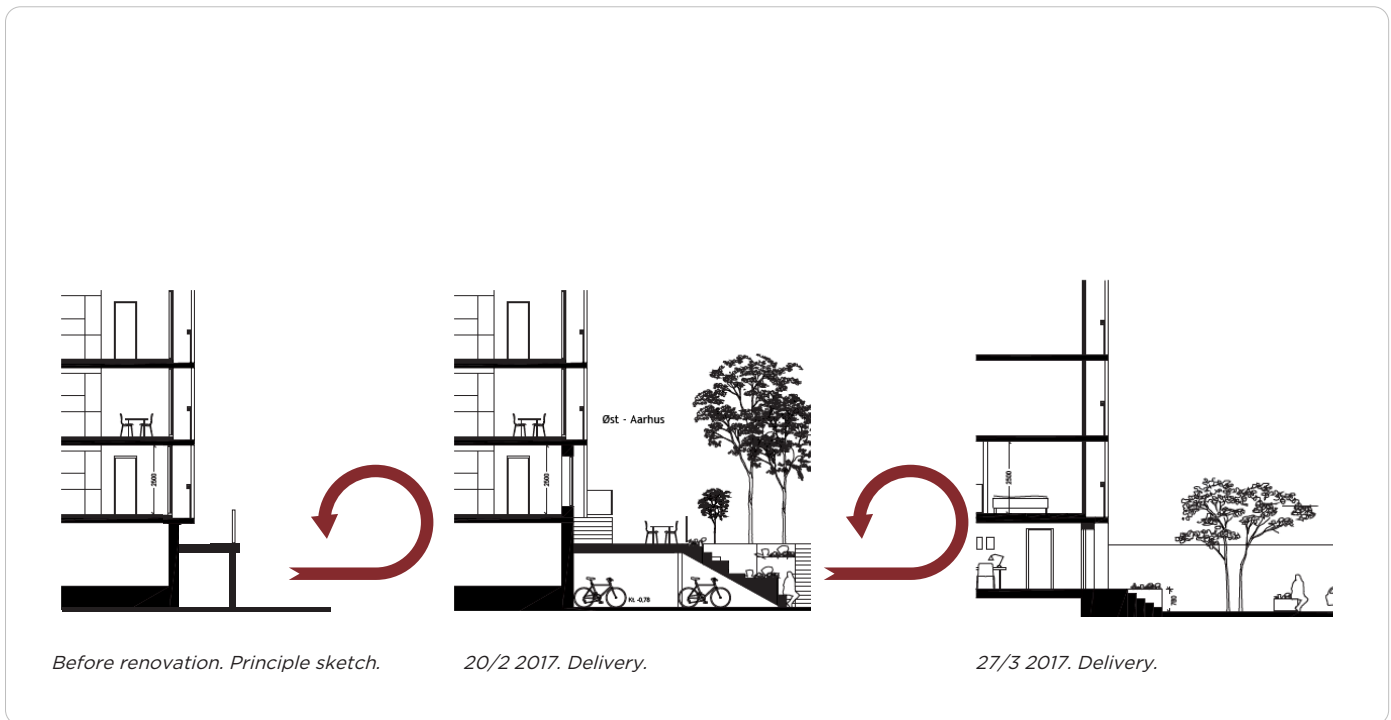
**Figure 97** Example of the engineers sketching on top of drawings from the architects. Sketch showing lowered ceiling due to ventilation system and cables. E-mail correspondence from the engineers to the architects (24/1 2017).

### Sketching formats/ - tools

The internal process at the architectural studio varied between manual sketching and computer sketching and drawing (Figure 96). Generally, the architectural team would produce drawings to form the basis for the weekly meetings within the interdisciplinary design team. The drawings presented to the interdisciplinary team during the weekly meetings were primarily computer drawings and renderings. This reflected a need for precision from early on. A Revit model was supplied by the client consultant in the beginning of the competition, but the primary software used in the process was Autodesk Autocad and Sketchup.

At the weekly meetings, drawings were presented on a screen and often also in printed versions for the team to draw on top of as part of the discussions. The engineers would produce principle drawings based on the latest floor plan produced by the architects (Figure 97). In addition, images of reference cases were used throughout the process internally and in the dialogue with the engineers and contractors as well as for communications with the client.

Purup and Petersen (2020) point to this back-and-forth between hand-sketches and digital tools. In relation to the specific context of renovation, a recent invitation to a meeting in the network "BIM Aarhus" (The building infor-



**Figure 98** Exemplification of the iterative character of the project. The threshold/edge has been revised continuously throughout the project. For overview, the same section is used to demonstrate the changes which influenced a number of other aspects of the built environment, e.g., layout on ground floor, wall materials, windows/doors, exterior articulation, etc.

mation modeling network, Aarhus, Denmark) stated that “*Particularly in Renovation and Transformation, there is a wide span in the which digital tools bring value [to the project], and there is not necessarily one way to solve the task*” (BIM Aarhus 2021, para. 1, translation by the author). This statement supports the findings of the RtD study that multiple sketching formats and sketching tools may be used in the early stages of renovation design processes.

#### Iterative process with multiple design alternatives

The process was highly iterative. Figure 98 depicts an example of how the design of the threshold zone was revisited and revised throughout the process. The iterations in Figure 98 depict the same section through the building (East-West) and show the development from the pre-renovation situation (closed ground floor with secondary functions) (left) to a suggestion for a terraced entrance with integrated bicycle parking – as requested in the building program (middle). Finally, Figure 98 (right) depicts a later iteration of the threshold, where the competition team suggested removing the terraced “base”

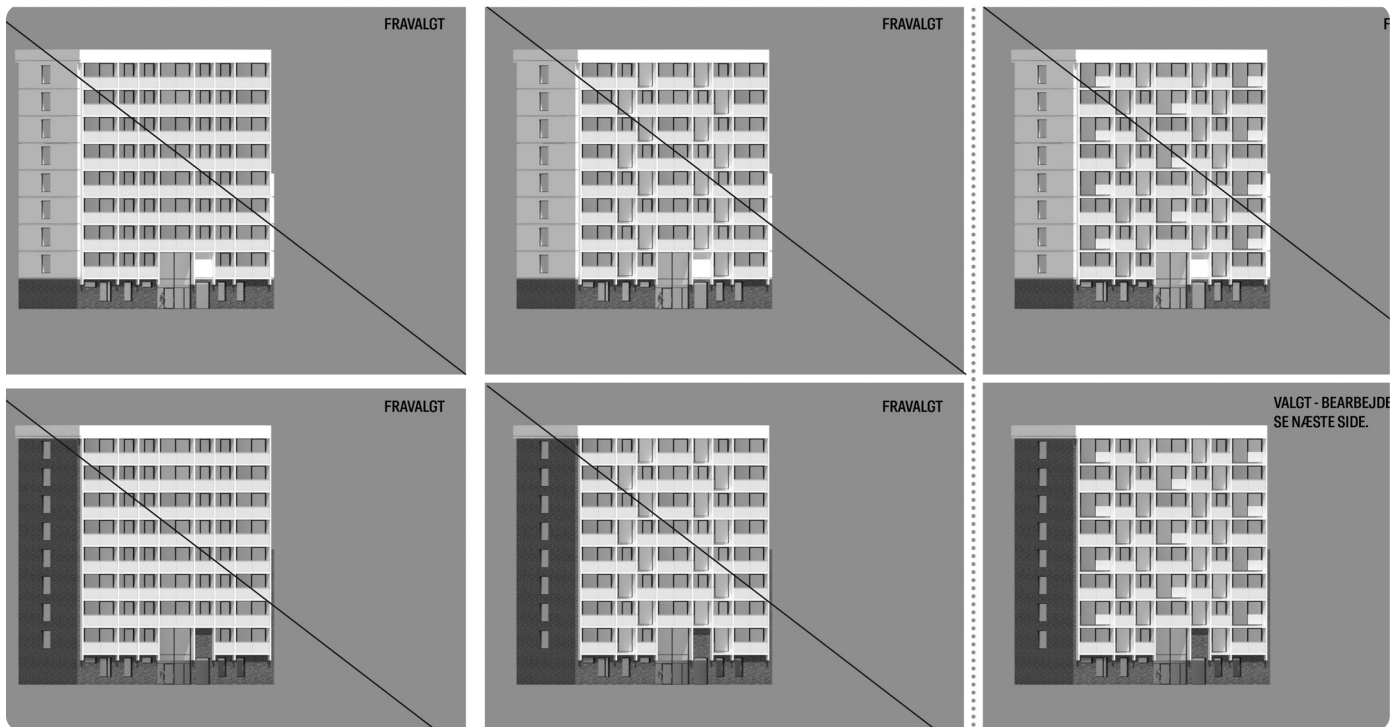
altogether and implementing a more open ground floor with direct access.

Several design theorists have addressed this non-linear character of design projects (e.g., Knudstrup 2005; Lawson 2006). In the B4 project, numerous iterations were carried out, even within the limited time of the competition phase.

Throughout the competition process, the architects worked with design alternatives. Overall, the interdisciplinary team decided early to work on two tracks; one track staying “true” to the tender material and one track challenging different aspects of the material, e.g., the articulation of the threshold.

Also, within each of these tracks, alternatives were set up for more or less all discussions, whether more informal discussions in the architectural studio or discussions in the interdisciplinary team. The façade studies in Figure 99 are an example of such alternative scenarios. In the specific example, the project group would discuss the level of preservation of the original expression in the gables through the use of, e.g., fiber concrete or bracing with





**Figure 99** Example of working with the overall facade expression. 3D sketches (screen dumps). From meeting 13/1 2017.

the original expression, through the use of brick. At this stage of the process, it was decided to propose a solution with brick on the gables – the argument being that the introduction of brick could be a way to add a sense of tactility and brake with the existing expression which was a parameter in the tender material. Nevertheless, between the first and second delivery, this was changed to fiber concrete elements due to an increased focus on preservation arising in the dialogue with the client and client consultants (Figure 99).

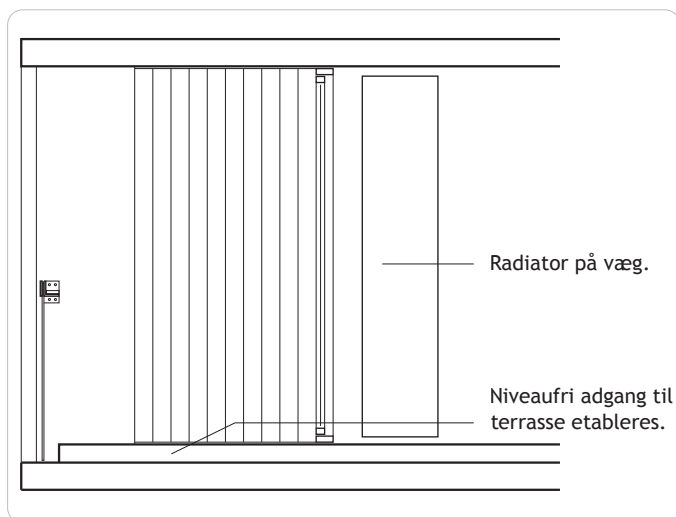
Lawson (2006) mentions the generation of alternative solutions as a commonly used approach in creative processes. Accordingly, Purup and Petersen (2020) mention “variations” as a recurring theme in their studies of typical design activities.

#### Detail / whole

Ghattas et al. in 2015 did a survey amongst architectural firms, homebuilders, and developers “...to understand what decisions are made at different points in the design pro-

cess so that tools can be targeted accordingly” (Ghattas et al. 2015, p. 2). They concluded that “...decisions about building and system geometry tend to be made in the conceptual design phase, while decisions about system components and details are increasingly made toward the design development and construction document phases” (Ghattas et al. 2015, p. 2). Lawson (2006), synthesizes that several prevailing descriptions of the design process state that “...the designer proceeds from the general to the specific, from ‘outline proposal’ to ‘detail design’” (Lawson 2006, p. 38). He argues that, depending on the project and the involved individuals, in fact, the process tends to be much more ‘messy.’ Some processes may be material- or detail-driven from the very outset.

In the case of B4, the team would discuss concerns related to the overall architectural idea of the building as well as more “detailed” aspects from the very first meetings. Figure 99 and Figure 100 from the same meeting are examples of this point. In this meeting between the architects, engineers, and contractors, the overall expression



**Figure 100** Example of more “detailed” (scale 1:75) attention to level access to the balcony, glass from floor to ceiling, and vertical heater. From meeting 13/1 2017. Also drawings in 1:20 were introduced as part of project group meetings.

of the façade was discussed through both 3D façade studies (Figure 99) and scale 1:75 sections (Figure 100), plans, and façades.

This duality reflects that alteration in the smallest scale influences the overall expression of the façade – and vice versa. This learning point corresponds to the findings of Objectives 1 and 2, pointing to the relevance of describing potentials for gestures in the interior, threshold, and façade every time alternative alteration measures are discussed. The need for addressing details at an early stage is perhaps even more profound in renovation than in new buildings because there is already an existing building to discuss, and, in the specific case of social housing renovation, the limited budget makes it crucial to get realistic price-estimates from craftsmen early in the process.

### Varying depth of renovation and level of design freedom

From participating in different projects in the architectural studio (only one of which is included in this thesis) and the studies in relation to Objective 2 (Identification), it was evident that each renovation project comes with varying “depth” and “design freedom”. Figure 101 and Figure 103 are included to exemplify this point in relation to heritage value; Søvangen in Western Aarhus was an example of a renovation project focusing on preservation, with only limited visible alterations of the existing construction

(Figure 101). B4 in Gellerupparken (under the same housing association and located close to Søvangen) on the other hand is not heritage listed, prompting discussion of preservation value and “allowing” for more extensive renovation measures, e.g., a road cutting through the building (Figure 103). This varying level of articulated heritage value in the existing building and subsequent level of “design freedom” was mentioned also by, e.g., Smidt-Jensen and Nørgaard (2011).

A number of other boundary conditions of the renovation process could influence the depth of renovation and level of design freedom as well, e.g., project economy and tender format (e.g., Rambøll 2018). The level of design freedom would also always depend on when in the process the architect is engaged.

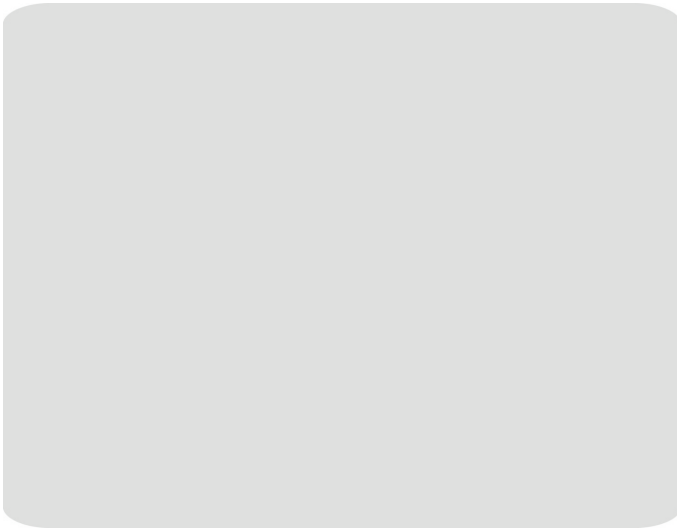
Although the B4 project is mentioned in the above text as an example of more extensive alterations, the level of design freedom was restricted by the fact that the competition team entered the process after a number of defining decisions had been made, such as the level of energy optimization and the aforementioned plans for a road to cut through the building block. In addition, also more detailed decisions had been made related to, e.g., choice of materials. It was possible to challenge decisions; for instance, the team did so by proposing a different articulation of the threshold (Figure 98, right). However, larger changes could potentially extend the process as it would require re-election amongst the residents.

As part of the site visits, the team would evaluate the state of the existing building, both in terms of technical aspects, such as damp and installations, and in terms of experiential value (spatial gestures). The value of the existing and prioritizing alteration measures relative hereto in order to preserve, accentuate, or renew the construction was a recurring theme throughout the process to maximize the value of alteration measures.

The purpose of including this theme is not to argue that extensive renovation is “better” than more limited renovation. Rather, the purpose is to draw attention to the variations between projects when aiming to inform the creative process.

### Sub-summary

The key learning points from this section about supporting the design process have been summarized in Figure 102. These points will be revisited when evaluating suggested prototypes for informing the process.

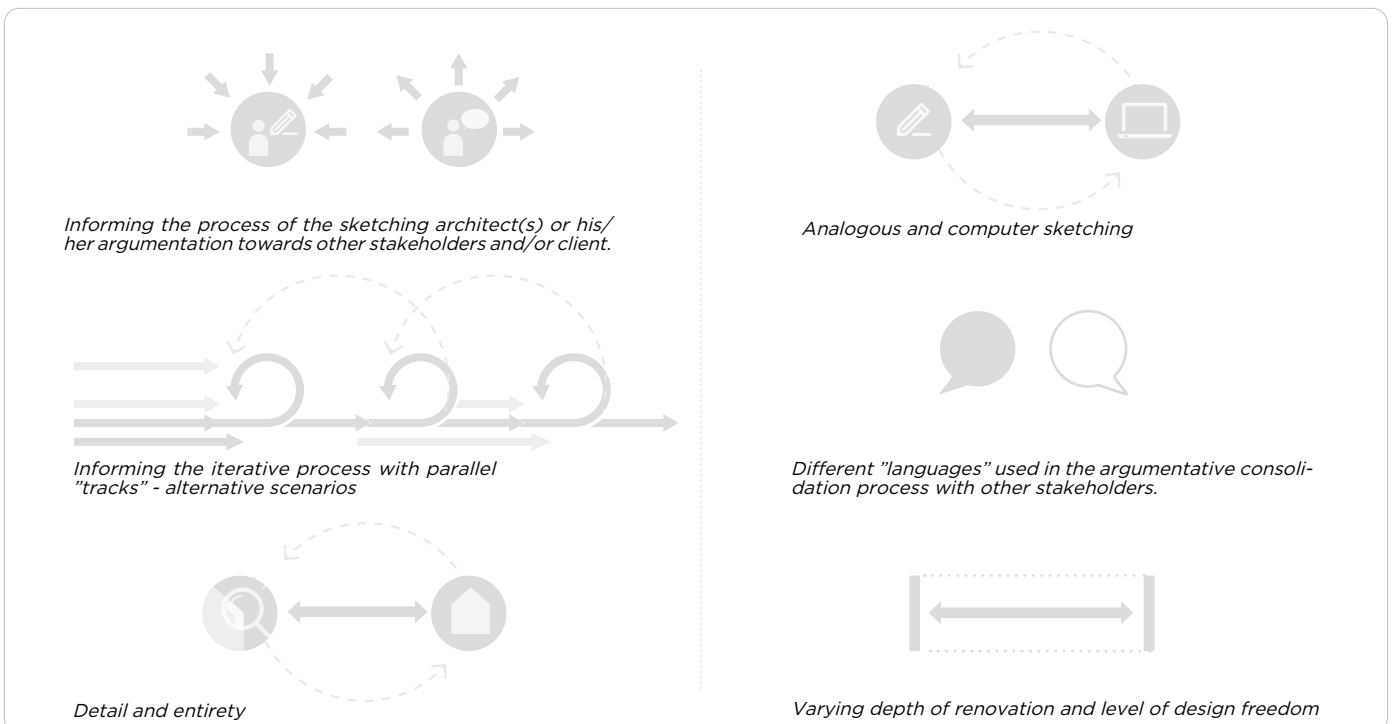


**Figure 101** Example of renovation case with limited “design freedom” for alterations due to heritage listing: Søvangen. Establishing direct access to the “park” via gable-dwellings. Image: (C.F. Møller architects and Transform architects 2019, p. 14) (gray scaling and square marking added by author).

The figure has been hidden in the published version of the thesis due to copyright issues.



**Figure 103** Example of renovation case involving more extensive alterations of the existing construction: Gellerupparken. Image from phase 2 delivery.



**Figure 102** Key learning point relative to supporting the decision process in the early design phases.

The section "Examples of working with gestures" is based on the paper "A tectonic approach to energy renovation of dwellings - the case of Gellerup" (Jensen et al. 2019b). The text has been edited to form a coherent part of the thesis. Further, the study has been elaborated with more examples and figures.

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## EXAMPLES OF WORKING WITH GESTURES

In the previous section, some key learning points in relation to the decision process have been summarized.

The following section serves to exemplify situations where resident well-being and energy savings have been on the agenda in the B4 project. As part of the analysis, 'lost potentials' are pointed out. That is, situations where knowledge on potentials for synergies between resident well-being and energy savings *may* have strengthened the argumentation in the interdisciplinary team and/or towards the client and competition jury. The section is a further development of the paper "A tectonic approach to energy renovation of dwellings - The case of Gellerup" presented at the International Conference in Structures and Architecture in Lisbon in 2019 (Jensen et al. 2019b). The original text and figures have been edited to form a coherent part of the thesis. Further, the study has been elaborated with more examples and drawing material.

The intention is not to highlight the entry as particularly successful or not, but rather to illustrate how efforts to inform the process could be targeted.

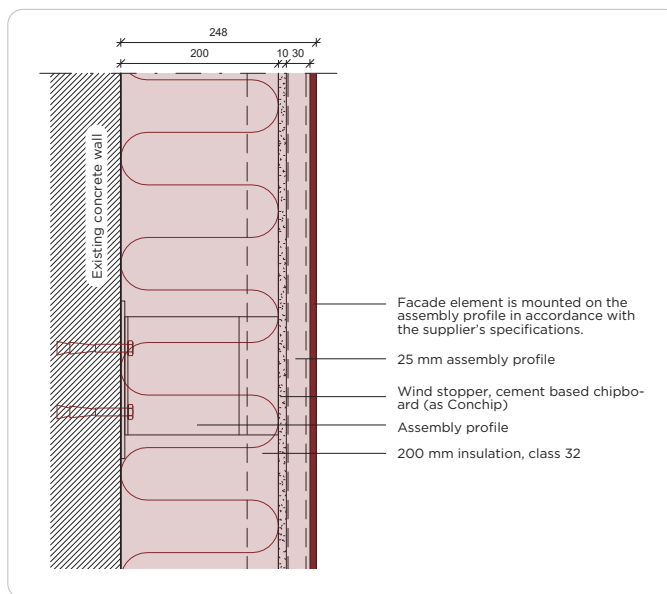
The conceptual framework developed in relation to Objective 1 is applied as an analytical lens for describing alterations of the construction and pointing to spatial gestures. The notion of spatial gestures was not used in the process but is used in the retrospective analysis to point to gestures in the interior, threshold, and from a distance, which may be linked to an aim to increase resident well-being while also addressing the building's energy performance. Furthermore, it is a point in itself that such a common architectural vocabulary may strengthen the process if applied.

As the competition entry is described at sketch level, the gestures should be understood as "intended gestures".

### Example 1: Gables

#### *Alteration of the construction:*

As part of the renovation, the exterior gable walls were to be reinsulated with 200 mm insulation and cladded with a new material (Figure 104). This prompted design discussions about the potential addition of windows in the gables, internal articulation of the window sills, and choice of external cladding material (Figure 105-Figure 110).



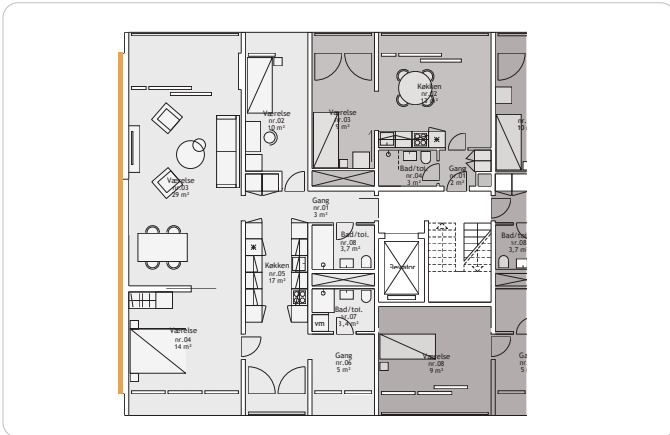
**Figure 104** Suggested new facade detail. 1:20 (originally 1:10). Red signifies elements which are added. Translation by author.

#### *Intended gestures - Interior*

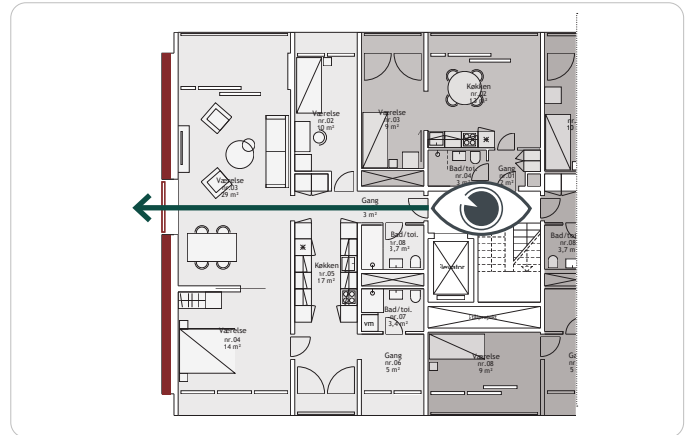
A focal point in the project was to heighten the quality of living in the existing dwellings within the limited budget. As an example of the latter, new windows were proposed at the end walls (see existing uninterrupted end wall in Figure 106 on page 159). The idea was to utilize the additional depth of the living room wall due to external re-insulation as a space for sitting and at the same time allow for views towards the Brabrand lake from the entrance corridor.

#### *Intended gestures - Façade*

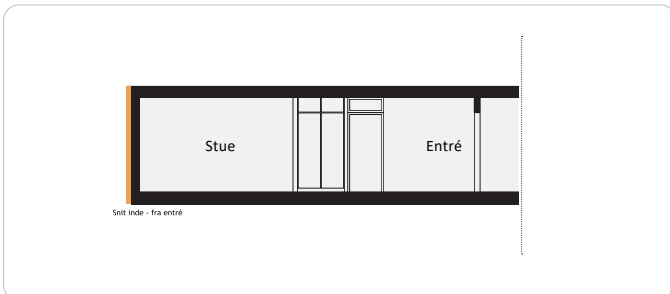
The original façades had a pixilated concrete cladding (ArkitekturDK 1974). The building is not heritage listed, and its value of preservation is a much-discussed topic (Exner et al. 2019). During the process, the interdisciplinary group discussed whether to suggest an interpretation of the original expression through fiber concrete or fiber cement panels or to suggest a renewed expression through the use of, e.g., brick (Figure 99 on page 155). From the jury report, it is evident that the jurors and clients went through a process themselves to decide on the level of preservation vs. a renewed expression (Pluskontoret Arkitekter et al. 2017). Eventually, the winning proposal suggested a façade expression close to the original pixilated expression and without windows.



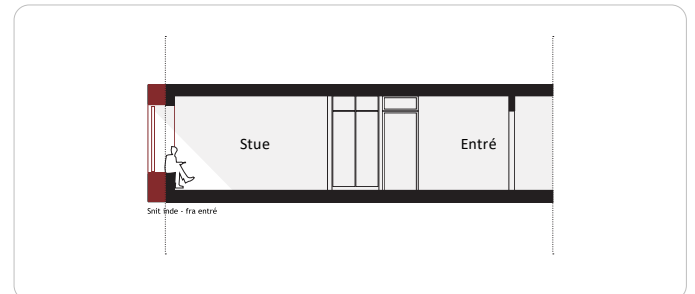
**Figure 108** Existing floor plan. Yellow signifies elements which are demolished, here focusing solely on the western gable. Not to scale.



**Figure 109** Suggested new floor plan. Red signifies elements which are added, here focusing solely on the western gable. Not to scale.



**Figure 110** Principle section before renovation. 1:200.



**Figure 105** Suggested section after renovation, including a new window in the gable. 1:200.

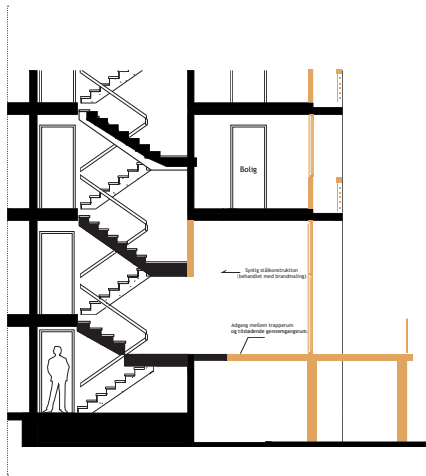


**Figure 106** Gable facade before renovation.



**Figure 107** Suggested gable facade after renovation.





**Figure 111** Principle section before renovation. Access to common stairway via elevated pathway or via “back entrance”. Not to scale.

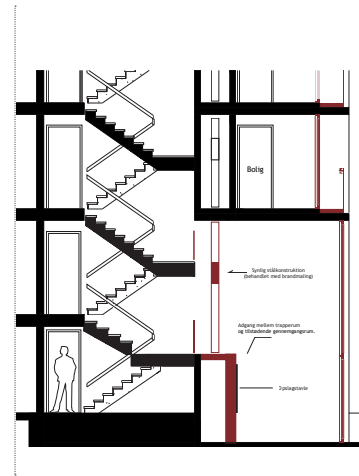


**Figure 113** Existing threshold at ground floor level (East facade).

#### *‘Lost potentials’ for informing the process*

The decision to leave out windows in the winning proposal can be seen as a deliberate preservative approach. Further, the saved costs for implementing windows were used for introducing other qualities. However, the process illustrates that it could have been valuable to be able to point to documented knowledge on potentials for an increased sense of safety through added windows when engaging in dialogue with the client. For instance, by arguing that windows would allow for supervision of a current ‘blind spot’, according to the “eyes on the street”-strategy (emanating from Jane Jacobs’ urban theories (Jacobs 1961)) and with reference to completed renovation cases (e.g., Nørgaard and Rudå 2021).

Further, as mentioned under the key learning points from the RtD study, simulations of the indoor thermal climate were ‘only’ performed to verify the final proposed solution.



**Figure 112** Principle section after renovation. Access to common stairway through entrance or decentral entrances to townhouses. Not to scale.



**Figure 114** Proposed threshold after renovation (East facade).

Access to early-stage data on the consequences of design alternatives on the indoor thermal climate (as well as daylight, views, etc.) may have helped qualify the design.

#### **Example 2: Townhouses and entrance situation**

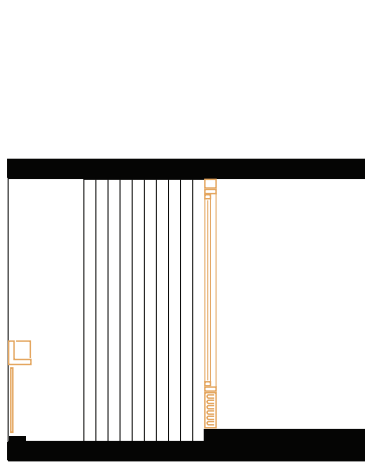
##### *Alteration of the construction:*

The competition brief included demolition of the existing gallery and establishing new entrances on ground level. Further, new ‘townhouses’ were established, using parts of the existing storage rooms on ground level and adding these square meters to the apartments above. Subsequently, the alterations included alterations of the building envelope and spatial refiguration of the ground floor level through new interior walls (Figure 111-Figure 114).

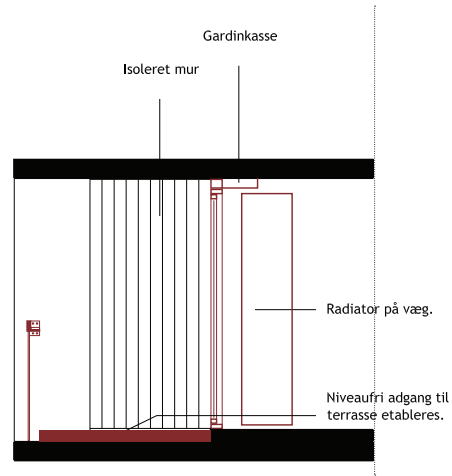
##### *Intended gestures - Threshold*

Rethinking the transition between the private and pub-





**Figure 115** Principle section before renovation. Existing section through balcony and living room. Not to scale.



**Figure 116** Principle section after renovation. Suggested section through balcony and living room. Not to scale.



**Figure 117** Existing West-facade.



**Figure 118** Proposed facade expression after renovation (West).

lic 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 on ground level, 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.

#### *'Lost potentials' for informing the process*

More knowledge on the value of semi-private outdoor areas to the well-being of the residents could have helped prioritize these aspects in the moment of savings.

### **Example 3: Façade refiguration**

#### *Alteration of the construction:*

The renovation included changing all windows to more thermally efficient ones. The competition proposal included removing the façade elements below the windows. Instead, a vertical closed panel in anodized aluminum was introduced. Further, the proposal included plans for adding flooring on the balconies (Figure 115-Figure 118).

#### *Intended gestures - Threshold*

The proposal included level access to private outdoor balconies to enhance accessibility (Figure 116).

#### *Intended gestures - Façade*

The intention with the façade was to create a contrast between the concrete grid and the "fill" (the windows and panels) to accentuate the grid. This highly influenced the strategy of alteration, e.g., concerns related to thermal

bridges in the concrete grid were de-emphasized in order to preserve the characteristic grid structure.

The competition brief included attention to replacing the “...tenant-driven solutions [for shading] which characterize the expression of the building block today...” (Pluskontoret Arkitekter and Rambøll Danmark A/S 2016b, p. 22, translation by author) with building-integrated user-controlled shading devices, shielding from the exterior. The interdisciplinary project team supplied an offer for the requested shading devices to comply with the terms of the competition, yet proposed to acknowledge the diversity posed by the use of different curtains, etc., rather than “hide” it.

#### *Intended gestures – Interior*

The intention was to create a more fluent movement between the living room and balcony by introducing wall-to-ceiling windows. And in addition, by introducing a transparent railing, to allow views towards the new park from within the living room.

#### *‘Lost potentials’ for informing the process*

The process did not include simulations of the thermal and visual indoor climate. Only simulations of the indoor thermal climate were carried out, and only in relation to the new infill dwellings. Performing simulations of the thermal and visual indoor climate in the dwellings undergoing renovation may have helped qualify the design choices. Furthermore, the empirical studies have indicated that it could be relevant to discuss privacy on balconies as part of the process.

#### **Sub-Summary**

This section included three examples of situations in which resident well-being and energy savings were addressed as part of the B4 project. As part of the analysis, ‘lost potentials’ have been pointed out; situations where knowledge on potentials for synergies between increased resident well-being and energy savings *could potentially* have strengthened the argumentation in the interdisciplinary team or towards the client and competition jury. It is also relevant to note that there may be additional ‘lost potentials’ in terms of both increased well-being and energy saving due to the sole fact that the knowledge to develop them was not present at the time of development internally in the architectural studio.

Together with the overall key learning points, the inclu-

ded examples will be used as a reference point in later discussions about possible formats for informing the process (Objective 3b).

The three examples display different levels of synergies between resident well-being and energy savings. This reflects that renovation may be motivated by diverse concerns. Especially in social housing, energy may not be the main motivating factor. However, every stage of the project represents an opportunity to promote both agendas. For instance, re-insulation of the gables allows introducing added spatial gestures, such as views. And visions to alter the threshold zone to be more welcoming prompt decisions that influence the energy performance of the building.

Further, the three examples illustrate that potentials for informing the process may be found in the internal process at the architectural studio (for instance, by visualizing the consequences of design alternatives in the façade on the indoor thermal climate – example 3) as well as in the ‘external’ dialogue with the other stakeholders in the competition team and with the client and jurors (in the argumentation for including windows in the gable – example 1) (see also key learning points, Figure 102). As demonstrated in previous parts of the thesis, there is an identified gap in identifying and visualizing, especially the soft well-being themes, as part of the interdisciplinary decision processes. As such, the focus of the following chapter will be on informing the ‘external’ dialogue.



The section "Examples of approaches" is based on the paper "Towards a Holistic approach to Low Energy-Building Design: Introducing Metrics for Evaluation of Spatial Quality" (Jensen et. al. 2017b). The text and table have been edited to form a coherent part of the thesis.

# Concepts for informing the design process

The previous section has focused on exploring the renovation design practice from the perspective of the architect to better understand how insights about potential synergies between resident well-being and energy-saving may inform the process.

In this section, the focus will be on different concepts for such "information" of the process. That is, how one could disseminate findings of potentials for synergies between resident well-being and energy-saving as an integral part of the renovation design process.

In the first sub-section, the use of the term 'information' is clarified relative to the specific problem field of this thesis. After that, different approaches to informing the process are discussed, based on a narrative analysis of the work of architectural theorists.

Thereafter, three proposals for concepts for informing the process are suggested:

The first proposed concept translates some of the traditionally more qualitative well-being themes into metrics, which can be introduced in computer simulation programs alongside traditionally more quantitative well-being themes and calculated energy performance.

The "reactions" from a focus group interview with practicing architects, constructing architects, and anthropologists are accounted for, leading to the proposal of two additional concepts. The second concept focuses on translating findings into an "examples catalog" of impact studies. The third concept proposes to pursue economic valuation of traditionally qualitative values.

The three proposed concepts for informing the process are discussed relative to the key learning points from the RtD study.

## INFORMING THE PROCESS

Before discussing different concepts, it is relevant to clarify the use of the term 'informing' relative to this thesis. In the context of this thesis, the definition by Peavey and Vander Wyst (2017) is used as a reference:

*"Common definitions characterize informed as having information or being prepared with knowledge (Informed, 2016a, 2016b). An informed individual is able to utilize data, information, and knowledge to guide their decisions in the appropriate manner"* (Peavey and Vander Wyst 2017, p. 148).

Relating the quotation to the problem field of this thesis, Objective 3b is thus concerned with "how-to" prepare the practicing architect with knowledge as a strategy for supporting his/her efforts to promote resident well-being in sustainable renovation of MSH.

The intention is *not* to substitute the creative process. Rather, the intention is to inform the creative process with documented insights to support weighing different design alternatives. Peavey and Vander Wyst address this aspect in the following way:

*"RID [research-informed design] can be defined as the process of applying credible research in integration with project-, client-, or population-specific empirical inquiry to inform the creation of environmental design and achieve project objectives"* (Peavey and Vander Wyst 2017, p. 152).

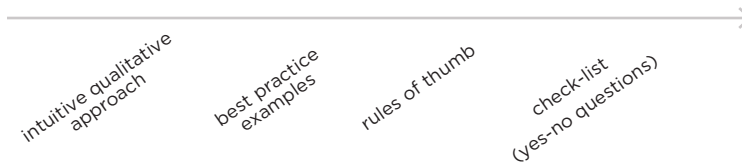
In this understanding, credible research must be used in integration with other sources of inquiry to support the creative process.

## EXAMPLES OF APPROACHES

The introduction to the thesis included a review of existing initiatives related to the problem field (Figure 10 on page 35). The review established a gap in existing frameworks and research regarding simultaneously promoting resident well-being and energy saving in the early design phases of a renovation process – especially regarding "softer" aspects of resident well-being in the built environment.

The focus of this section is to take a step back and look more broadly at different approaches to informing the creative process. The section is based on the paper "Towards a Holistic approach to Low Energy-Building Design: Introducing Metrics for Evaluation of Spatial Quality," presented at PLEA 2017 conference in Edinburgh, Scotland. The paper was developed in collaboration with Pil Brix Purup, Steffen Petersen, Anders Strange and Poul Henning Kirkegaard (Jensen et al. 2017b).

The section is devoted to the findings of a small analysis of how four different architectural theoreticians have communicated findings to fellow architects. Table 12 presents an overview of 'parameters' put forward by the theoreticians. The columns "Examples of statements related to view quality" and "Examples of statements related to the degree of privacy" serve to exemplify how each of the four architectural theoreticians translates knowledge



**Figure 119** The chapter focuses on how to visualize potentials for synergies between energy savings and increased resident well-being as part of the early design process. The continuum displayed in this figure is based on the approaches identified in Table 12.

**Table 12** Examples of different approaches to “showing the way” for future architectural projects.

	Typology in focus	Parameters (a mixture of alteration measures/architectural quality themes and spatial gestures)	Method of inquiry	Example of statements related to view quality	Example of statement related to degree of privacy	Approach (spanning from an intuitive qualitative approach to more quantitative ‘check-list’ approach)
<b>Acre &amp; Wyckmans</b> (Acre and Wyckmans 2015)	Renovation of dwellings	<ul style="list-style-type: none"> <li>Views</li> <li>Internal spatiality and spatial arrangements</li> <li>Transition between private and public spaces</li> <li>Perceived human and built densities</li> </ul>	Literature review	<p>“Spatial quality assesment for views.” [...]</p> <p>“2. Quality of the view (composition of the view)<sup>a,c</sup></p> <p>a) Distance of the view (depth) is &gt;6 m (yes or no question)</p> <p>b) Width of the view through window(s) is &gt; 28° (yes or no question).</p> <p>c) Presence of layers of proximity (sky, landscape and ground) (yes or no question)” (Acre and Wyckmans 2015, p. 15)</p>	<p>“(C) Distance and degree of sight protection (visual privacy and protection of the private domain)</p> <p>1. View of arriving visitors and entrance, and entry-lock (hall) to the dwelling</p> <p>a) Possibility to see arriving visitors (yes or no question)</p> <p>b) Possibility to see arriving visitors without being seen (yes or no question)” (Acre and Wyckmans 2015, p. 15)</p>	
<b>Jan Gehl</b> (Gehl 2003)	Outdoor spaces and transition spaces	<ul style="list-style-type: none"> <li>To gather or scatter</li> <li>To integrate or segregate</li> <li>To invite or reject</li> <li>To open up or enclose</li> </ul>	Field studies Literature review	<p>“Many details of the building, the outdoor areas, and the entrance can influence the use of the outdoor spaces”...“The bench by the entrance, sheltered from the rain and wind and with a nice view to the access road, is a modest, yet obvious way to support the life between the houses” (Gehl 2003, p. 179, translation by author).</p>	<p>“The houses were placed 3-4 m from the pavement, far enough to secure a certain level of privacy in the area in front of the house - to keep the activities at an arm’s length” (Gehl 2003, p. 181, translation by author).</p>	
<b>Pierre von Meiss</b> (Meiss 1990)	The built environment in general	<p>Depth of space</p> <p>Density of space</p> <p>Openings</p> <p>Spatial juxtaposition and interpenetration</p> <p>Geometry of plan, sections and spaces</p> <p>Light and shade</p> <p>Floor, wall, and ceiling (enclosure, demarcation, texture)</p>	Case studies Literature review	<p>“The degree of enclosure does not only depend on the quantity and the size of the openings. When we wish to create a space which tends to open to the exterior, we are trying to make it less explicit”...“The larger these openings become the more they designate ‘an absence of wall...’” (Meiss 1990, pp. 107-108).</p>	<p>“The space of the window is a potential privileged place in the room. Its transparency, the direct light and sun which enters it, invite and encourage particular activities: to sit near the window and follow the comings and goings outside without being seen...” (Meiss 1990, p. 152).</p>	
<b>Juhani Pallasmaa</b> (Pallasmaa 2012)	The built environment in general	<ul style="list-style-type: none"> <li>Multi-sensory experience</li> <li>Shadow</li> <li>Acoustics</li> <li>Scent</li> <li>Taste</li> <li>Bodily identification</li> </ul>	Case studies Literature review	<p>“In our time, light has turned into a mere quantitative matter and the window has lost its significance as a mediator between two worlds, between enclosed and open, interiority and exteriority, private and public, shadow and light. Having lost its ontological meaning, the window has turned into a mere absence of the wall” (Pallasmaa 2012, p. 51).</p>		



The section about Concept 1 includes sections from the papers “Towards a Holistic approach to Low Energy-Building Design: Introducing Metrics for Evaluation of Spatial Quality” (Jensen et al. 2017b) and “Towards a Holistic approach to Low Energy-Building Design: Consequences of Metrics for Evaluation of Spatial Quality on Design” (Purup et al. 2017). The text and figures have been edited to form a coherent part of the thesis.

into what can be referred to as “decision-support.” In the analysis, ‘views’ and ‘privacy’ are used as two examples to illustrate their respective approaches. The themes – views and privacy – have both been identified through the empirical studies as examples of values that may be compromised or improved through renovation. As such, the themes are considered relevant for the current thesis.

As seen in Table 12, the four included theoreticians represent different approaches. Meiss points out the “strings” of the instrument of architecture, which can be put into use but refrains from establishing rules for how to play on it (Meiss 1990). Gehl puts forward “rules of thumb” based on observations and literature studies (Gehl 2003). Acre and Wyckmans use references such as Gehl to establish a set of more generally applicable and quantifiable “rules”, organized in an evaluation scheme, for assessing the consequences of renovation initiatives on so-called ‘spatial quality determinants’ (Acre and Wyckmans 2015). This, in turn, contrasts the more phenomenological, sensuous approach proposed by, e.g., Pallasmaa (2012).

The different approaches have been summarized in Table 12, right, under the headline “Approaches” by proposing where the theoreticians may be positioned on a continuum spanning from an intuitive qualitative approach to a ‘check-list- approach’.

### **Towards new concepts for informing the process**

The following section proposes three concepts to translate knowledge on potentials for joint social and environmental value creation into a format that can inform the process. The concepts focus on traditionally “softer” themes related to resident well-being in the built environment.

Each represents different ‘positions’ along the mentioned continuum.

A graphical expression is developed for each proposed concept. It is relevant to stress the exploratory character of the thesis; the purpose has been to propose and discuss the concepts and the value of applying each of these concepts in the early stages of renovation of MSH, not to discuss the graphical specifics of each framework. For more details on this subject, please refer to, e.g., Purup and Petersen (2020) and Kamari et al. (2021a).

### **CONCEPT FOR INFORMING THE PROCESS NO. 1 – EXEMPLIFYING METRICS FOR EVALUATION OF SPATIAL GESTURES**

In the previous section, it was outlined how four architectural theorists have communicated insights. The analysis exemplified different types of “decision support” for informing the design process with “softer” well-being themes.

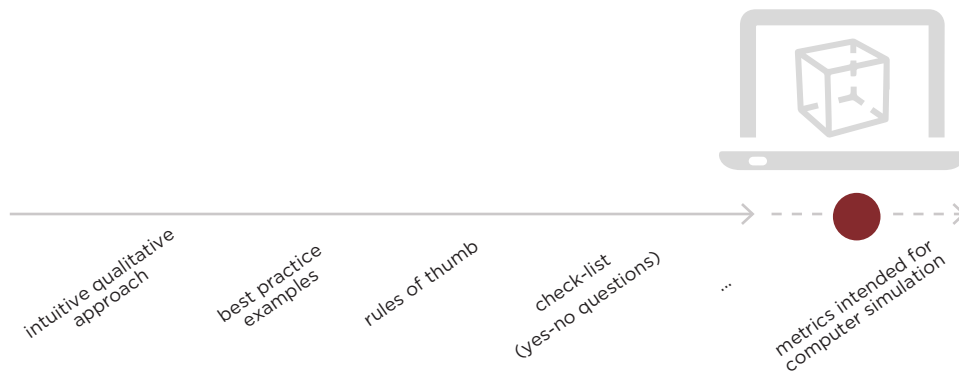
In this section, it is examined if it is possible to further develop themes towards more quantifiable metrics which can be made operational for building performance evaluation through computer simulation. View quality and privacy from the surroundings are two themes identified in relation to Objective 2 (identification) and are traditionally treated more qualitatively as part of an argumentative design process. The following sections discuss how to translate the themes into examples of metrics applicable for computer simulation (Figure 120).

The study was carried out in collaboration with Pil Brix Purup, Poul Henning Kirkegaard, and Steffen Petersen and disseminated in the papers “Towards a Holistic approach to Low Energy-Building Design: Introducing Metrics for Evaluation of Spatial Quality” (Jensen et al. 2017b) and “Towards a Holistic approach to Low Energy-Building Design: Consequences of Metrics for Evaluation of Spatial Quality on Design” (Purup et al. 2017)E79}. Both papers were presented at the Passive Low Energy Architecture (PLEA) conference in Edinburgh in 2017. The distribution of roles between the authors was accounted for in “Part 2: Methodology.” The text and illustrations have been edited to form a coherent part of this thesis. Further, the original paper also included attention to daylight and thermal comfort. These themes have been left out of the thesis to focus on traditionally “softer” well-being themes.

### **View quality and degree of privacy through windows**

It is well recognized that the possibility to look out and observe nature and orient oneself in relation to time and place is important for human well-being (Hauge 2013; VELUX 2013). On the other hand, the window also comprises a “social boundary,” making it possible to remain private (Hauge 2013). From Table 12 on page 165 it shows that the included theoretical statements span from discussions about the window from an ontological and phenomenological perspective (Meiss 1990; Pallasmaa 2012) to more concrete guidelines for how to practically deal with this threshold (Gehl 2003) and an actual “check list” (Acre and Wyckmans 2015).





**Figure 120** The chapter focuses on how to visualize potentials for synergies between energy savings and increased resident well-being as part of the early design process. The continuum displayed in this figure is based on the approaches identified in Table 12 on page 165. The suggested concept proposes metrics intended for computer simulation.

In testing metrics for application in computational simulation, the latter approach is used as a point of departure. Acre and Wyckmans suggested an approach to view quality through windows based on “yes/no” questions. This offers a means to compare different alternatives based on similar parameters. Principles from Acre and Wyckmans (2015) have been modified into a new computational calculation procedure for evaluating the quality of views through windows and the privacy from the surroundings.

For evaluation of view quality through windows as part of the design process, it is suggested to establish an expression: “View-out quality” that takes into account the extent of the potential view to the exterior through the proposed windows and a weighing of the elements that constitute the view. For evaluation of “Degree of privacy,” it is suggested to establish an expression based on the complementary percentage of the view potential and a weighing of areas in the exterior, which represent a risk of views to the interior. Equations (1) and (2) sum up the calculation procedures for the proposed metrics:

$$\text{View-Out Quality} = \frac{\sum(A_{lim} \cdot F_q)}{A_{ref}} \quad (1)$$

$$\text{Degree of privacy} = 1 - \frac{\sum(A_{lim} \cdot F_v)}{A_{ref}} \quad (2)$$

$A_{ref}$  refers to area of total sphere in the reference view (view from top of a tower) [m<sup>2</sup>] (Figure 121, A).

$A_{lim}$  refers to limited view-out area projected onto the reference view area seen through windows [m<sup>2</sup>] (Figure 121, B).

$F_q$  is a factor that weighs the quality of the reference view areas (0-1) [-] (Figure 121, C), and  $F_v$  is a factor that weighs the potential view from outside in the surrounding areas to the indoor (0 or 1) [-] (Figure 121, C). Central to the idea of the proposed metrics is that stakeholders discuss and weigh areas in the exterior on behalf of or in collaboration with the residents and/or with attention to best available research on view preferences for the target group.

Figure 121 includes a written and graphical explanation of the elements of the proposed calculation procedure. For further elaboration of the proposed metrics, see Jensen et al. (2017b) and Purup et al. (2017).

The final View-Out Quality metric can be calculated by equation (1) for all possible viewer locations in the room, e.g., in a horizontal grid of 0.5 m. The vertical evaluation

level of this grid may differ depending on the eye position of the viewer; the viewer may enjoy the view from a standing or sitting position, and some viewers might be children (Figure 121, D), in which case the eye position will naturally be lower.

The Degree of Privacy is estimated similarly to the View-Out Quality as the complementary percentage of the view potential (equation 2) but with binary quality factors in relation to risk of view from outside to the certain location in the room. The vertical evaluation level can be the whole body of the occupants in the room (Figure 121, D).

### Case study

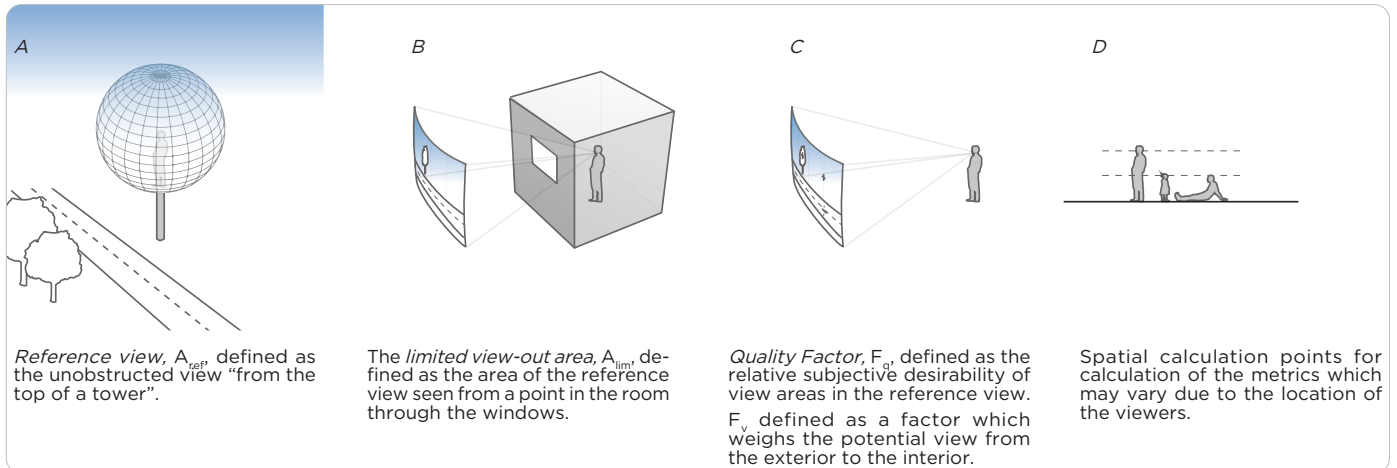
The proposed metrics were used in a fictive case study, using real project information from an ongoing project in Aarhus, Denmark, where design of a façade for a living room in a senior dwelling was conducted (Figure 123 and Figure 124). The case was a MSH building block referred to as A17 in the area Toveshøj, also described in relation to the empirical study.

The purpose of the study was to illustrate how the new set of measurable architectural metrics may instigate a more qualified and holistic discussion on feasible trade-offs between energy use and metrics related to resident well-being – including aspects which are already included in simulation software as well as ‘softer’ aspects which are traditionally not included (such as view-out and privacy). Figure 122 displays examples of how the reference view in the case project can be weighed to (left) preferences of view and (right) risk of view from the outside.

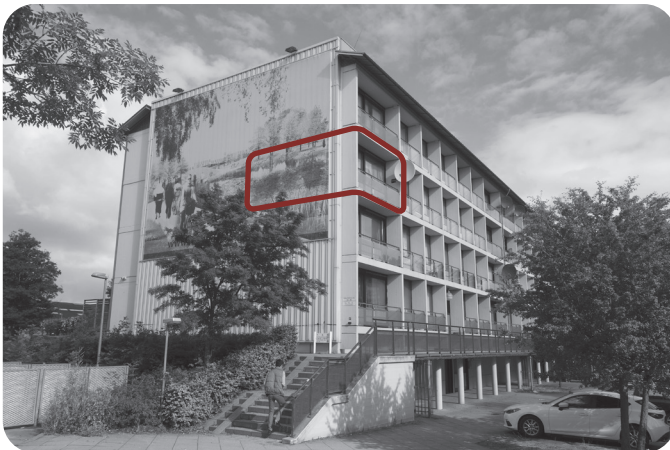
Figure 125 on page 171 displays a screenshot from the output of the simulation software for the existing situation and for three alternative renovation scenarios. The screenshot shows how users get a graphical output of ‘view-out quality’ and ‘privacy’ similar to outputs related to other, more ‘developed’ well-being metrics, such as daylight and thermal performance, as well as an indication of energy performance in order to evaluate the potential for synergies between resident well-being and energy savings.

### Discussion

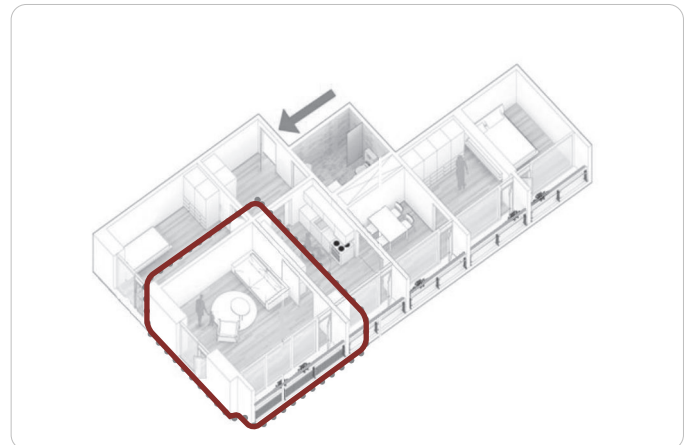
The following text includes a brief discussion about the relevance of including metrics for evaluation of traditionally more “soft” well-being themes in building performance evaluation as a way to promote resident well-being as part of the early design stages. The key learning points from the RtD study (Figure 102 on page 157) are used to structure the discussion.



**Figure 121** Explanation of the elements of the calculation procedure.



**Figure 123** The case study apartment in Toveshøj, Aarhus, Denmark. Image from before renovation.



**Figure 124** The case study apartment in Toveshøj, Aarhus, Denmark. Visualisation of new apartment type. (Image: BBBO 2016, p. 26, grayscaling and red marking by author). (The figure was previously published in Purup et al. 2017).



**Figure 122** Example of how the reference view can be weighted according to (left) preferences of view, and (right) risk of view from the outside. (The figure was previously published in Purup et al. 2017).



#### *Informing the process of the sketching architect(s) or their argumentation towards other stakeholders*

For an experienced architect, it may not be surprising that one solution may offer a better view than another does. However, the point of putting views and privacy into the same tool as, e.g., calculated energy consumption, is to put them on the agenda in interdisciplinary discussions as something the project needs to “deal with”. As such, the approach may be a way forward for promoting the more “soft” values alongside the “hard” values in an equal manner which can ultimately lead to different design choices compared to design decisions based on “hard” values only. Also, Concept no. 1 demonstrates how two conflicting values, such as views and privacy, may be visualized to instigate qualitative discussions within the group. When graphically displaying the quantitative outcomes of the simulations related to, e.g., daylight, view, and privacy alongside the results related to energy consumption, stakeholders in interdisciplinary design teams may be more inclined to accept design solutions that have slightly reduced performance in terms of energy consumption but perform significantly better in terms of daylight and view quality. As such, the value of the concept lies in strengthening the architects’ argumentation towards other stakeholders.



#### *Bridging different “languages”*

As described above, a strength of this approach is to articulate traditionally “soft” and “hard” values in an equal manner. Concept no. 1 is based on the idea of approximating an “engineering language”, based on quantitative evaluation results.



#### *Informing the iterative process with parallel tracks*

The framework allows for rapid evaluation of the performance of different design alternatives.



#### *Detail and entirety*

The proposed concept focuses on evaluating the performance of design alternatives at room level. As such, the concept mainly has the potential to inform the process at this level of detail. Nevertheless, interventions on several levels may influence the evaluation, be it the layout of spaces (e.g., new dwellings types), skin (e.g., changed window placement or depth of the wall), or site (e.g., trees or densification). As such, the approach may be applied to inform decisions at different levels of detail.



#### *Analogue and computer sketching*

The approach requires a digital model and, as such, supports computer sketching.

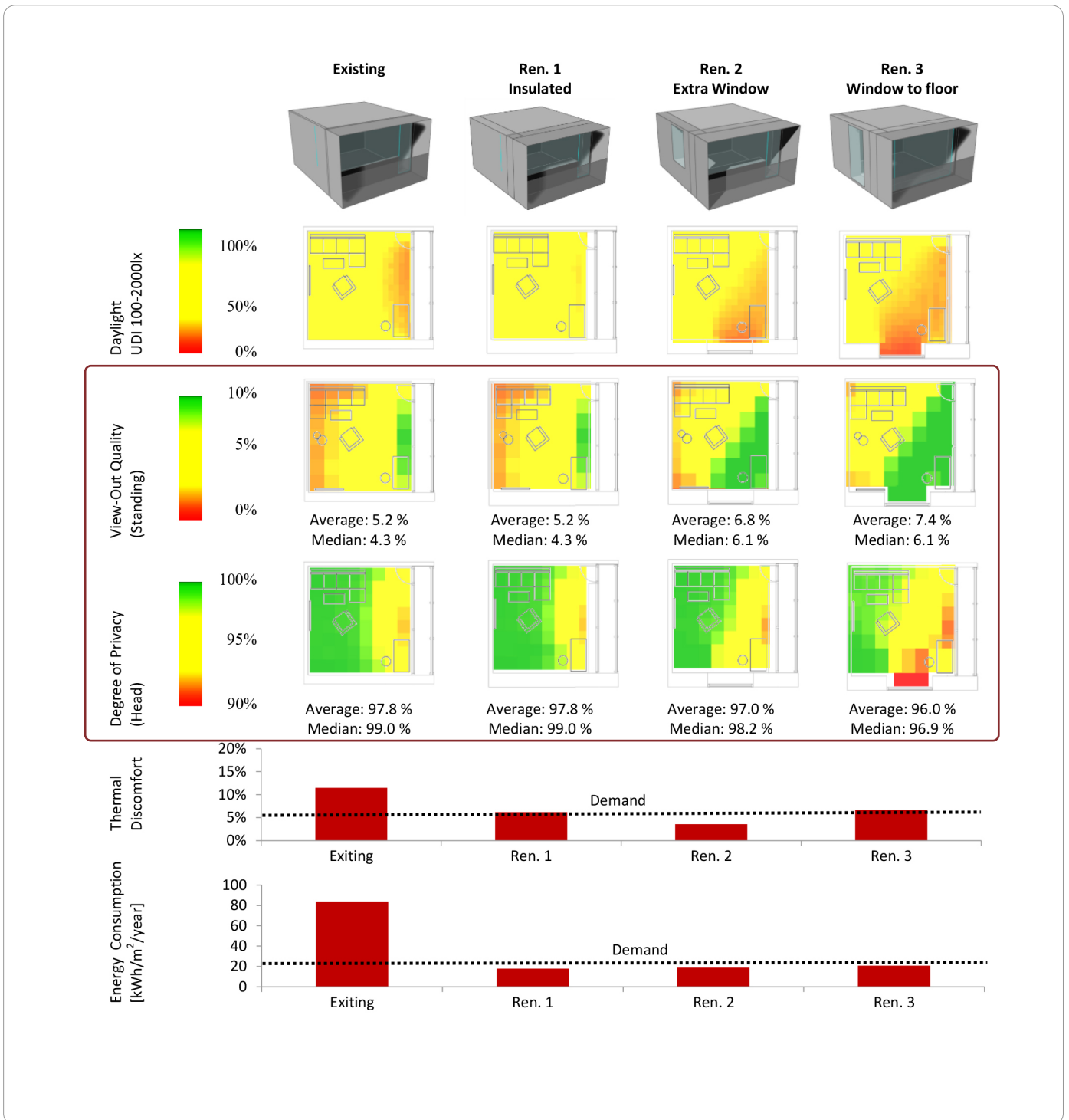


#### *Varying depth of renovation*

Depending on the depth of the renovation (i.e., what measures of alteration can be applied in the renovation), it may be more or less relevant to use the approach.

### **Summary**

As stated in this discussion relative to the findings of the RtD study, the primary potential of the concept for informing the early stage of renovation of MSH is found in strengthening the argumentation towards other stakeholders. This approach should not be seen as a replacement of the creative argumentative process. The architect must still evaluate the results relative to the expected activities within the space and with a specific user group in mind. Seen from a phenomenological perspective, in this study, represented by, e.g., Pallasmaa (2012), the spatial experience cannot be understood separately through quantification of single components but must be understood as a totality, as it is experienced by a subject through bodily encounters (Pallasmaa 2012). An example where the quantitative metrics on “View-out quality” and “Degree of privacy” may be insufficient for a holistic performance evaluation is that they do not account for aspects such as “ambience” (Meiss 1990),



**Figure 125** Simulation output evaluated with multiple metrics. Themes highlighted with a red box are the ones proposed based on the research of this thesis. (The figure was previously published in Purup et al. 2017 without the red marking).



The preliminary evaluation (focus group interview) was previously published in the paper “Sustainability Key Performance Indicators’ (KPIs) assessment and visualization aimed at architects in (early) renovation design processes” (Kamari et al. 2021a). Only parts of the paper with relevance for the thesis’ focus on traditionally softer well-being themes are included in this section.

“material encounters” (Pallasmaa 2012; Rasmussen 1975), or the ability for people to personalize the windowsill with “knick-knack” (Hauge 2013) when, e.g., exploring façade scenarios. By proposing Concept no. 1, it is merely suggested that quantifying some of the qualities related to spatial quality may establish a shared language for equal evaluation of both “soft” and “hard” metrics in the early stage of the renovation process.

### Preliminary evaluation by practitioners

The idea of turning values, which have previously been addressed more qualitatively, into metrics (exemplified by ‘view out quality’ and ‘degree of privacy’), was integrated into a study of a proposed decision-support tool developed as part of the ReVALUE project. The decision support-tool PARADIS was developed as part of the ReVALUE-project to rapidly evaluate several alternative renovation scenarios in terms of a number of criteria (Kamari et al. 2021a; Kamari et al. 2021b). The development of the tool itself was managed by professor Poul Henning Kirkegaard and post-doc Aliakbar Kamari. The author of this thesis became engaged in the process to discuss the potential inclusion of the new metrics.

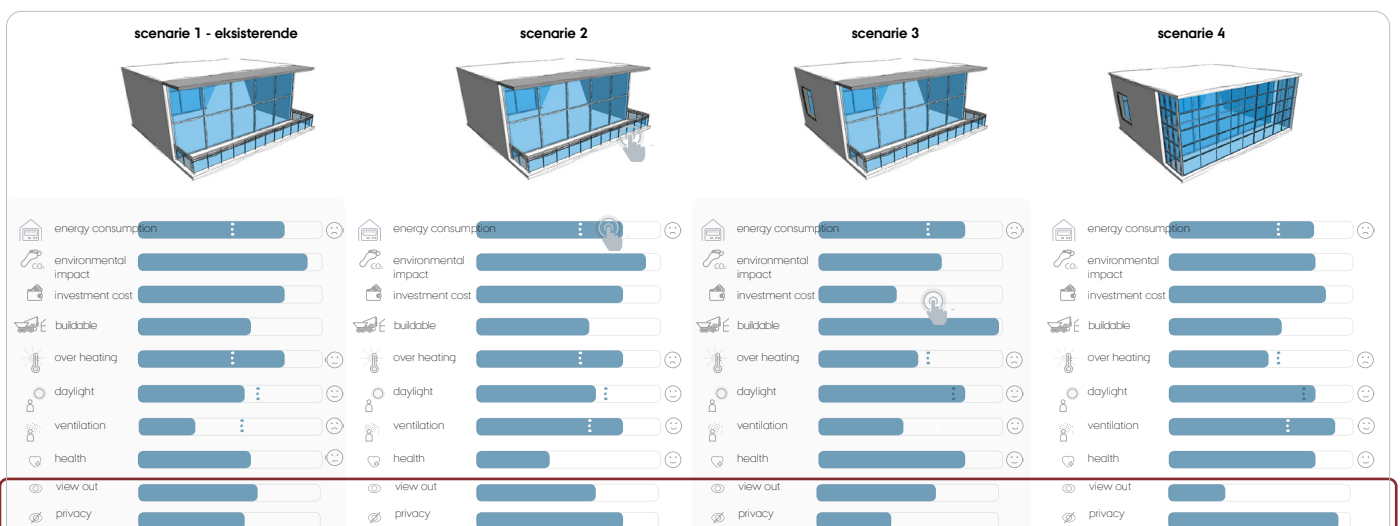
Three different sketches for user interfaces (referred to as ‘paper prototypes’) were discussed with potential users in a focus group interview in May 2019. The aim of the study in its entirety was to investigate how to visualize data to best inform the early renovation design stages with decision support. The study is described in more detail in the paper “Sustainability Key Performance Indicators’

(KPIs) assessment and visualization aimed at architects in (early) renovation design processes” published in The Nordic Journal of Architectural Research (Kamari et al. 2021a). The following section only includes parts of the paper that focus on “softer” well-being themes.

The author of this thesis functioned as a facilitator of the plenum sessions and as an observer during the exercises/group discussion with the “hidden agenda” (purposefully not disclosed to the participants before the discussions) to test the participants’ reaction to the inclusion of traditionally more qualitative metrics related to resident well-being alongside “traditional” metrics such as energy consumption. The idea was to make a preliminary evaluation of the idea based on these reactions.

Four architects, two constructing architects, and two anthropologists participated. The participants represented three larger architectural companies in Denmark: AART architects, Friis & Moltke, and CEBRA (Figure 127 and Figure 128). The workshop setup is described in more depth in ‘Part 2: Methodology’ and in (Kamari et al. 2021a).

Figure 126 displays one of the three alternative paper prototypes for data visualization discussed with the participants. All three prototypes can be found in Appendix F. The proposed metrics were presented in a different, more simplified format than described in the previous pages. The reason was to present the output in a way similar to the outputs of other included metrics prepared by other researchers in the ReVALUE project. The red marking in Figure 126 displays how the outputs related to ‘View out



**Figure 126** Example of prototype presented to the participants in the user group interview (English translation). Please refer to Appendix F for all three prototypes from the workshop. Prototype A is included here since it was the preferred form amongst the participants. Themes highlighted with a red box are the ones proposed based on the research of this thesis.



quality' and 'Degree of privacy' appeared in one of the paper prototypes.

As such, the focus group interview was a way to get feedback on the idea of turning "soft" values into metrics intended for multi-criteria performance simulation, not on specifics of the proposed metrics.

Also, it is important to note that the proposed metrics of 'View out quality' and 'Degree of privacy' were based on the idea that stakeholders evaluate areas in the exterior qualitatively before performing the simulation. This qualitative layer was not accounted for in the focus group interview. Thus, the paper prototypes presented in the focus group study indicate a level of objectification which is not (yet) supported by research.

### Feedback

The feedback on the individual paper prototypes for data visualization is summarized in Kamari et al. (2021a). In this section, the focus is on deduced feedback on including traditionally more qualitative metrics related to resident well-being, exemplified by "view out quality" and "degree of privacy", alongside "traditional" metrics such as calculated energy consumption.

The approach received dual reactions. As a general finding, introducing the new metrics was considered valuable in terms of putting the "softer" themes on the agenda in the dialogue with other stakeholders and instigating a more equal discussion. For instance, one participant stated, *"If they [the individual themes] are to be addressed equally, they should also be represented equally."* Another participant stated that *"[It is] nice to get numbers on some*

*of the qualitative!"*

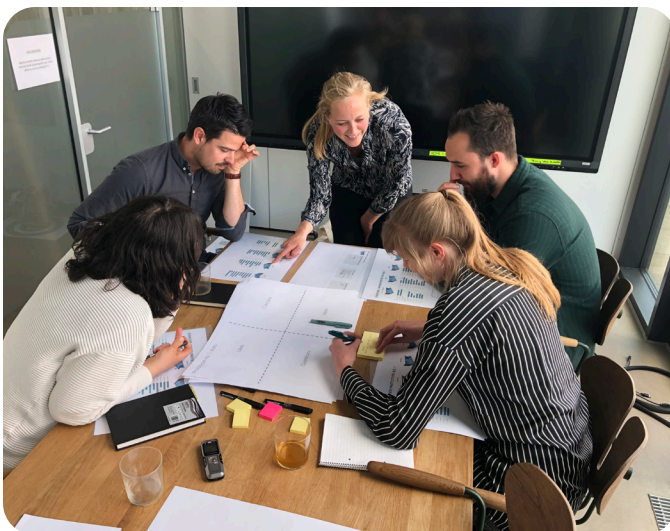
However, the study also pointed to the fact that well-being themes are very different in character. A statement like *"Some of the qualitative [aspects] are very contextually dependent"* shows the importance of acknowledging the complexity of the creative process to avoid reductionism.

Also, participants stated that there might be KPIs, which are more "suitable" for objective evaluation than others, e.g., acoustics, the ability to furnish the spaces ["møblerbarhed"], etc.

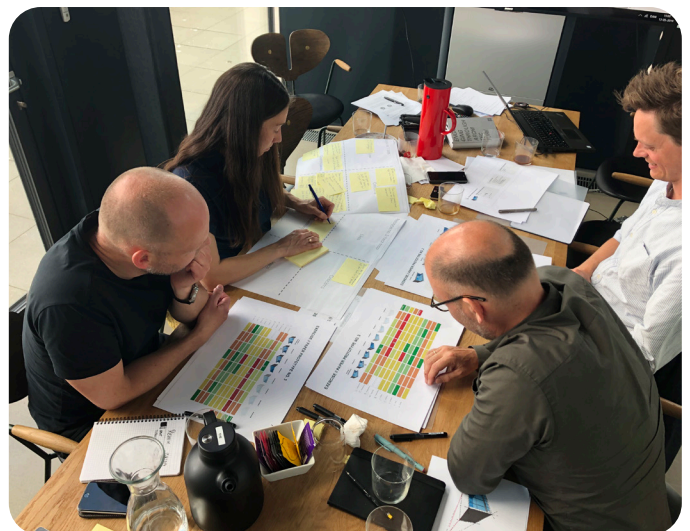
It is interesting to note that, while contextual dependence is a concern for, e.g., views and privacy, it did not prompt objections that energy consumption was presented "objectively" in the paper prototypes. Research into the "performance gap" (also mentioned in the delimitations as part of Part 1: Introduction) shows that energy consumption is, in fact, highly contextual (e.g., by Madsen 2017; Hansen et al. 2018). This makes for a relevant discussion in further studies on the subject.

The mentioned feedback from the practitioners indicated that establishing metrics for well-being themes, traditionally addressed more qualitatively, could be a way forward for supporting more holistic discussions amongst stakeholders in the early renovation design phase. The feedback also supported the relevance of maintaining a qualitative discussion as part of the simulation process.

In summary, the evaluation relative to the key learning points from the RtD study and this preliminary evaluation



**Figure 127** Image from user group interview. All people in the image have consented to the image being presented as part of the thesis.



**Figure 128** Image from user group interview. All people in the image have consented to the image being presented as part of the thesis.

by practitioners indicates potential in translating some values into metrics, not to substitute the creative process but to inform and instigate discussion across professions in order to promote well-being as part of sustainable renovation of MSH. Further research is needed to “mature” the approach, develop in-depth knowledge of individual metrics, and evaluate the concept in actual projects.

The preliminary evaluation also indicated that not all themes are equally “suited” or evaluation through computer simulation. Based on this input, it is found relevant to suggest alternative concepts for informing the process, focusing more on collecting and communicating experiences from previous projects and refraining from “predicting” the performance of new design alternatives. This has led to the following concepts:

- Concept for informing the process no. 2: Framework based on dissemination of “impact cases.”
- Concept for informing the process no. 3: Economic valuation as part of “impact cases.”

### CONCEPT FOR INFORMING THE PROCESS NO. 2: FRAMEWORK BASED ON THE DISSEMINATION OF “IMPACT CASES”

In the previous text, examples of metrics related to traditionally more “soft” façade properties were put forward. These formed the basis for a discussion about the relevance of including and quantifying such metrics as an integral part of a holistic approach to sustainable renovation. The following subsection focuses on the potential of informing practice by disseminating the documented impact of renovation interventions on resident well-being through “impact cases” (Figure 129). That is, acknowledging that not all the identified potentials for synergies (Objective 2) are suitable/mature for “prediction” of new outcomes through computer simulation. The architect becomes the agent of utilizing the collected insights at the right time in the process.

As such, Concept no. 2 is to develop a framework which could be unfolded in a physical popular science pamphlet and/or for digital distribution with hyperlinks. Essentially, the idea is to utilize the vocabulary developed in relation to Objective 1 (Articulation) as the basis for a catalog with examples of cases where such potentials have been documented with credible research. The proposed “wheel” is displayed in Figure 130 on page 176.

In the context of this thesis “credible research” is understood as: “*Credible research includes qualitative, quantitative, and mixed methods approaches with the highest standards of rigor suitable for their methodology*” (Peavey and Vander Wyst 2017, p. 151).

The elements of the proposed wheel are the following: The inner circle includes the overall *well-being themes* identified as part of Objective 2 (Identification). As such, more themes could be added as more themes are identified.

The second circle includes the “*means of altering the construction*”. In the context of this thesis, these means would always be identified to hold relevance for the specific context of energy renovation and, hence, hold a joint potential for energy savings and increased resident well-being. It is proposed to use the division into “skin”, “structure”, “installation”, “space plan”, and “site” inspired by Steward Brand (Brand 1995) and used in Objective 2 (Identification) as a way to structure the identified relations.

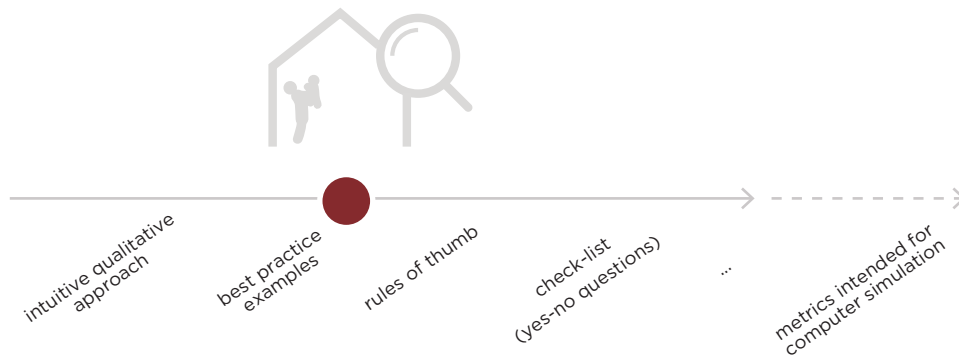
The circle “*Context*” refers to the prevailing contextual conditions of the renovation intervention which may serve to inhibit or promote the successful implementation of an intervention. Such contextual conditions may be related to, e.g., individual, organizational, or societal conditions, or more material conditions related to the built environment (Entwistle et al. 2015; Entwistle and Rasmussen 2014).

The circle “*Social value creation*” refers to documented changes in residents’ experience and/or behavior due to spatial gestures. Do the “means of altering the construction” result in experiential/behavioral changes which positively influence the well-being of the residents? In Concept no. 2, the term “social value creation” is used rather than “resident well-being” to signal that the impact wheel may include documentation of other aspects of social value creation.

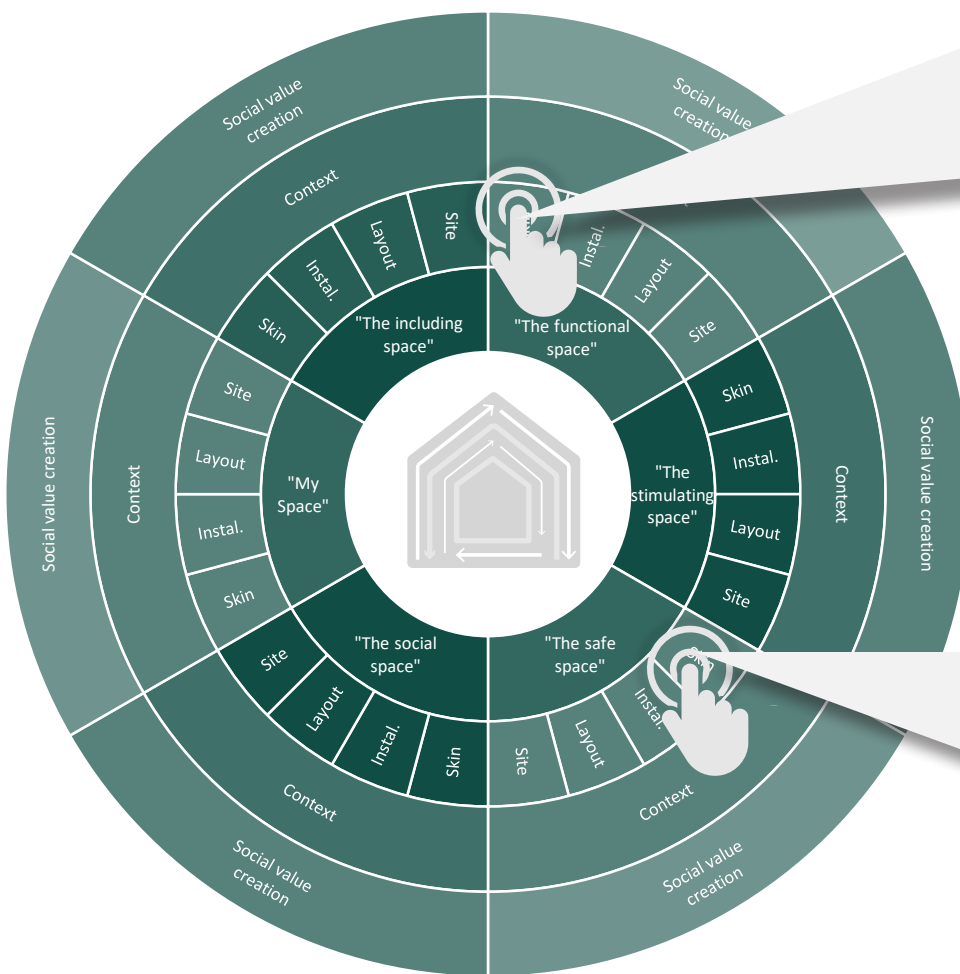
Knowledge about relations between certain alterations (through the spatial gestures they induce under certain contextual circumstances) and social value creation may then form the basis for “intended gestures” in future projects.

Figure 131-Figure 132 on page 177 show that the intention is that the user can get more in-depth information about the identified relation by hovering/clicking on the wheel. Two examples are included:

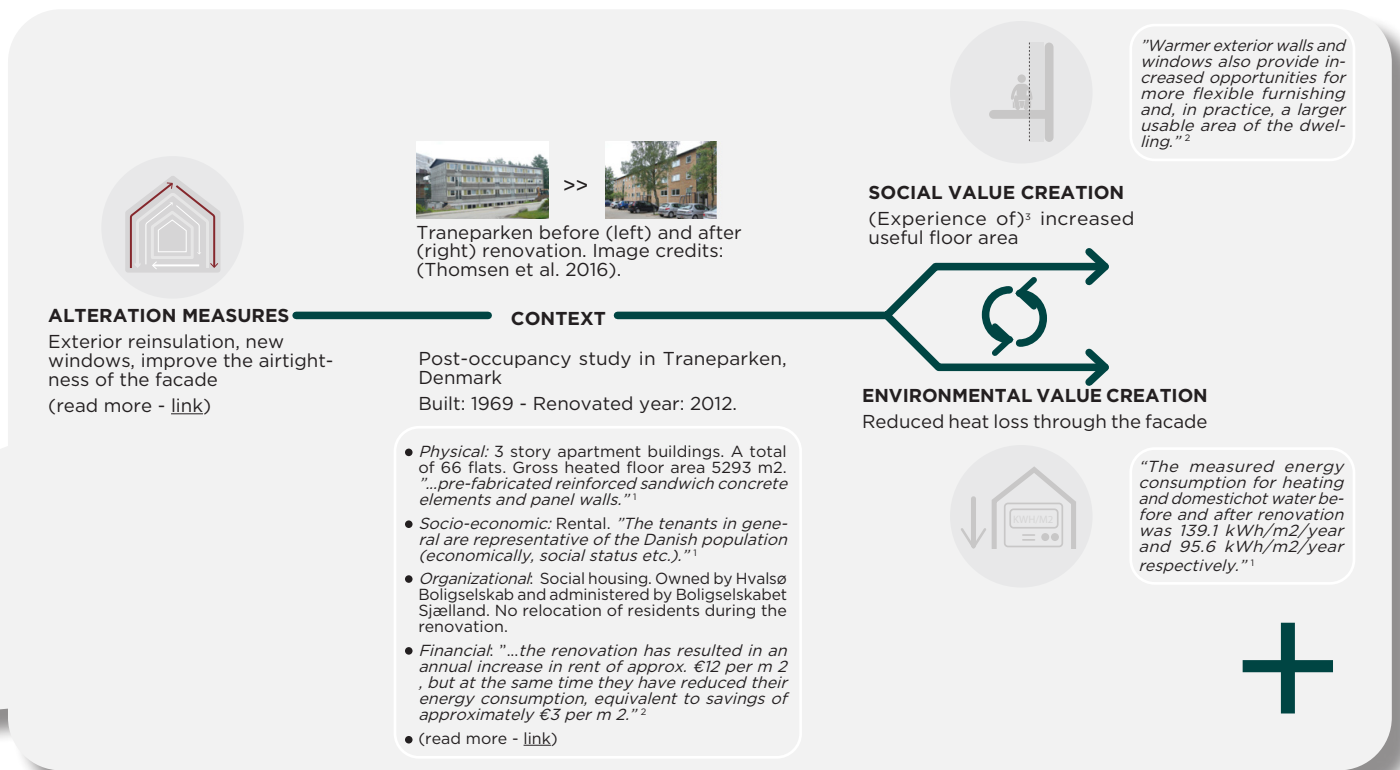
- How reinsulating the building envelope may contribute to increased usable floor area (Figure 131).
- How introducing more windows in otherwise closed areas may contribute to an increased sense of safety (Figure 132).



**Figure 129** The chapter focuses on how to visualize potentials for energy savings and increased resident well-being as part of the design process. The continuum displayed in this figure are based on the approaches identified in Table 12 on page 165. The suggested concept is based on disseminating impact cases.



**Figure 130** Proposed "Impact wheel" as a means to visualize previously identified synergies between resident well-being and energy savings. The wheel can be extended as more relations between architectural means of alteration and outcomes are identified and documented.



**Figure 131** Example of how the user may get more in-depth information about the identified relation by hovering/clicking the wheel. Proposed "(read more - link)" links to (Thomsen et al. 2016) and (Rose et al. 2019). <sup>1</sup>(Quotations from Thomsen et al. 2016) <sup>2</sup>(Quotation from Rose et al. 2019). <sup>3</sup>The reference (Rose et al. 2019) discusses useful floor area based on the authors' reasoning and not documented changes in the residents' experience based on, e.g., an interview - therefore this is a constructed example which serves to exemplify the proposed concept.



**Figure 132** Example of how the user may get more in-depth information about the identified relation by hovering/clicking the wheel. "(read more)" links to (Nørgaard & Rudå 2021). <sup>4</sup>(Nørgaard & Rudå 2021, p. 82f., translation by the author). <sup>5</sup>(Almennet 2017, slide 3 and 32, translations by the author). <sup>6</sup>(Quotation from Jensen et al. 2019a, p. 169).



### Discussion relative to the key learning points of the RtD process

As with Concept no. 1, Concept no. 2 and the associated examples for elaboration should be considered a prototype that should be further developed.



#### *Informing the process of the sketching architect(s) or their argumentation towards other stakeholders*

Insights from previous projects may help qualify the creative process at the architectural studio. But the primary value of the proposed concept is to help visualize the impact of certain intervention measures over others in the dialogue with other stakeholders.



#### *Bridging different “languages”*

Compared to Concept no. 1 (metrics), Concept no. 2 does not include “translating” insights from previous projects into “predictions” in new projects. Further, the format of the insights reflects the applied research design. As such, “soft”, qualitative findings are kept qualitative. However, by collecting examples of explanatory knowledge from previous projects, the architect is equipped with arguments, thereby moving from creative intuition to a more knowledge-based argumentation.



#### *Informing the iterative process with parallel tracks*

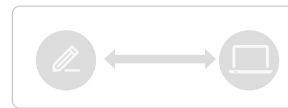
Informing the process with experiences from previous projects may help qualify one alternative over another.



#### *Detail and entirety*

The examples may include alteration measures at different scales, e.g., re-insulation with 190 mm insulation in the renovation of Traneparken (Rose et al. 2019) and adding new public functions within an area (Stender and Bech-Danielsen 2019). Also, the individual alteration me-

asures may influence the residents' well-being through spatial gestures at different scales, e.g., in the interior, the threshold, and in the façade from a distance. As such, the framework may support the process of “juggling” between detail and entirety.



#### *Analogue and computer sketching*

The approach is independent of the sketching tool. However, at the same time, the use of the framework requires that the users “translate” the findings into the context of the new project themselves.



#### *Varying depth of renovation*

Depending on the depth of the renovation, i.e., what means of alteration can be applied in the renovation, some of the examples may be more or less relevant to the process.

#### *Sub-summary*

Concept no. 2 represents a potential for communicating the best available knowledge on the subject to qualify the decision process internally at the architectural studio but also in the dialogue with other stakeholders – the latter by equipping the architect with arguments for one design alternative over another and thereby promoting well-being as part of interdisciplinary discussions.

A strength of the “Impact wheel” is that it visualizes insights from previous projects across different professions and methodological ‘school of thoughts.’ A related challenge is then that the underlying studies represent different contextual conditions, for instance, in terms of societal conditions or more material conditions related to the built environment (Entwistle et al. 2015; Entwistle and Rasmussen 2014), and in the research design applied in evaluating the impact of certain alteration measures. Also, depending on the methodological basis, some of the included “impact cases” may have stronger causal relations between renovation measures and documented resident well-being and energy savings. This should be considered when the user “translates” the findings into the context of the new project.





Paragraphs in the sub-section "Existing initiatives" were previously published as part of the paper: "Renovation as a catalyst for social and environmental value creation: Towards holistic strategies for sustainable housing transformation" (Jensen et al. 2020). The text has been edited to form a coherent part of the thesis.

### CONCEPT FOR INFORMING THE PROCESS NO. 3: ECONOMIC VALUATION AS PART OF "IMPACT CASES"

Based on findings from the literature review, RtD-study, and statements from the focus group interview with practitioners, it was found relevant to reflect on the perspectives for economic valuation of the identified potentials for increased well-being as a way to put the otherwise "soft" values on the agenda in interdisciplinary discussions. As such, Concept no. 3 builds on Concept no. 2 by adding a layer of economic valuation.

This section includes a brief introduction to existing knowledge on the subject within the field of MSH renovation and different methodological approaches. After that, the section includes examples of economic valuation of potentials for increased well-being identified in relation to Objective 2 (Identification) – examples, which could be included in a concept for informing the creative process. Lastly, Concept no. 3 (economic valuation) is discussed relative to the key learning points from the RtD process.

#### Existing initiatives

Only a few of the references identified in the literature study (Objective 2) addressed the economic potential of the identified social value creation. Darby (2017) illustrated that renovation might contribute with direct economic benefits for the residents, which can increase well-being in its own right, e.g., through reduced household expenses for heating. Almeida and Ferreira (2017) also addressed how renovation may contribute to reduced exposure to energy price fluctuations. Weber and Wolff (2018) emphasized that renovation may have the opposite effect for residents, who already keep their heating expenses at a minimum and are vulnerable to rent increases prompted by the renovation.

Rose et al. (2019) exemplified that added exterior insulation might increase the usable area for an apartment, the worth of which can be calculated based on information about rent (Rose et al. 2019). Haverinen-Shaughnessy et al. (2018) linked renovation initiatives to lower odds for reporting respiratory symptoms as well as not missing school or work due to respiratory infections (Haverinen-Shaughnessy et al. 2018). This link to health makes for interesting socio-economic perspectives and was also addressed in relation to the empirical studies in Toveshøj, Gellerupparken, and Søvungen (Objective 2).

Almeida and Ferreira (2017) included considerations on how identified "co-benefits" to energy renovation may be evaluated through 'willingness to pay,' and suggested that the approach can be included in a multi-methodology alongside 'traditional' Life Cycle Cost analysis (Almeida

and Ferreira 2017).

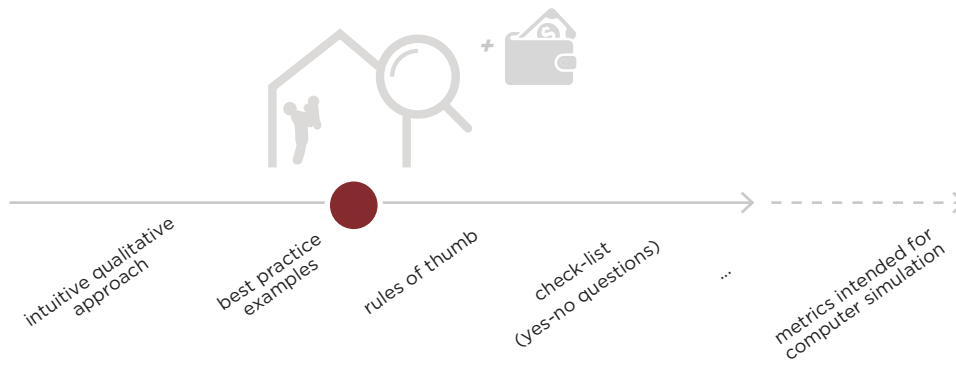
In addition to the references identified in the literature study (naturally limited by its methodological setup), efforts to economically evaluate the social value creation for the residents can be found in the work of, e.g. Skumatz et al. (2000), Næss-Schmidt et al. (2012), the International Energy Agency (2014), and Barnard et al. (2011). The intention of this section is not to make a thorough account of existing research. Rather, the intention is to illustrate that there is indeed emerging research on economic valuation of potentials for social value creation which could form the basis for further exploration and inclusion in the proposed Concept no. 3.

The references identified in the literature review as part of Objective 2, and referenced above, reflect different approaches for the economic valuation of social value creation. Before proposing specific examples for inclusion in Concept no. 3, it is found relevant to take a step back and consider the task relative to welfare economics in order to gain a methodological foothold. Within the field of welfare economics, "soft" qualitative values are referred to as "non-marketed goods," e.g., in (Mariel et al. 2021). According to Mariel et al. (2021) "*Welfare theory distinguishes two ways in which changes in environmental quality may affect an individual's utility: either by changes in the prices paid for marketed goods or by changes in the quantities or qualities of non-marketed goods*" (Mariel et al. 2021, p. 2).

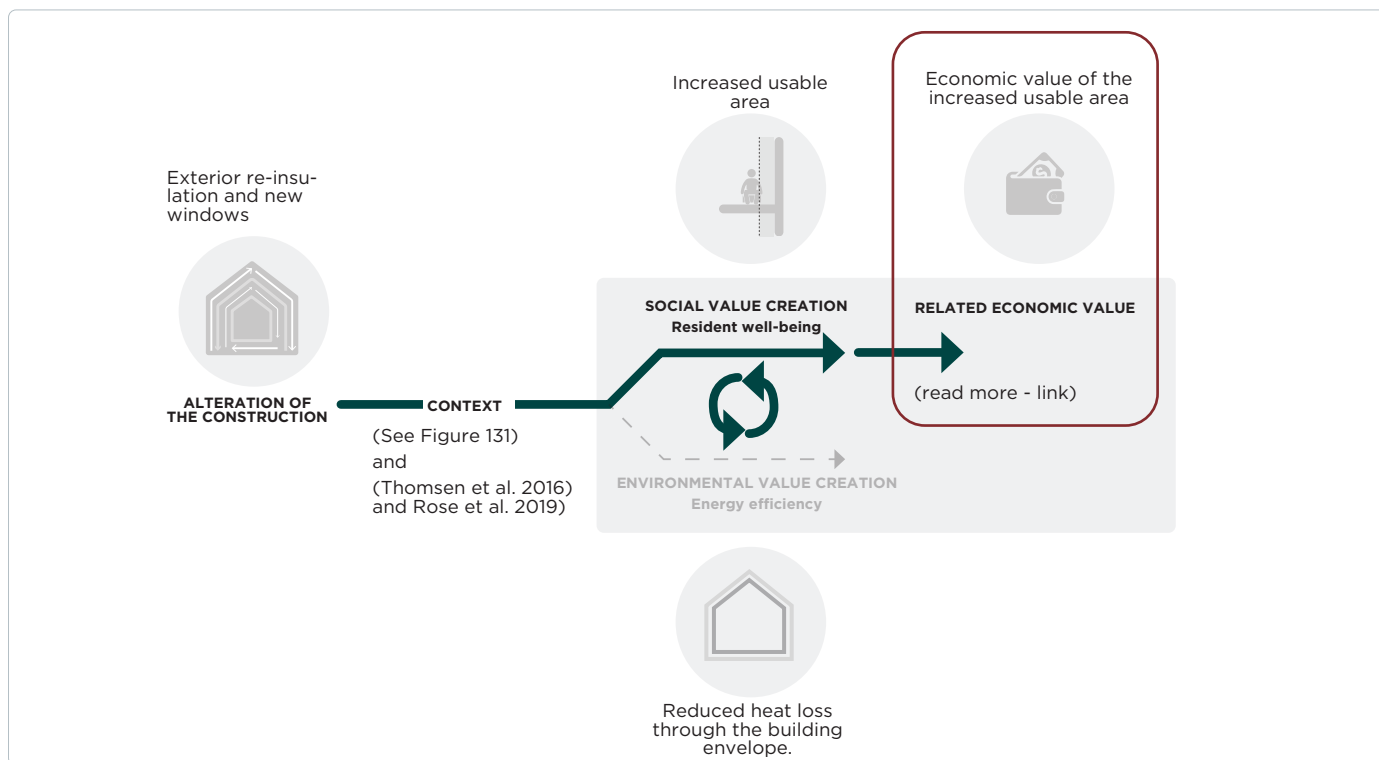
In brief, there are two ways of evaluating non-marketed goods:

- Directly: by setting up a hypothetical market and asking people directly how much would they pay (Mariel et al. 2021). In the case of renovation of MSH, an example could be how much residents would pay in rent for an apartment that has certain characteristics.
- Indirectly: looking at the real market and finding correlations with economic indicators or socio-economic indicators (Mariel et al. 2021).

Most examples from the literature study could be seen as examples of indirect valuation. However, the example of using the willingness to pay as a welfare economic measure could be seen as an example of direct valuation. The following section of the thesis will provide three examples based on an indirect valuation of increased resident well-being. The examples are based on potentials identified as part of Objective 2. After that, willingness to pay (WTP) is discussed as a way forward for exemplifying the more experiential values through direct valuation.



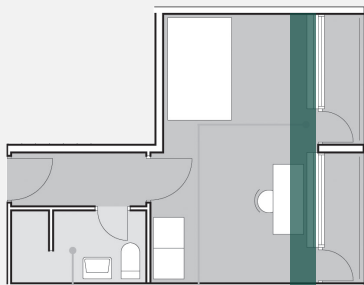
**Figure 133** Concept no. 3 builds on Concept no. 2. As such, it proposes to identify and visualize examples of the economic value of identified examples of increased well-being.



**Figure 135** Example of indirect valuation of increased thermal comfort and subsequent increased useful floor area. The red square signifies the proposed addition to Concept no. 2 (Figure 131). Figure 134 shows an example of an elaboration of the the red excerpt. NB: contextual factors should be communicated in a developed version of the concept.

**The economic value of the increase in usable floor area for the example apartment (inspired by Rose et al. 2019):**

- Net rent before renovation (1/1 2019): 2.559 dk kr.\* (BBBO 2021) (rent per m2 before renovation:  $2.559 \text{ kr.} / 23,5 \text{ m}^2 = 109 \text{ dk kr. per m}^2 \text{ per month}$ )
- Net rent after renovation (13/2 2021): 2.768 dk kr.\* (BBBO 2021) (rent per m2 after renovation:  $2.768 \text{ kr.} / 23,5 \text{ m}^2 = 118 \text{ dk kr. per m}^2 \text{ per month}$ )
- Increase in useful area:  $0,5\text{m} \times 5\text{m} = 2,5 \text{ m}^2$ .
- If we multiply by the monthly rent per m2 after renovation, this corresponds to getting 294 dk kr. worth of relative extra usable floor area per month. Subtracting the rent increase, the resident gets 85 dk kr. worth of relative extra usable floor area per month.
- On a yearly basis, this corresponds to 3534 dk kr. "worth of" relative extra usable floor area. Subtracting the rent increase, the resident gets 1026 dk kr worth of relative extra usable floor area per year.



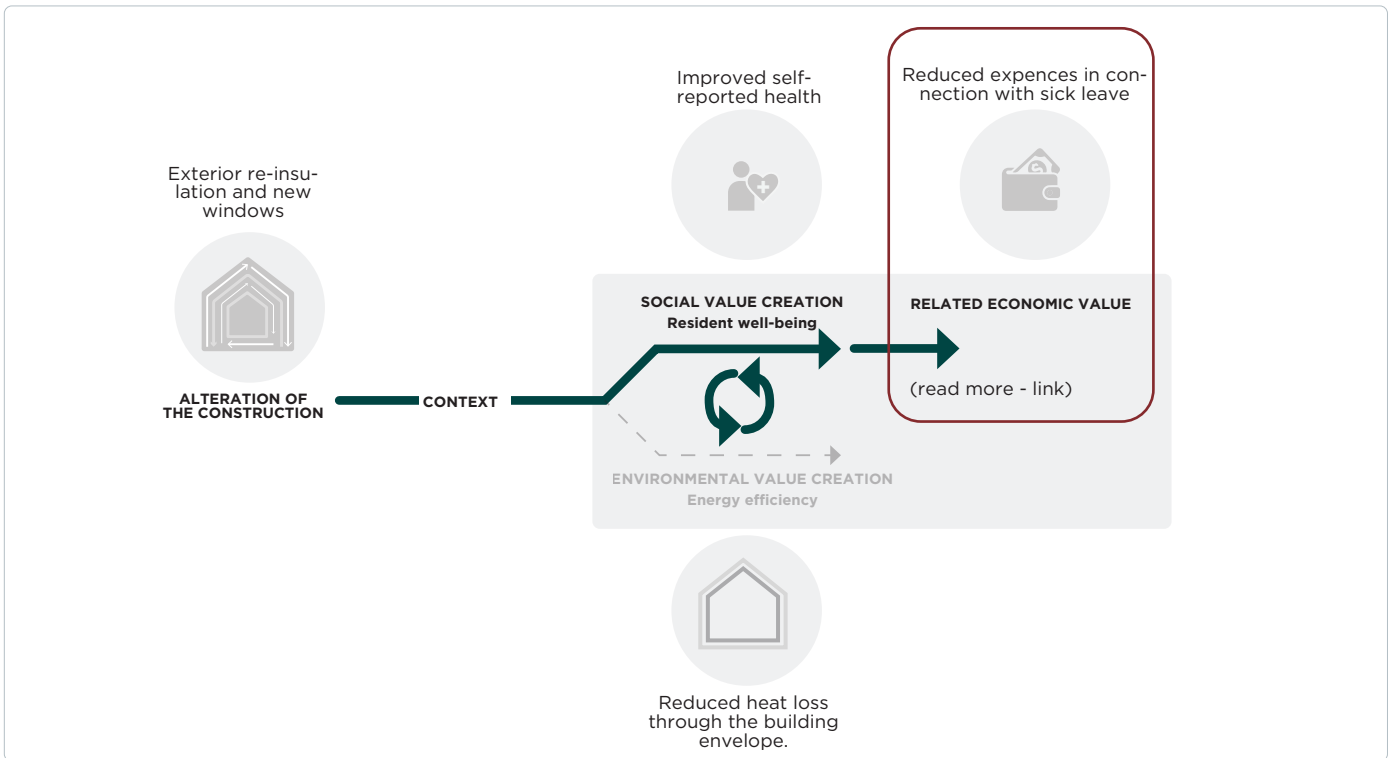
**Figure 134** Example of indirect valuation of potentials for increased well-being. Apartment in Toveshøj A17. Not to scale. Green ■ signals the relative increase in the useful area. \*Levels of rent before and after renovation are provided by BBBO (BBBO 2021). \*\*NB Numbers are based on measurements by the author in CAD-model provided by BBBO and does not necessarily align with the housing association's numbers.

**Exemplification of economic value (thermal comfort): useful area and rent.**

As part of the literature study (Objective 2: Identification), Rose et al. (2019) was identified as an example of monetizing the added social value of certain renovation measures. To recap, Rose et al. stated 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  $9 \text{ m}^2$  for an average-sized Danish apartment, and with a typical rent of  $160 \text{ €/m}^2/\text{year}$ , the co-benefit is worth approximately  $\text{€}1,440 \text{ per year per apartment}$ " (Rose et al. 2019, p. 2).

In the following, this way of thinking is applied to the specific case of Toveshøj. In the empirical studies (Objective 2: Identification), it was seen that 67% of the residents in Tovehøj feel cold or too cold in their living room. Further, 60% experience draught. Reinsulation, new thermally efficient windows, and a general tightening of the building envelope are likely to increase the usable floor area because the residents can stay closer to the periphery of the dwelling without feeling discomfort.

Using the single-room apartment in Figure 134 as an example, this line of thought would visualize that the resident gets 3534 dk kr. per year worth of "extra" usable floor area as a result of increased thermal comfort due to façade renovation. Due to the limited rent increase (Figure



**Figure 137** Example of indirect valuation of increased thermal comfort and subsequent improved health. Figure 136 shows an example of an elaboration of the the red excerpt. NB: contextual factors for the relevant reference project should be communicated in a developed version of the concept.

134), the relative extra usable area is likely to become a tangible benefit for the individual tenant (1026 dk kr. after subtracting the rent increase).

It should be investigated whether the extra usable floor area due to improved thermal comfort is, in fact, perceived as “extra value” by the residents (to establish a documented ‘lived gesture’). Nevertheless, the approach serves to visualize the *potential* added value for the residents in economic terms.

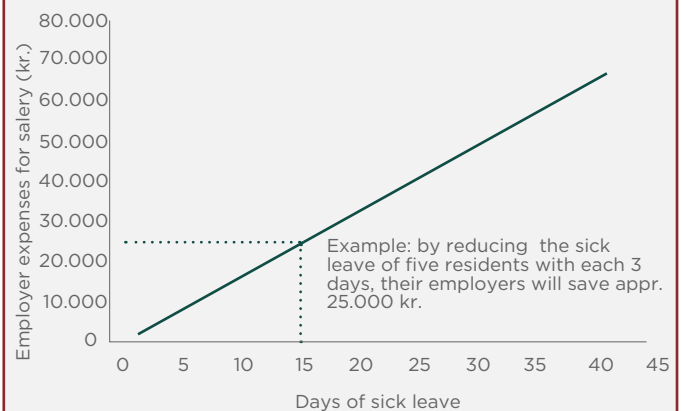
#### Exemplification of economic value (thermal comfort - health impact): reduced sick days

The findings of the empirical studies indicated a relation between thermal comfort and atmospheric comfort in a dwelling and self-reported health (Objective 2: Identification). As such, the findings also point to a potential for improving the health of residents by improving the thermal and atmospheric comfort of the dwelling through renovation. Particularly, reducing the heat loss and draught through the façade and improving ventilation in the apartment may be seen as alteration measures that could lead to improved health. The findings need to be studied further to establish a causal link; nevertheless, they resonate with existing research (e.g., Ortiz et al. 2019).

Besides the negative consequences for the individual, sick leave represents a huge cost for the employers and

#### The economic value of improving the residents' health, exemplified through reduced expenses in relation to sick leave:

As a fictive example, reducing the sick leave of five residents with three days each (amounting to 15 days in total), represents a potential saving of 25.000 dk kr. for their employer.



**Figure 136** Example of indirect valuation of the identified potential for increased well-being. Graph showing relation between days of sick leave and employers' expenses for an employee earning 30.000 kr. incl. retirement benefit. Based on numbers from (Cabi n.d.).

society at large. In a 2019 report from the Confederation of Danish Employers, the costs for relief in connection with illness are estimated to be 45 billion Kr./Year. The employer pays two-thirds of this cost (Høeg et al. 2019).

Figure 136 on page 183 shows an example of the relation between days of sick leave and expenses for the employer (based on numbers by the information center Cabi, established by the Danish Ministry of Employment (Cabi n.d.). The numbers in the example include the gross expenses for salary for a person earning a monthly average salary of 30.000 dk kr. including retirement benefit. The figure only includes expenses for salary. On a societal level, additional expenses, e.g. doctors, sickness benefit, administration etc., could be added.

Thus, by improving the residents' health through renovation measures, it is possible to reduce the expenses for the employer – and for society – related to sick leave. The extent of this potential naturally depends on the employment rate in the given area.

#### **Exemplification of economic value (improved accessibility to and in dwellings): reduced expenses for building new dwellings for elderly**

In the empirical studies, improved accessibility has been identified as a potential for improved well-being (Objective 2: Identification). Figure 138 on page 185 shows an example of a bathroom in Toveshøj, where the elderly residents express issues regarding showering due to the current layout.

A study from Copenhagen Economics (Hansen et al. 2014) points to two socio-economic benefits from increasing the accessibility in social housing dwellings:

- If the elderly person can stay in his or her own dwelling, it is generally valuable for him or her as it represents a familiar environment. Further, it represents a saving on a societal level if the resident remains self-sustaining for a longer period of time and needs less external help (Hansen et al. 2014).
- By improving accessibility as part of renovation efforts, the need for new accessibility dwellings for the elderly is reduced (Hansen et al. 2014).

According to BL - Danmarks Almene boliger (Danish Social Housing), the average cost for converting an existing

social housing dwelling into an “accessibility dwelling” targeted elderly people is 600.000 kr. The sum includes measures related to accessibility but also other measures of the renovation (BL - Danmarks Almene boliger n.d.).

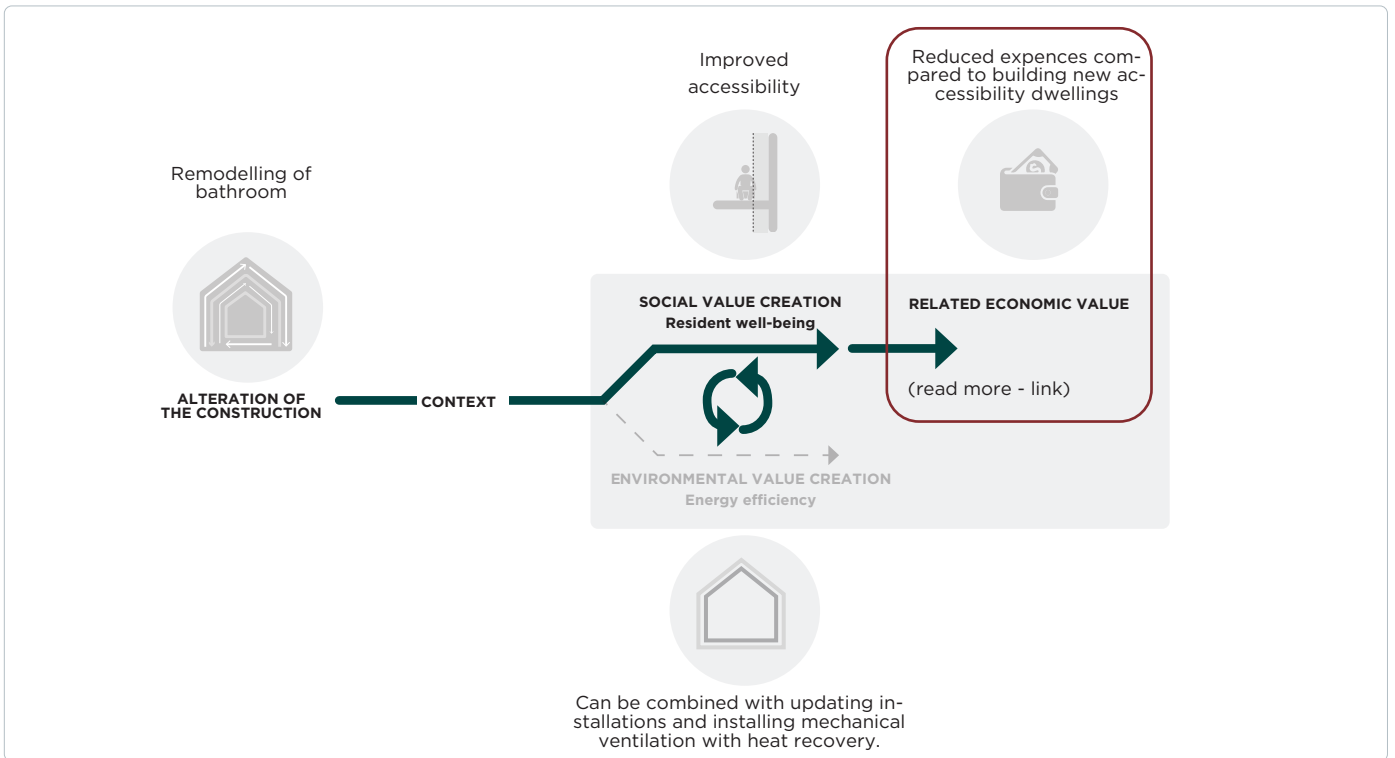
When building a new dwelling for elderly people, there is a maximum figure per square meter which is publicly subsidized. Today, that figure is between 23.230 kr. and 29.710 kr. depending on the geographical location of the building. For instance, the figure is larger in the capital region than in the provinces. BL puts forward the following example: for an average dwelling for the elderly (66 m<sup>2</sup>), the maximum figure would then be appr. 1,5-2 million kr. (when multiplying the subsidized sum with 66 m<sup>2</sup>). Even if that amount is not fully exploited, the figures demonstrate a significant saving if more existing dwellings are made more accessible through renovation measures.

Figure 140 on page 185 is a graphical representation of the second-mentioned socio-economic benefit. This could be an example of insights which could be gathered as part of an example catalog and thus serve to inform the process. It is important to note that the economic potential is not realized based on the remodeling of the bathroom alone – this measure “only” contributes to the full “accessibility renovation” which would normally also include measures such as level access, implementing elevators, and rebuilding the kitchens to ensure a bigger turning radius.

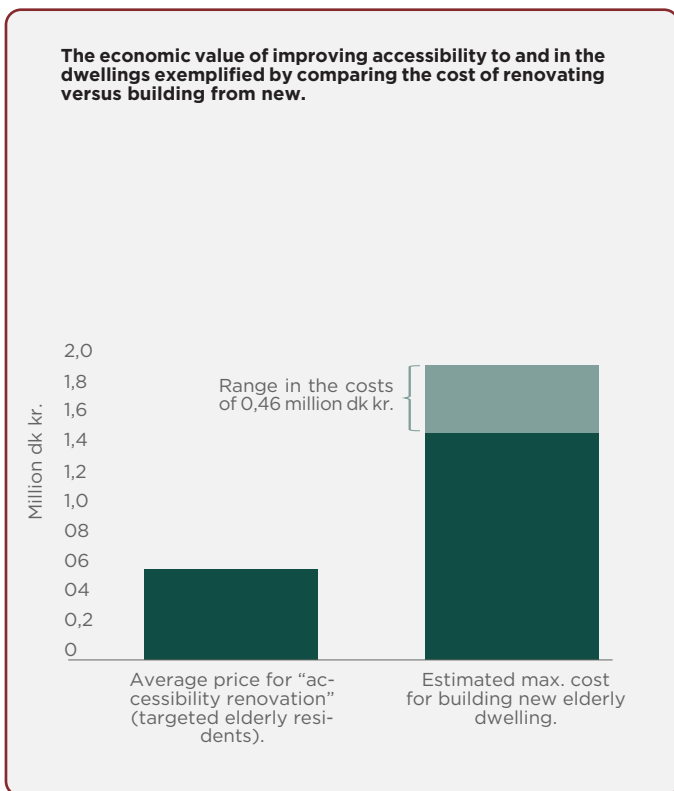
#### **Examples of using WTP to demonstrate the economic value**

The previous examples were examples of linking the identified increased well-being to socio-economic indicators – what could be referred to as an indirect valuation approach. As an example of direct valuation, Pollinger (2014) calculated individuals' Willingness-To-Pay (WTP) for health and wellness improvements within their homes (non-marketed goods) based on a so-called choice experiment (Pollinger 2014). The study by Pollinger does not relate directly to renovation of (rental) MSH dwellings. Yet, as suggested by (Almeida and Ferreira 2017), WTP as a method may be a way forward for including “softer” benefits in weighings of alternative renovation scenarios.





**Figure 139** Example of indirect valuation of changes to the floorplan and subsequent improved accessibility. NB: contextual factors for the relevant reference project should be communicated in a developed version of the concept.



**Figure 140** Example of indirect valuation of the social value creation. Costs for "accessibility renovation" (left) versus building an accessibility dwelling from new (right). (Based on BL - Danmarks Almene Boliger n.d.).



**Figure 138** Existing bathroom in Toveshøj before renovation.

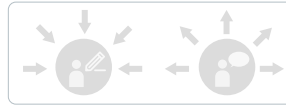
In the context of this thesis, WTP is thus proposed as a possible way forward when it comes to exemplifying the economic value of also the more experiential social values. Femenias et al. (2018) applied the approach in a study of residents' willingness to pay for restoring culture-historical elements in connection with the renovation of two multi-family housing buildings (Femenias et al. 2018). The two studied buildings were originally built in the 1930s and 1890s, respectively. The respondents in the study included both owners and tenants. The results showed that respondents generally appreciate the heritage of their living environment, and the authors stated that heritage provided a "sense of belonging" for the residents – both people owning their apartment and tenants. This makes for an example of the built environment impacting resident well-being. However, for the majority of the tenants, this was not reflected in their willingness to pay a higher rent.

*"The question of willingness to pay for heritage values is delicate. For owner-occupiers, there is a driver as heritage can be linked to higher property values [4]. While earlier studies have claimed that at least companies are willing to pay higher rents for heritage buildings [4], the situation is likely to be different for tenants of housing. The respondents in the questionnaire indicate a lower interest to pay a higher rent for living in a heritage building. When asked about the issue, some of the interviewees in A2 stated that even though they value heritage they do not want a rent increase"* (Femenias et al. 2018, p. 180).

Even if the results cannot be directly included in a framework as a positive "impact case" exemplifying the economic valuation of the social value creation, the approach may serve as an inspiration for further exploration of the subject of economic valuation of otherwise "soft", qualitative values in renovation of MSH. It also points to the importance of considering ownership as an important contextual factor when "translating" findings from one study to a new project.

#### **Discussion relative to the key learning points of the RtD process**

The examples in this section illustrate how "soft" qualitative values can be evaluated in economic terms. The approach should, of course, be examined and evaluated through further, more in-depth studies on the subject. In the following, the proposed concept is discussed relative to the key learning point of the RtD process.



#### *Informing the process of the sketching architect(s) or their argumentation towards other stakeholders*

The idea of valuating traditionally more "soft" values in economic terms holds an interesting perspective which may help strengthen the architects' argumentation in dialogue with other stakeholders and the client, and thus promote well-being in synergy with energy savings as part of interdisciplinary discussions.

As seen, it is possible to visualize the economic value of increased resident well-being on different levels, e.g., for the individual (example 1: increased usable floor area) or for society at large (example 3: renovating for increased accessibility). Depending on the timing and whether the framework is used in the argumentation towards "fellow" team members in an interdisciplinary team, the residents themselves, the client, or, e.g., the authorities, different kinds of examples may have a bigger impact.



#### *Bridging different "languages"*

As with Concept no. 1 (metrics), visualizing the economic potential of social value creation may help instigate an equal weighing of traditionally "soft" and "hard" well-being themes by communicating in a quantitative "language."



#### *Informing the iterative process with parallel tracks*

Pointing to examples of economic valuation may make it more difficult to "cut" alteration measures at different stages of the project. As such, this way of arguing may prove valuable at different stages of the process.



#### *Detail and entirety*

As with Concept no. 2, the examples of the economic valuation may relate to intervention measures at different scales. As such, the proposed concept may support the process of “juggling” between detail and entirety. However, as a general thing, it may be a challenge to find examples of relations between a specific renovation measure and its social value creation (and related economic value). In other words, it may be difficult to “prove” that the economic value can be attributed to a specific measure.



#### *Analogue and computer sketching*

The approach is independent of the sketching tool.



#### *Varying depth of renovation*

Depending on the depth of the renovation, i.e., what measures of alteration are applied in the renovation, some of the examples may be more or less relevant to the process.

#### **Sub-summary**

Renovation of MSH represents a complex task. As with Concept no. 2, the use of the examples of economic valuation requires critical consideration of the contextual conditions for the referenced impact study when the user works to “translate” the findings into the context of the new renovation project. In most cases, there is no “one size fits all” solution. And it can be difficult to establish causal links between specific renovation measures and the economic valuation of the increased well-being in the project. Results cannot be directly transferred to a new context. As such, the concept is intended to inform the process with insights that can help promote well-being in sustainable renovation, rather than representing a fixed set of solutions.

# Summary

This chapter has focused on informing the early design processes with insights on potentials for synergies between energy savings and “softer” aspects of resident well-being when assessing alternative renovation measures. This was investigated as a strategy for promoting resident well-being as part of more holistically sustainable renovation of MSH.

The first part of the chapter focused on exemplifying the early-stage design process in the renovation of MSH from the architect’s perspective. Key learning points relevant to informing the decision process were identified. After that, three downstrokes into the decision process served as a basis for discussing how insights into potential synergies between energy savings and resident well-being might have supported the process.

Next, three concepts for informing the process were proposed. Concept no. 1 focused on including traditionally “softer” well-being themes in computer simulation alongside traditionally “harder” well-being themes and simulations of energy performance to instigate discussion and promote an equal weighing. Potentials and challenges of the approach were discussed relative to the learning points from the RtD study and preliminary feedback from practitioners.

Subsequently, two additional concepts were proposed and discussed. Concept no. 2 focused on communicating examples of documented insights in an “impact wheel,” visualizing a number of “impact cases”. Concept no. 3 was, in fact, more an elaboration of concept no. 2 than an isolated concept, and focused on adding examples of economic valuation to the “impact cases.” As with Concept no. 1, the two additional concepts were discussed relative to the learning points of the RtD study.

Identified potentials and challenges of each of the three proposed concepts are summarized in Table 13 on page 189.

In brief, Concept no. 1 provides similar visualization of traditionally “soft” and “hard” themes which may be valuable in terms of bringing soft values on the agenda and instigating an equal discussion. Further, it provides rapid evaluation of a number of design alternatives which may be valuable in the early design stages when working iteratively with parallel “tracks” of alternative renovation scenarios. However, it is important to emphasize that more research is needed to mature the approach. Further, the

approach should be used with caution – as one of many inputs to inform the creative process – in order to not invite reductionism.




Concept no. 2 makes it possible to collect and visualize previous experiences from different ‘schools of thought’ in a homogenous format independent of the sketching format. However, it requires that the architect “translates” the finding into the context of the new project.

It is a challenge to identify previous impact studies where researchers have established a link between certain alteration measures and the well-being of residents. Also, the relation between well-being themes and energy performance may be less explicit than in Concept no. 1 unless this relationship is addressed explicitly as part of the disseminated impact case.

Similar challenges can be mentioned in relation to Concept no. 3. However, Concept no. 3 may be a way forward for further strengthening the argumentation towards stakeholders which focus on the economic bottom line. Also, the approach may be a way forward to visualize the societal value creation of certain renovation measures beyond the individual.

It is relevant to note that the concepts are not considered “either-or.” They offer different kinds of decision support and may be useful for different purposes. The intention is by no means to substitute the creative process but rather to inform the process to help promote well-being as part of sustainable renovation.

**Table 13** Identified potentials and challenges of each of the three proposed concepts for informing the process relative to Objective 3: To exemplify how a framework could be developed to visualize potentials for synergies between energy savings and improved resident well-being in order to inform decision-making in the early stages of interdisciplinary renovation processes.

	Potentials	Challenges
<p><b>Concept no. 1:</b> <b>Metrics for evaluation of spatial gestures</b></p> 	<ul style="list-style-type: none"> <li>• Similar visualization of "hard" and "soft" themes.</li> <li>• Valuable in terms of instigating a more equal discussion.</li> <li>• Rapid evaluation of the performance of a number of design alternatives.</li> </ul>	<ul style="list-style-type: none"> <li>• Tied to a specific digital sketching tool.</li> <li>• This kind of representation may not be 'suitable' for all well-being themes.</li> <li>• May invite reductionism if the framework is not used with caution as one of many inputs to inform the creative process.</li> </ul>
<p><b>Concept no. 2:</b> <b>Dissemination of "impact cases"</b></p> 	<ul style="list-style-type: none"> <li>• Independent of sketching tool.</li> <li>• Possible to visualize previous experiences collected from different methodological 'schools of thought' in a homogeneous format.</li> </ul>	<ul style="list-style-type: none"> <li>• Requires that the users "translate" the findings into the context of the new project themselves.</li> <li>• In a number of cases, it can be difficult to establish a causal link between isolated renovation measures and increased resident well-being.</li> <li>• Depending on the methodological basis of the underlying study, some studies have stronger causal relations than others. In general, attention to contextual conditions is crucial.</li> <li>• The mutual relation between well-being and energy savings may be less explicit than in Concept. no. 1.</li> </ul>
<p><b>Concept no. 3:</b> <b>Economic valuation as part of "impact cases"</b></p> 	<ul style="list-style-type: none"> <li>• Independent of sketching tool.</li> <li>• Visualising the economic potential of social value creation may help instigate a more equal weighing of "soft" and "hard" well-being themes.</li> <li>• Visualising the economic potential of increased well-being may be a way to visualize the societal value creation of certain renovation measures.</li> </ul>	<ul style="list-style-type: none"> <li>• Requires that the users "translate" the findings into the context of the new project themselves.</li> <li>• It can be difficult to establish causal links between isolated renovation measures and the economic valuation.</li> <li>• The mutual relation between well-being and energy savings may be less explicit than in Concept. no. 1.</li> </ul>

# Part 6 : Closing





# Conclusion

The post-war social housing stock faces extensive renovation over the coming years. This represents a significant potential for implementing energy savings while updating the housing stock to better support the well-being of the residents.

The ability to influence a project is highest in the early design stages. Nevertheless, especially in the renovation of MSH, the early stages represent a high level of complexity as many concerns are to be addressed simultaneously amongst a large interdisciplinary group of stakeholders. Looking more broadly at the building sector, several frameworks have been developed to navigate the complexity of building projects and push the development of the sector (including renovation) in a more sustainable direction. However, currently, there is a gap in existing initiatives when it comes to supporting the architect's role as a promoter of well-being as part of sustainable renovation of MSH, especially when it comes to promoting softer, traditionally more qualitative well-being themes.

Based on the established knowledge gap, the following research question was put forward: *“How can resident well-being be promoted by architects in the early design phases of interdisciplinary, sustainable renovation processes?”*

The research question was explored through three objectives. In brief, the objectives focused on respectively articulating (Objective 1), identifying (Objective 2), and communicating (Objective 3) the impact of renovation on resident well-being and potentials for synergies between resident well-being and energy savings in the early design phases of a renovation process.

Overall, the project was based on a mixed-methods research design. Objective 1 proposed a conceptual framework based on a hermeneutic-interpretive approach; Objective 2 combined architectural analysis, empirical studies, and a literature review as three lenses for identifying examples of synergies in previous projects. Objective 3 combined a research through design study (RtD study) with a literature review to gain more knowledge on the early design process as a basis for proposing three new concepts for informing the process through the vocabulary identified through Objective 1 and the examples of synergies identified through Objective 2.

In the following, the findings in relation to each of the three objectives are summarized, followed by a unifying summary.



## OBJECTIVE 1: ARTICULATION

The research contributed with a conceptual framework for articulating synergies between energy efficiency and improved resident well-being in renovation from an architectural perspective.

The research contributed to repositioning the concept of well-being in the context of sustainable renovation, going beyond prevailing understandings of (thermal) indoor comfort.

Based on a rereading of architectural theory relative to the context of sustainable renovation of MSH, the thesis proposed a combination of tectonic architectural theory and renovation theory to articulate how alterations of the construction may contribute to both energy savings and improved well-being through the spatial gestures they preserve, accentuate, or add.

By combining this with key concepts from evaluation theory, the research provided a vocabulary for articulating if the added spatial gestures prompted by the alterations of the constructions do, in fact, lead to documented positive changes in residents' experience and/or behavior. As such, the proposed framework helps distinguish between “intended” gestures and actual “lived” gestures, which is relevant when looking to inform new projects with documented insights.

The proposed conceptual framework provided a theoretical basis for engaging in the two remaining objectives, focusing on identifying and visualizing potentials for synergies, respectively. The conceptual framework also contributes to the field's knowledge base in its own right by suggesting a vocabulary for articulating architecture as a catalyst for value creation – in this project, focusing on energy savings and resident well-being.



## OBJECTIVE 2: IDENTIFICATION

The research contributed to expanding the existing knowledge base on how alteration of the construction may influence the well-being of residents and how this may form a synergy with energy savings. The findings were synthesized as so-called ‘well-being’ themes including “The sensuous space,” “The safe space,” “The social space,” “‘My’ space,” “The including space,” and “The functional space.” As part of the synthesis, it was illustrated how spatial gestures in the built environment might be com-

bined with attention to energy savings.

The identified themes exemplify that “softer” aspects of resident well-being also may be influenced as part of the sustainable renovation of MSH. As such, the research contributes to expanding existing understandings of well-being in a more holistic direction. The individual themes and their relationship should be studied in more depth. Further, the themes should not be considered a final list but rather a starting point, a “skeleton,” to be elaborated and extended, especially regarding softer well-being aspects. The proposed well-being themes were identified using three different methodological approaches: architectural analysis of completed renovation cases, empirical studies in three MSH areas, and a literature study of existing impact cases. The thesis includes methodological reflections on the three approaches which may inform future studies on the subject.



### OBJECTIVE 3: COMMUNICATION

The chapter contributed with insights on the early-stage interdisciplinary design process based on a RtD study. The findings were used as a reference for proposing three different concepts for informing the early-stage design phase with knowledge about the potential for synergies between energy savings and increased resident well-being. The focus was on promoting traditionally “softer” well-being themes and challenging how these are articulated as part of the process.

Concept no. 1 focused on including traditionally “softer” well-being themes in computer simulation alongside traditionally “harder” well-being themes and simulations of energy performance to instigate discussion and promote an equal weighing. Potentials and challenges of the approach were discussed relative to the learning points from the RtD study and preliminary feedback from practitioners. After that, two additional concepts were proposed and discussed. Concept no. 2 focused on communicating documented insights in an “impact wheel,” visualizing impact cases (evaluation of completed renovation cases). Concept no. 3 focused on adding examples of economic valuation to the “impact cases.” As with Concept no. 1, the two additional concepts were discussed relative to the learning points of the RtD study.

It was seen that the three concepts offer different kinds of decision support. The proposed concepts should not

be considered “neither-or” but supplementary ways of communicating knowledge which may bring value to the process depending on the application context. The perspective is to develop further, qualify, and test the concepts in collaboration with practitioners in ongoing renovation projects.

### SUMMARY

The PhD project investigated how resident well-being can be promoted by architects in the early design phases of sustainable renovation processes. This was done through three objectives. The main findings were:

#### *Objective 1 Articulation*

- A conceptual framework for articulating the impact of alterations on residents’ well-being in synergy with energy savings.

#### *Objective 2 Identification*

- Examples of documented impacts of alteration measures on resident well-being, categorized as “well-being themes.”
- Illustrating how the “well-being themes” may form synergies with energy savings.
- Methodological reflections relevant to future impact studies.

#### *Objective 3 Communication*

- Insights into the interdisciplinary decision process.
- Proposing three concepts for informing the process.

The three objectives and related findings and reflections offer strategies for promoting well-being in sustainable renovation of social housing. Overall, the suggested strategies demonstrate new paths which may help push contemporary practice and direct further studies on the subject – with the aim to contribute to a development where the evaluation of well-being in a broad sense becomes a fully integrated part of more holistically sustainable renovation practices.

# Discussion

The thesis chapters included integral reflections of the research strategy and findings of the individual studies. As such, this chapter is devoted to discussing the summarized findings of each of the three objectives. After that follows a discussion of more overall methodological concerns.



## OBJECTIVE 1: ARTICULATION

The main contribution in relation to Objective 1 was a conceptual framework for articulating the implications of different alteration measures on the residents' well-being and the building's energy performance.

While the conceptual framework has formed the basis for the remaining objectives, it may also be considered a contribution to the field in its own right as a strategy for supporting architects' role as promoters of well-being in the early design phases of sustainable renovation processes. This prompts reflections on the approach and application of the results.

### Iterative approach

As mentioned, the conceptual framework has formed the basis for engaging in Objectives 2 (Identification) and 3 (Communication). The other way around, Objectives 2 and 3 have also helped "shape" the research related to Objective 1. Especially, the studies across all three objectives led to combining the architectural theoretical framework with evaluation theory to articulate a documented impact on resident well-being ('lived' gestures).

As such, the conceptual framework is not the result of linear development, e.g., establishing the conceptual framework and testing it through application. Rather, different development stages of the conceptual framework have been applied to frame sub-studies in Objectives 2 and 3. Based on the reflections from these sub-studies, the conceptual framework was then further developed. The iterative approach in relation to Objective 1 reflects the explorative character of the project in general but also the dependence on collaboration with other researchers and involvement in ongoing projects. While the approach has posed pragmatic challenges, it has served to continuously qualify the approach relative to the context of early-stage renovation of MSH.

### Application

As an independent research result, the conceptual framework can be used as an analytical lens in architectural analysis of cases. Further, the conceptual framework may contribute to establishing a shared vocabulary in design projects for articulating the 'impact' of architecture. As stated under "Perspectives," the use of the conceptual framework for these purposes should be examined in more depth with potential users. Further, the conceptual framework should not be mistaken for a process tool which would require moving from a theoretical lens to a more hands-on format (suggested in Objective 3).



## OBJECTIVE 2: IDENTIFICATION

The main contribution from Objective 2 was to exemplify documented impacts of alteration measures on resident well-being, categorized as "well-being themes" and to illustrate how the "well-being themes" may form synergies with energy savings.

### Well-being themes – a skeleton for further elaboration

It is important to stress that other methods of inquiry may have led to the identification of different/more examples of relations. As such, the presented themes should be seen as a starting point for gathering documented relations between alteration to the construction and synergies between increased resident well-being and energy savings. Also, the "wording" of the well-being themes is a product of interpretation of the findings – as such, the grouping could be a subject of further discussion and elaboration.

### Contextual dependency

The themes identified through the literature review are based on references with different methodological and contextual outsets. This should be disseminated when seeking to inform the design process in future projects. As a common denominator, the references convey what Groat and Wang (2013) refer to as "explanatory knowledge". However, it is important to stress the complexity of MSH renovation and that no "one size fits all" solution exists when aiming to translate the findings from completed projects into future projects.

### Documented insights

The explanatory knowledge identified through the literature review was used as the main source for establishing

the proposed “well-being themes.” The assumption is that such documented insights can inform future projects. It is relevant to discuss the contribution of the architectural analysis and empirical studies for Objective 2 when they were not decisive for the synthesized “well-being themes.”

First of all, the architectural analysis and empirical studies served to supplement and nuance the well-being themes. Further, the studies contribute with methodological perspectives:

**Architectural analysis:** It is widely used for architects to look to reference projects as a basis for new projects (Lawson 2006; Purup and Petersen 2020). The architectural analysis provides examples (and an analytical lens for further studies) to direct attention to synergies between spatial gestures and energy saving as part of these efforts. This could be relevant in educational programs or within an architectural studio. Architectural analysis before and after renovation may also help target empirical studies.

**Empirical studies:** The studies propose a mixed-methods approach for baseline and post-occupancy studies which could inform the “well-being themes” (Objective 2) and “impact wheel” (Objective 3) with explanatory knowledge. Further, it provides an approach for project-specific inquiry before larger renovation cases which may help target the renovation efforts in a specific project.

In this light, the three different approaches may supplement each other when aiming to exemplify potentials for increased well-being as part of renovation efforts. However, when looking to elaborate the “well-being themes,” with additional documented insights, it is important to distinguish between the hypothesized, “intended” gestures and documented, “lived” gestures.

### Approach to well-being

The thesis has aimed to promote an understanding of resident well-being in the built environment, spanning both physiological and psychological concerns. Further, the thesis focuses on limiting negative stimuli *as well as* promoting positive stimuli. Nevertheless, the identified examples have an “overweight” of potentials to limit negative stimuli, especially in relation to indoor climate – and the physical well-being themes are generally substantiated through more examples and references. This reflects the

identified references in the literature review (and may also reflect the chosen search strategy). Further, the empirical studies have generally focused on indoor climate themes and themes with which residents express dissatisfaction. As such, there is a potential to further unfold a broader understanding of the well-being concept in future studies.

However, the synthesis has pointed to examples of relations across a broad spectrum of well-being themes – also demonstrating synergies between softer well-being themes and energy savings. Further, the synthesis has demonstrated that it is crucial to consider not only potentials for added value but also the fact that existing values may be compromised during renovation. As such, the findings support the relevance of promoting a broad understanding of well-being.

Future studies should examine more psychological well-being aspects in the context of sustainable renovation. In addition, the identified well-being themes should be further substantiated and elaborated, going beyond the “meta-perspective” of this thesis and addressing the individual themes and their relations in more depth.



### OBJECTIVE 3: COMMUNICATION

The main contribution of Objective 3 was proposing three concepts for informing the process.

The summary of Part 5: Communication included a summary of identified potentials and challenges relative to promoting well-being in the context of sustainable renovation of MSH. To recap, Concept no. 1 (metrics) provides similar visualization of traditionally “soft” and “hard” themes which may be valuable in terms of bringing soft values on the agenda and instigating an equal discussion. Further, it provides rapid evaluation of design alternatives which may be valuable when working iteratively with alternative renovation scenarios. However, the approach should be used with caution – as one of many inputs to inform the creative process. Further, not all themes may be mature or suited for this objectification. As such, the idea of systematically collecting insights from previous projects in an impact catalogue (Concept no. 2) may be a way forward for qualifying design decisions across a broader spectrum of well-being themes. The concept makes it possible to visualize evaluation studies from different ‘schools of thought’ and spanning qualitative and quantitative results in a homogenous format. However,

it requires that the architect “translates” the finding into the context of the new project. For now, it is a challenge to identify previous impact studies, where researchers have documented the impact of alteration measures on the well-being of residents. Also, the relation between well-being themes and energy performance may be less explicit than in Concept no. 1, unless this relationship is addressed explicitly as part of the underlying, referenced impact case.

Similar challenges may be mentioned for Concept no. 3 (economic valuation). Nevertheless, the economic valuation may be a way forward for further strengthening the argumentation towards stakeholders, which focus on the economic bottom line, and as a way to visualize the societal value creation of certain renovation measures.

It is relevant to note that the concepts are not considered “either-or” but can inform the process at different stages.

### **The importance of the architectural holistic view**

The thesis argues that it is necessary to establish a more explicit vocabulary for articulating what architecture does to people to help support the architect’s role as a promoter of well-being in sustainable renovation. When working towards a more explicit vocabulary, and venturing down the road of ‘quantification,’ we start isolating themes which are, in reality, experienced as part of a whole (Pallasmaa 2012). As mentioned in the introduction, some voices in the architectural field oppose this idea. From their perspective, efforts to establish a more explicit vocabulary may invite reductionism and are incompatible with the field’s creative nature (these concerns within the architectural field are mentioned by, e.g., Nygaard 2002; Jensen 2015). The PhD project emanated from the ReVALUE project, which had as a preassumption that it is relevant, and possible, to quantify also more experiential aspects of the built environment. The three proposed concepts for informing the process (Objective 3) are a result of a journey investigating the span between the two “stances” and reaching a meaningful level of explication/quantification.

It is imperative to stress that the intention with the proposed concepts is not to substitute the creative process but rather to inform the process to help put a broad understanding of well-being “on the agenda” in sustainable renovation. The individual alteration measures and well-being themes may be articulated separately as part

of an analytical process but should always be viewed as part of a holistic whole.

In this regard, the thesis leans on Erik Nygaard, who states that *“In any case, I would argue, that architectural quality is about it all [...] You may very well, in an analytical manner, divide and treat the themes in isolation, but you cannot reduce architecture to one or a few of these themes”* (Nygaard 2002, p. 93, translation by the author). According to Nygaard, a holistic approach and attention to the architectural main idea/main concept is at the core of the architectural profession.

The three suggested concepts for informing the process include a more explicit distinction between means and end, and a more explicit listing of individual themes than what is custom in today’s architectural practice. To avoid the risk of reductionism, it is essential that the architects become active players in sustainability discussions and take on the role of “gathering the threads,” synthesizing various inputs into new meaningful wholes.

### **GENERAL REFLECTIONS**

#### **Knowledge as a driver of change**

The thesis (in particular, Objective 3, focusing on informing practice) was based on the underlying assumption that providing stakeholders involved in the early design phases with knowledge at the right time and in the right format will trigger a positive change and ultimately influence their design choices. It is relevant to reflect on this assumption. Within the field of practice theory (originated by Pierre Bourdieu and developed in the social sciences in the 1970s and 1980s), knowledge is considered only one of multiple factors influencing people’s practices (Reckwitz 2002; Entwistle et al. 2015). Reckwitz (2002) defines ‘practice’ in the following way:

*“A ‘practice’ (Praktik) is a routinized type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, ‘things’ and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge. A practice – a way of cooking, of consuming, of working, of investigating, of taking care of oneself or of others, etc. – forms so to speak a ‘block’ whose existence necessarily depends on the existence and specific interconnectedness of these elements, and which cannot be reduced to any one of these single elements”* (Reckwitz 2002, pp. 249-250).



In the context of this thesis, the aim has been to contribute to a development where the evaluation of well-being in a broad sense becomes a fully integrated part of holistically sustainable renovation practices. From a practice-theoretical perspective, changing this practice would require a broader understanding of factors influencing the decision flow. This reflection does not make the findings of this thesis less relevant. However, it does call attention to the complexity of factors that may promote or inhibit the desired change. Further development of the proposed formats for informing the process should consider this.

#### **Architectural research involving interdisciplinary collaborations**

Throughout the project period, the author had the privilege to collaborate with a number of researchers and practitioners. For instance, the author collaborated with engineers, public health researchers, and anthropologists concerning the empirical studies, and with architects, engineers, and contractors as part of the RtD-study.

The collaborations have opened the author's eyes to different perspectives and provided valuable opportunities for exploring the problem field.

The interdisciplinary collaborations have also prompted continuous reflections and discussions which can be partly explained by different underlying research paradigms. In 'Part 2: Methodology,' Groat and Wang's (2013) continuum was used as a basis for describing the underlying assumptions of this thesis. Revisiting the continuum, it can be argued that some collaborators come closer to a postpositivist stance in the sense that an "[e]xternal reality [is] revealed probabilistically" (Groat and Wang 2013, p. 77). In contrast, others represent a more constructivist stance where "...multiple realities are understood as being socially constructed" (Groat and Wang 2013, p. 78). In reality, the differences were less pronounced. Nevertheless, the varying methodological starting points prompted discussions in the planning, analysis, and dissemination of findings. In this regard, the following quotation by Groat and Wang (2013) is found relevant:

*"In an inherently interdisciplinary field, such as architecture, a common tendency is for researchers, who might work primarily or only within one system of inquiry, to evaluate research from a different system of inquiry according to the standards of quality they know best. For example, researchers whose work falls clearly within the*

*positivist paradigm may nevertheless tend to judge research done in either a constructivist or intersubjective paradigm by the standards they themselves employ. Not surprisingly, this can lead to a lot of heated arguments about whose work is really "research" and whose is not"* (Groat and Wang 2013, p. 79).

Observing and participating in such arguments have been a vast source of learning for the author. More than any PhD course attended during the project period, the mentioned experiences have equipped the author with a greater understanding of different perspectives and, thus, prepared the author for engaging in future collaborations with practitioners and researchers from across the building sector.

#### **Architectural research involving ongoing projects and research agendas**

As mentioned briefly in 'Part 2: Methodology', the research design has been continuously revisited based on learnings from the individual studies; however, the research design has also been revisited to manage unforeseen developments related to ongoing projects. The latter was especially relevant concerning the empirical study and the RtD study which depended on the competition outcome and delays in the renovation process. Further, collaboration with other researchers has meant that the research design depended on other research designs and related time schedules.

In summary, the decision to engage in ongoing projects and collaborations has influenced the research design of the PhD project and, ultimately, the research findings. Despite the described challenges related to this 'opportunistic' approach, the possibilities for engaging in ongoing projects and collaborations have provided valuable insights into the professional and academic field of sustainable renovation of social housing. The experiences from the PhD period have prepared the author for better navigating the "uncertainty" of the field and collaborations within the field when engaging in future projects.

# Further perspectives

This section is devoted to a brief reflection on the perspectives and transferability of the findings.

The term ‘transferability’ “...has to do with the extent to which the conclusions of one study can be applied to another setting or circumstance” (Groat and Wang 2013, p. 85). It is used deliberately to signal that the aim has not been to establish generalizability in line with an objective, postpositivist paradigm (Groat and Wang 2013). Rather, the aim has been to explore the problem field from different angles to point to possible strategies for promoting well-being in the sustainable renovation of social housing.

Overall, the natural next step would be to move from the explorative approach applied in this project to more in-depth studies of the individual strategies. In the following, the perspectives and transferability of the research findings are discussed relative to the three objectives of the thesis.

## OBJECTIVE 1: ARTICULATION



The proposed conceptual framework has formed the basis for the remaining objectives in the thesis. As such, the perspectives of the conceptual framework are indirectly addressed as part of the following subsections focusing on Objectives 2 and 3.

Looking at the conceptual framework in “its own right”, further research could include systematic feedback from students and practitioners applying the framework as a vocabulary and an analytical tool.

### *Transferability:*

Though developed for the specific context of sustainable renovation of social housing, the framework may be applied to other typologies and new buildings as a vocabulary for articulating joint social and environmental value creation in the built environment.



## OBJECTIVE 2: IDENTIFICATION

As mentioned under Objective 1, a natural next step in relation to the architectural analysis would be to examine students’ and practitioners’ experiences using the framework as an analytical lens.

The immediate perspective of the empirical studies is to follow up on the pre-renovation studies. The follow up-studies are scheduled for spring 2022. Further, the perspective is to statistically analyze the identified potentials in more depth.

From a methodological perspective, it is also relevant to investigate the approach as a way forward for gaining project-specific insights before initiating larger renovation projects.

The immediate perspective of the literature review would be to extend the study, targeting “softer” well-being themes which are still under-represented in existing research on sustainable renovation.

### *Transferability:*

In terms of transferability, especially the findings of the literature review and synthesis of “well-being themes” may be used to inform future renovation projects with explanatory knowledge from previous projects. In this regard, the thesis has stressed the methodological and contextual differences between the identified examples of explanatory “impact studies.” In line with the realist evaluation approach, disseminating the contextual conditions is key to qualifying the transferability of the results to other settings or circumstances.

The three approaches for identifying examples of the impact of renovation of resident well-being – and synergies with energy savings (architectural analysis, empirical studies, and literature review) may be useful in other contexts than MSH renovation. In that connection, the included reflections could help inform and further develop the proposed research design and tactics.



### OBJECTIVE 3: COMMUNICATION

The natural next step in regards to the three proposed concepts in Objective 3 would be to evaluate them with practitioners. In this regard, a research design could be to:

- Do a series of focus group interviews with practitioners – for example, with different potential user groups within architectural studios and potential collaborators such as engineers, developers, and clients.
- Test the strategies through application in real projects.

The concepts introduced in this thesis are developed to a conceptual, sketch level. Further research is needed to develop the concepts into readily applicable frameworks.

#### Further perspectives for Concept no. 1

At this time, Concept no. 1 (metrics) has been applied in two ongoing competition projects. Both projects are new buildings within the health care sector and are not directly related to the context of MSH renovation (Figure 141).

Nevertheless, it will be possible to follow up on the experiences from these processes and revise the metrics on the basis hereof. The use of the metrics in these projects is briefly described in Purup (2021).

Since the development of the metrics in 2017, master students and researchers at the Department of Civil and Architectural Engineering, Aarhus University, have conducted a virtual reality study with 90 participants. A developed version of the metrics was evaluated in a virtual reality experiment where the participants assessed two different window sizes in three different types of urban settings. The study concluded that *“The results indicate that the proposed metrics to a wide extend are on par with the actual mean votes of room occupants and could, therefore, be useful to qualify the view-out quality and degree of privacy design proposals during the design process”* (Petersen et al. 2020, abstract). More experiments are needed to ensure the validity of the results and to test the metrics in other virtual settings.

Further, since the proposed metrics were developed in 2017, a European standard on Daylight in Buildings has been developed, including attention to “Quality of view out” (European Committee for Standardization 2018), focusing on horizontal sight angle, outside distance of the view, and number of layers to be seen from the interior

(European Committee for Standardization 2018).

The standard includes checklist recommendations which are methodologically in line with those of, e.g., Acre and Wyckmans (2015). The proposed way of addressing views in the European standard may be a way forward for visualizing the otherwise “soft” value of views to the outside. However, recent research has questioned the validity of the proposed metric in the standard:

Waczynska et al. (2021) compared *“...a computational evaluation of the outside view according to the standards’ recommendations”* with *“...a view out evaluation based on a direct questionnaire in the selected indoor spaces...”* (Waczynska et al. 2021, abstract). The researchers concluded that the results from the two investigations differ. As such, more studies and subsequent refinement of the metric is needed.

The studies of Petersen et al. (2020) and the European standard on Daylight in Buildings (European Committee for Standardization 2018) both suggest moving towards an objective metric.

The study of (Petersen et al. 2020) mainly involved students in their 20’s and took place under certain physical contextual conditions. As such, testing the metrics with other user groups and in different settings may reveal different preferences. This calls for further research which the researchers themselves also stress.

Central to the development of the metrics presented in this thesis was the idea that the interdisciplinary team assigns a quality factor to elements in the exterior. For now, and based on the preliminary evaluation in this thesis, the author argues for maintaining this qualitative weighing based on the best available research or in collaboration with existing or future residents.

#### Further perspectives for Concept no. 2

Concept no. 2 could be further developed into a popular science publication targeting the building sector. Alternatively, it could be integrated into a new digital tool for gathering experiences, recently launched by The National Building Foundation (Hansen n.d.).

The idea of communicating the impact of interventions is being implemented at the architectural studio of AART architects, i.e., through a tool referred to as Effektkompasset [the Impact Compass] (Rasmussen and Entwistle

2021) (Figure 142). There was a symbiotic relationship between the research presented in this thesis and ongoing research and development work in the architectural studio.

Rather than focusing “solely” on the communication of insights as in this thesis, the Impact Compass is intended as a graphical tool to ensure focus on the impact of architectural interventions at all stages of the process, both when articulating the “intended gestures” and when documenting the “lived gestures” when the building is in use. Continuous focus group interviews are being executed with the users of the tool, and the first experiences from using it are being collected. As such, future studies could include systemized evaluation and revision of the tool on the basis hereof.

### Further perspectives for Concept no. 3

At this time, the principles of Concept no. 3 are being further addressed by industrial PhD fellow Eszter Sántha in a collaboration between AART architects, Aalborg University, and the University of Copenhagen. As part of her studies, Sántha identifies “intended gestures” (through interviews with architects and architectural analysis) and “lived gestures” in the built environment (through

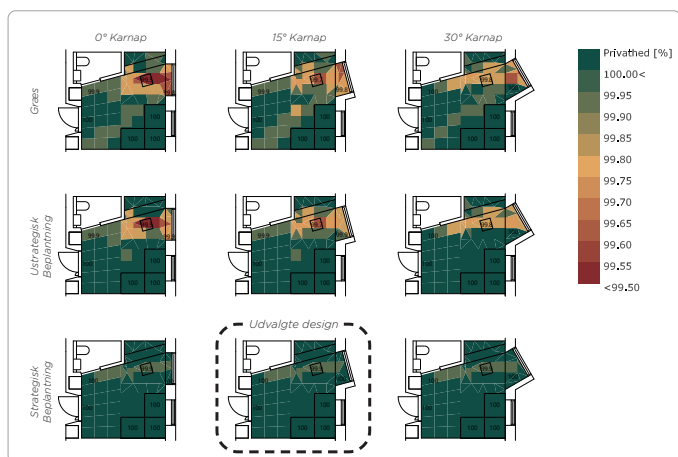
observations of and interviews with users) (Santha et al. 2022a; Santha et al. 2022b). She uses this as a point of departure for welfare-economic valuation through choice experiments with users.

Choice experiments (and direct valuation) could be an interesting path to pursue in order to develop more examples of economic valuation of also more “soft” experiential values. Further studies could include interviews with stakeholders to evaluate the approach itself.

### Transferability:

In terms of transferability, Concept no. 1 (metrics intended for computer simulation) is being tested for use in new buildings within the health care and domestic sector. The applicability of the proposed metrics may be even more relevant in the context of new buildings, with a higher degree of geometrical design freedom. Such application calls for separate evaluation.

Concepts no. 2 and 3 (impact cases and economic valuation as an “add-on” to the impact cases) are based on the specific context of MSH renovation. Nevertheless, the approach may be relevant across typologies to more explicitly account for the impact of architectural measures and promote an informed design approach.



**Figure 141** Perspectives for Concept no. 1. Application of metrics in a competition entry for a psychiatric department. From the project description. The study shown is this figure, focused on the influence of the angle of the bay window and plants in the exterior on the degree of privacy (AART architects).



**Figure 142** Perspectives for Concept no. 2. Workshop focusing on the implementation of the “Impact Compass” at AART architects. January 2022. All people in the image have consented to the image being presented as part of the thesis.



# Part 7 : Bibliography





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## Abbreviations

n.d.: no date

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# Figures

Where nothing else is stated, the figure is a photograph or diagram taken/developed by the author or by the project team as part of the RtD study at AART architects.

**Figure 2** Graphics by the author based on text in (Rambøll 2018, p. 8).

**Figure 3** Graphics by the author based on text and figures in (Rambøll 2018, p. 10; Kamari 2018, p. 52; Mortensen et al. 2017b, p. 14).

**Figure 4** Graphics by the author based on text and figures in (COWI 2018, p. 9; Rambøll 2018, p. 14; Mortensen et al. 2017b, p. 13). Translation by the author based on (The Danish Association of Consulting Engineers (FRI) and The Danish Association of Architectural Firms 2018).

**Figure 7** Graphics by the author based on figure in (Nygaard Rasmussen and Birgisdóttir 2015, p. 12).

**Figure 12** AART architects.

**Figure 13** Frontpage from ReVALUE publication (Wandahl and Hansen 2018).

**Figure 14** Graphics by the author based on figure in (Groat and Wang 2013, p. 10).

**Figure 15** Graphics by the author based on text and figure in (Groat and Wang 2013, p. 76).

**Figure 22** Graphics by the author based on text and figure in (Groat and Wang 2013, p. 111).

**Figure 24** Graphics by the author based on figure in (Dalsgaard 2009, p. 41). The terms used in the diagram are changed from the original to reflect the thesis's wording better.

**Figure 25** Graphics by the author based on figure in (Dalsgaard 2009, p. 41). The terms used in the diagram are changed from the original to reflect the thesis's wording better.

**Figure 27** Graphics by the author based on figure by (Interaction Design Foundation n.d.-b). The original illustration was developed by Teo Yu Siang/the Interaction Design Foundation.

**Figure 32** Principle section by the author based on drawing material in (Levitt 2010, pp. 221–22).

**Figure 33** Sketches by the author loosely based on photos of Park Hill before and after renovation. The photos were provided by the architects Studio Egret West (Egret 2017, pp. 21, 36, 126).

**Figure 34** Sketches by the author loosely based on photos of Park Hill before and after renovation. The photos were provided by the architects Studio Egret West (Egret 2017, pp. 87, 105).

**Figure 35** Principle section by the author based on drawing material provided by Aarhus Omegn housing association via the engineering consultancy firm Viggo Madsen (in e-mail from engineer Søren L. Nielsen to the author 2/10 2018).

**Figure 36** Sketches by the author loosely based on photos from before and after renovation. The sketch to the left (before renovation) is based on (Aarhus Municipality et al. 2010, p. 17) and the sketch to the right (after renovation) is based the author's own images from site visit.

**Figure 37** Sketches by the author loosely based on renderings of the situation before and after renovation (Jensen 2017, p. 30).

**Figure 38** Yellow and red color-coding added by the author on top of original drawing material. The drawing material was provided by Aarhus Omegn housing association via the engineering consultancy firm Viggo Madsen (in e-mail from engineer Søren L. Nielsen to the author 2/10 2018). The Yellow/Red color coding is inspired by (Boesh et al. 2017).

**Figure 39** Graphics by the author. The diagram in the center is inspired by (Brand 1995, p. 13).

**Figure 41** Graphics by the author. The diagram to the far right is inspired by (Brand 1995, p. 13). The examples of strategies are based on (Tommerup 2010; Marsh et al. 2013; Smidt-Jensen and Nørgaard 2011).

**Figure 43** Based on diagram by (Pawson and Tilley 1997, p. 58) and adapted to the problem field of this thesis.



**Figure 44** Graphics by the author. The diagram in the center is inspired by (Brand 1995, p. 13).

**Figure 46** AART architects. The green circles with numbers are added by the author.

**Figure 49** To the right: principle plan by the author based on drawing material from the construction of the building - provided by Spridd architects (via e-mail from Ola Broms Wessel 9/1 2019).

**Figure 50** Sketches by the author loosely based on photos from (Spriid n.d.-b, p. 4).

**Figure 51** To the right: principle section by the author based on drawing material from (NL architects n.d., slide 55).

**Figure 52** Sketches by the author loosely based on photos from (NL architects n.d., slides 48 and 53).

**Figure 53** To the right: principle section by the author based on drawing material from (Lacaton & Vassal n.d.).

**Figure 54** Sketches by the author loosely based on photos from (Lacaton & Vassal n.d.).

**Figure 55** To the right: Principle section by the author based on drawing material from (Kahn 2015, p. 17).

**Figure 56** Sketches by the author loosely based on video from (Nordic Innovation 2017) (left, before renovation) and photo from (Johansen 2019a, p. 13) (right, after renovation).

**Figure 60** AART architects.

**Figures in Table 6** Plan drawings provided by BBBO (green elements added by the author) (Plan drawings from Toveshøj and Gellerupparken provided as part of material in connection with competitions, and plan drawings from Søvangen via e-mail from Morten Meldgaard Christensen, BBBO, 4/10 2019). Area plans from Google maps (grayscale by the author).

**Figure 69** The illustration in the center of the figure is provided by AART architects.

**Figure 85** Section of map from AART architects. Red dot added by the author.

**Figure 86** Google maps. Gray scaled and red dot added by the author.

**Figure 87-Figure 90** Graphics by the author based on illustrations in (Pluskontoret Arkitekter and Rambøll Danmark A/S 2016a, p. 13).

**Figure 95** Reference image in upper right corner depicting a sitting niche in window: Alan Lorentzen (Lorenzen n.d.).

**Figure 96** Reference images in the middle of the figure:

- Top: Lights in the ceiling (Lightinthebox n.d.)
- Mid: Section of image from the interior of Kunsthaus Bregenz, Austria, by Peter Zumthor (Kunsthaus Bregenz 2014)
- Bottom: Graphic concrete by Ruth Campau/CUBO architects. Photo by Helene Høyer Mikkelsen. (Campau n.d.)

**Figure 101** Rendering by C.F. Møller architects and Transform architects (C.F. Møller architects and Transform architects 2019, p. 14). Grayscale and red marking added by the author.

**Figure 124** Drawing material provided by BBBO (BBBO 2016, p. 26). Grayscale and red marking added by the author.

**Figure 131** The two included images of Traneparken before and after renovation respectively are from (Thomsen et al. 2016, pp. 9 and 11). Permission for reuse granted by Kirsten E. Thomsen via e-mail 18/2 2022.

**Figure 132** The included image to the left is provided by Aarhus Omegn housing association (via e-mail from Tina Axelsen to the author on the 21/4 2017).

**Figure 134** Plan drawing is provided by BBBO (BBBO 2016, p. 18). Grayscale and green marking added by the author.

**Figure 136** Principle graph by the author based on numbers from (Cabi n.d.).

**Figure 140** Graphics by the author based on figure and numbers in (BL - Danmarks Almene boliger n.d.).

**Figure 141** AART architects.

# Part 8 : Appendix



The appendix was previously published in the paper “Potentials for increasing resident wellbeing in energy renovation of multi-family social housing” (Jensen et al. 2021). The chapter is identical to the published version, except for the page layout.

# Appendix A

**Table A1** Timeline for preliminary information process and data collection in the three housing areas.

Activity	Time
Meeting with BBBO	Nov 2016
Meetings and e-mail correspondence with boards of the MSH areas	Dec-Feb 2016/2017
Info movie, post on Facebook and via www.gellerup.nu.	Feb 2017
'Block visits': handing out flyers, coffee, and cake and putting up posters in Toveshøj and Gellerupparken	Jan+Feb 2017
Data collection in Toveshøj distributing and collecting measuring devices	Feb-Mar 2017
Data collection in Toveshøj and Gellerupparken	Feb-May 2017
Focus group interview with interview corps and subsequent adjustment of material	May+Aug 2017
'Questions cafe' informal chat about the ReVALUE-project and data collection in Søvangen	Aug 2017
Data collection in Toveshøj and Gellerupparken	Aug-Oct 2017
Data collection in Søvangen	Aug 2017-Sep 2018

A full description of domains and subdomains, data collection methods and scales will be published in the paper (Gabel et al. 2022) [Manuscript submitted for publication].

# Appendix B

**Table B1** Domains and subdomains relevant to the present thesis.

Domain	Subdomains
<b>Demographics</b>	CPR Age Gender Current educational level Current occupation Own and parental ethnicity
<b>Health</b>	General health
<b>Perception</b>	Daylight Temperature (heating/non-heating season) Dampness Air circulation Air quality A need for more ventilation? Smells Openness to the surroundings General acoustics/sound Noise in the apartment Noise from neighbors Materials in the apartment Possibility to furnish/arrange the apartment Ability to influence conditions: <ul style="list-style-type: none"> <li>• Sound/acoustics</li> <li>• Daylight</li> <li>• Openness</li> <li>• Temperature</li> <li>• Air quality</li> <li>• Air circulation</li> <li>• Dampness</li> </ul> Expression of the building Access to private outdoor spaces Ability to get chatting with neighbors or other residents Sense of safety <ul style="list-style-type: none"> <li>• When arriving at the building block</li> <li>• Outside the entrance to the apartment</li> </ul>

The appendix was previously published in the paper "Potentials for increasing resident wellbeing in energy renovation of multi-family social housing" (Jensen et al. 2021). The chapter is identical to the published version, except for the page layout.

# Appendix C

**Table C1** Demographic overview of the questionnaire sample (heating season) relative to the population of the given housing area (data provided by Brabrand Housing Association – extract from a database by The Danish National Building Fund based on information by Statistics Denmark and The Danish National Buildings Foundation's 'rent register').

Toveshøj	BBBO***	ReVALUE	Søvangen	BBBO***	ReVALUE	Gellerupparken	BBBO***	ReVALUE
	2017/2018	2017/2018		2017/2018	2017/2018		2017/2018	2017/2018
Age	1.556	15	Age	813(100)	47 (100)	Age	4058 (100)	59 (100)
0-17 years	535 (34)	0	0-17 years	157 (19)	-	0-17 years	1308 (32)	-
18-29 years	347 (22)	<5	18-29 years	135 (17)	<5	18-29 years	963 (24)	11 (19)
30-64 years	565 (36)	7 (47)	30-64 years	354 (44)	30 (64)	30-64 years	1582 (39)	43 (73)
65 years or older	109 (7)	5 (33)	65 years or older	167 (21)	13 (28)	65 years or more	205 (5)	5 (8)
<b>Immigrants and descendants</b>	<b>1316 (85)</b>	<b>11 (73)</b>	<b>Immigrants and descendants</b>	<b>350 (43)</b>	<b>7 (15)</b>	<b>Immigrants and descendants</b>	<b>3479 (86)</b>	<b>40 (68)</b>
Immigrants of non-Western origin	638 (41)*	<5**	Immigrants of non-Western origin	158 (19)*	5 (11)**	Immigrants of non-Western origin	1735 (43)*	30 (51)**
<b>Education (15 - 64 years)</b>	<b>1011 (100)</b>		<b>Education (15 - 64 years)</b>	<b>515 (100)</b>		<b>Education (15 - 64 years)</b>	<b>2881 (100)</b>	
Primary school	356 (35)	< 5 (22)	Primary school	104 (20)	<5	Primary school	982 (34)	16 (33)
Upper secondary school	101 (10)	5 (56)	Upper secondary school	52 (10)	5 (15)	Upper secondary school	305 (11)	15 (31)
Vocational - or short further education	158 (16)	N/A	Vocational - or short further education	127 (25)	N/A	Vocational - or short further education	469 (16)	N/A
Middle or long further education	114 (11)	<5	Middle or long further education	121 (24)	22 (65)	Middle or long further education	267 (9)	11 (23)
Unspecified	40 (4)	N/A	Unspecified	28 (5)	N/A	Unspecified	116 (4)	N/A
Under education	242 (24)	N/A	Under education	83 (16)	N/A	Under education	742 (26)	N/A
<b>Association with the labour market (18-64 years)</b>	<b>930 (100)</b>	<b>10 (100)</b>	<b>Association with the labour market (18-64 years)</b>	<b>493 (100)</b>	<b>34 (100)</b>	<b>Association with the labour market (18-64 years)</b>	<b>2282 (100)</b>	<b>54 (100)</b>
Employed	320 (34)	8 (80)	Employed	260 (53)	23 (68)	Employed	768 (34)	28 (52)
Unemployed	50 (5)	<5	Unemployed	34 (7)	10 (29)	Unemployed	93 (4)	11 (20)
Outside the labour force	560 (60)		Outside the labour force	199 (40)	<5	Outside the labour force	1415 (62)	15 (28)
<b>Gender****</b>								
Male		6 (40%)			23 (49%)			21 (36%)
Female		9 (60%)			24 (51%)			36 (61%)

(2 missing responses in G related to gender, corresponding to 3%)

\* Based on definition in (Landsbyggefonden 2017, p. 74): "Indvandrere er født i udlandet. Ingen af forældrene er danske statsborgere eller født i Danmark. Hvis der ikke findes oplysninger om nogen af forældrene, og personen er født i udlandet, opfattes den pågældende som indvandrer." Free translation of the definition: Immigrants are born abroad. None of the parents are Danish citizens or born in Denmark. If there is no information regarding the parents, and the person is born abroad, the person in question is considered an immigrant.

\*\* In the ReVALUE -project, we do not have information about the residents' and parents' citizenship. Therefore, the ReVALUE -numbers are based on the participant's statement that he/she is born in a different country than Denmark and about the country of birth of his/her parents. As such, the numbers are not directly comparable to the BBBO-data.

\*\*\* Data for the ReVALUE-project were collected in 2017-2018. Generally, data from 2018 is used to compare the sample to the populations of the three housing areas (except for data on employment, for which BBBO only has data from 2017). Generally, the difference between BBBO's data on age, immigrants, and educational level varies less than 3% from 2017 to 2018.

\*\*\*\* Data for comparison to the population not available.



# Appendix D

## ANNOTATED BIBLIOGRAPHY

**Table D1** This appendix includes an annotated bibliography developed for the literature review in Part 4: Identification. The annotated bibliography has not been published previously. However, the text within the thesis is a revised version of (Jensen et al., 2020), edited to form a cohe-

rent part of this thesis. Since the publication of the study (Jensen et al., 2020) two references have been added (Nørgaard and Rudå, 2021, Stender and Bech-Danielsen, 2019). The references are listed below in the order, they are numbered in Table 11 on page 128.

Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
(Haverinen-Shaughnessy et al. 2018) <i>Occupant satisfaction with indoor environmental quality and health after energy retrofits of multi-family buildings: Results from INSULATE-project</i>	Measurements of IEQ parameters and questionnaire to residents before and after renovation.	<i>Measures described in isolation</i> Adding insulation	Finland: • 39 buildings • Located within 300 km radius of Tampere.	Focus on IEQ and health.  + Improve thermal comfort.	No.	Yes. However, only articulated in overall terms, focusing on "energy retrofits".
	Data from non-retrofitted control buildings.	Better insulation and airtightness of building envelope  Mechanical ventilation system	Lithuania: • 15 buildings • Located in the Kaunas region.  Multifamily buildings retrofitted between 2012-15	+ Decreased nuisances from the surrounding environment (traffic, industry etc.) in both countries. The authors discuss that this can be ascribed to better insulation and airtightness.  ÷ "Noise nuisance related to the buildings appeared to be reduced among Lithuanian cases" (p. 927) - authors discuss that the noise nuisances in Finland can be ascribed to the mechanical ventilation system		
		<i>Packages</i> Most common retrofit actions in Finnish buildings: "...replacing windows and/or installing heat recovery to the existing exhaust ventilation system." (p. 922)  Most common retrofit actions in Lithuanian buildings: "...adding thermal insulation to the walls and roof, replacing windows and glazing balconies, but did not typically include changes to the ventilation systems." (p. 922)	(Building characteristics p. 922 and in sub-reference).  Varying tenure status ("Rent", "Own", "Other")	+ "Satisfaction with indoor air quality (IAQ) improved in both countries, and reports of respiratory symptoms, infections and missed work or school days appeared to have decreased after the retrofits." (p. 924)  + "The odds of not reporting upper respiratory symptoms increased after the retrofits [...] as well as not missing school or work due to respiratory infections [...] These outcomes were not significantly associated with any other factors or covariates, including measured IEQ parameters." (p. 925)		

Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
(Almeida and Ferreira 2017) Cost effective energy and carbon emissions optimization in building renovation (Annex 56)	“...a literature review [...], evaluation of the detailed case studies [...] supported by interview based surveys to the residents and users of three of the case studies and also on the expert contributions of participants from the project” (p. 724).	<u>Measures described in Isolation</u>	Austria Czech Republic Denmark Portugal Spain Sweden	The paper presents a matrix of relations between alteration measures and co-benefits. Refer to Table 1, p. 724 for this matrix. Included themes: +/- Thermal comfort +/-Natural lighting (not formulated as an experienced quality, but interpreted as such in this appendix based on the text in the paper) +/- Air quality (not formulated as an experienced quality, but interpreted as such in this appendix) -Internal noise + External noise +/-Ease of use + Reduced exposure to energy price fluctuations +/- Useful living area + Safety (intrusion and accidents) + Pride/prestige + /- Ease of installation	Yes. Addressed through developed methodology including “willingness to pay” in relation to LCC and LCA analysis, and not an explicit, account of relations.	Yes. Focus on near-zero energy and carbon emission interventions. The social outcome is articulated as “co-benefit” of the energy renovation.  For explicit results from the case studies, refer to the paper.
		Facade insulation (exterior) Facade insulation (internal) Roof insulation Ground floor insulation Cellar ceiling insulation Windows replacement Insulation of entire building envelope Larger window areas Roof light or Sun pipes External shading Balconies and loggias Heat Pump for heating Biomass heating system Efficient DHW system Automatic control systems Air renewal systems MVHR systems Solar Thermal systems	School, Multi-family, Two-family building  An example of a more detailed case description is included in the paper (see section 4.1)	In this appendix, results across case studies (see paper, table 1) are included even if it unclear in which cases the three mentioned interviews have been performed.  Only co-benefits to tenants are included in this appendix.  An alternative, would be to only use information on “co-benefit” from the included example to be certain of the underlying conditions.		
(Liu et al. 2015) Evaluating indoor environment of a retrofitted multi-family building with improved energy performance in Sweden	Measurements (after renovation) Building energy simulation Questionnaire (after renovation)  Non-retrofitted reference building.  + Suggestions for improvements based on a parameter study	<u>Measures described in Isolation</u>	A retrofitted multi-family building in Linköping, Sweden.  One of six buildings, of which the remaining five will undergo renovation during the coming years.	Satisfied with indoor temperature (however, the tenants do still experience high indoor temperature during summer).  Dissatisfaction with noise from ventilation (ascribed to the MVHR-system by the authors of the paper).	-	Higher household electricity consumption and domestic hot water use in the retrofitted building (due to installing washing machines and dryers in each apartments and an increase in number of residents).  However, potential to reduce space heating by 39%.
		<u>Packages</u>	Changes in layout (more apartment after renovation) Insulation added to exterior walls. Moisture and infiltration barrier added into the wall. From brick to rendered façade. Windows replaced. Added roof insulation. MVHR-system.  Potential to reduce overheating by adding blinds is not included in this paper, because it is not validated through e.g. post-occupancy evaluations.	Built in late 1970s as part of the “Million Programme”.  Generally, improved perceived air quality, indoor temperature, noise, and less health problems in retrofitted buildings.  See the paper for an elaboration of results.  “The survey results show that there has been a drastic improvement in health problems in the retrofitted building.” (p. 41)		

Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
(Byrne et al. 2016) Case studies of cavity and external wall insulation retrofitted under the Irish Home Energy Saving Scheme. Technical analysis and occupant perspectives	Monitoring and thermal images: immediately before and after retrofit.  Survey: pre-retrofit.  Semi-structured in-depth interviews with occupants: post-retrofit.  Triangulation. Mixed methods.  9 cases.	<i>"The examination focused on specific measures commonly introduced through the HES/BEH programme – cavity and external wall insulation."</i> (abstract)  (note: unclear if these measures were isolated in the study or performed as part of a larger "package").	Ireland  <i>"All homes were built between 1960 and 1990 and owner occupied, apart from the two Respond council houses which were built in 2000 and occupied by council tenants."</i> (p. 424)  Varying degrees of insulation before retrofitting.	<i>"...comfort improvement to the occupant showed unanimous improvements regardless of time of year, housing type, occupancy or heating patterns."</i> (p. 424)  Occupants claim comfort increases in all cases (see paper, table 2).  (note: in other parts of the paper, comfort is articulated as thermal comfort – in this thesis, we therefore assume that "comfort" can be interpreted as "thermal comfort") throughout the paper.  <i>"Two out of six homeowners who were interviewed reported that their homes took a shorter time to heat up."</i> (p. 430)	-	Yes. However, only reductions in some households, due to especially increase in comfort ("comfort take-back").  See paper, table 3 and 4.  <i>"...a beneficial by-product of the retrofit was the reduction in the use of 'dirty' fuels such as coal."</i> (p. 431)
(Mørck et al. 2016) Shining examples analysed within the EBC Annex 56 project	Cross-section analysis of case studies  Unclear methodology for identifying co-benefits – however, included due to fact that we know from related references that a questionnaire study has been included.	<i>Measures mentioned in isolation</i> Changing windows   <i>Packages</i> Refer to paper for full account of interventions.  Intervention measures in overall terms: <i>"All cases have had insulation added, most of them on facades and roofs. 17 cases have included new energy efficient windows in the renovation [except the Montarrio case study in Coimbra]...]. Solar heating is exploited either in an active or passive way in 10 of the cases. In most of the cases the heating system was renovated and/or supplemented with renewable energy systems."</i> (p. 995)	18 examples from 9 countries.  Non-residential, Multi family, Single family housing (11 multifamily cases).  Austria Czech Republic Denmark Italy Netherlands Portugal Spain Sweden Switzerland	Less noise   The formulation <i>"In Annex 56 the following co-benefits are considered..."</i> (p. 995) makes it difficult to understand if the co-benefits are in fact identified or hypothetical. Therefore the full account of co-benefits is left out in this reference.  <i>"...better indoor climate, comfort and architecture"</i> (p. 995)  (in this review, "indoor climate" and "comfort" is interpreted as thermal comfort. "Architecture" is left out due to ambiguity as to how it influences resident wellbeing)  Process value: communicating co-benefits <i>"...to building owners or tenants helped to overcome barriers that homeowners and housing associations were experiencing."</i> (p. 995)	Yes. Focus on cost effective energy and carbon emissions optimization.  Importance of implementing energy efficient renovation measures as part of "anyway measures".	Yes. <i>"The total energy reductions achieved by the combination of RUE and RE technologies are between 40% and 95%. Here the extremes are 29% and 98%."</i> (p. 996) See paper, fig. 3 for energy consumption specifically in multifamily buildings.
(Abdul Hamid et al. 2019) Measuring the impact of MVHR on the energy efficiency and the IEQ in multifamily buildings	Field measurements and survey with inhabitants before and after implementation of MVHR system.  Similar study performed in two control buildings.	<i>Isolated measure</i> Mechanical ventilation with heat recovery (MVHR) installed in two buildings.  <i>"In conclusion, this paper has shown that [...] it is possible to isolate the impact of an intervention through detailed measurements of a select few parameters."</i> (p. 104)	2 buildings in Linköping in Sweden  Unspecified ownership.  Multifamily buildings, built in 1965. Two levels + basement. (Description of building characteristics on page 94.)  Potentially impacting factors are analysed in section 3.1.1., p. 97.  No indications that the inhabitants and their habits have changed (in the population and in the relative humidity). (p. 102)	Focus on IEQ <i>"The inhabitants in houses with a MVHR-system:</i> <ul style="list-style-type: none"><li>• <i>feel in more control over their ventilation</i></li><li>• <i>feel that it is easier to get rid of moisture in the indoor air</i></li><li>• <i>report that no condensation occurs on the windows when cooking, in contrast to before</i></li><li>• <i>experience improved thermal comfort</i></li><li>• <i>experience less discomfort with:</i><ul style="list-style-type: none"><li>• <i>too low room temperature</i></li><li>• <i>cold floors</i></li><li>• <i>cold during the winter</i></li><li>• <i>draught from doors and windows</i></li><li>• <i>tobacco smoke and other odors from neighbors"</i> (p. 103)</li></ul></li></ul>	-	<i>"In conclusion, this paper has shown that an MVHR-system does contribute to significant improvement of the buildings' energy efficiency as well as the perceived indoor environmental quality..."</i> (p. 104)  Energy reduction of 15% and 34% (after corrections).

Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
(Thomsen et al. 2016) Energy consumption and indoor climate in a residential building before and after comprehensive energy retrofitting	Questionnaire survey (after renovation). Measurements of ventilation conditions “[C] ontinuous registration of the room air temperature, the relative humidity and the CO <sub>2</sub> -concentration” (abstract) (in three flats) (after renovation)  Measured and calculated energy consumption for heating and domestic hot water (before and after renovation)	<u>Measures described in isolation</u> Mechanical ventilation with heat recovery  <u>Packages</u> “...comprehensive energy retrofit including new facades, new windows, additional insulation, mechanical ventilation with heat recovery and a photovoltaic installation on the roof.” (abstract)	The apartment complex Traneparken, Denmark.  3 multi-story blocks of flats.  Originally built in 1969. Retrofitted in 2012. Building description p. 9.  “...tenants were not relocated during the renovation process.” (p. 12)	- “Some of the tenants had tampered with the supply air terminals in order to prevent draught [...] This may be regarded as a result of the rather high ventilation rates.” (p. 12)  <u>Improved perceived indoor climate.</u> + “The most improved indoor climate factors were temperature conditions during winter, where problems with low temperature draught and cold areas in the flat were reduced. In addition, improvements were experienced by a majority of the tenants regarding air quality and problems with mould growth, and some tenants perceived less noise from outside.” (p. 15)	Includes account of project economy and rent increase but not explicit valuation of “co-benefits”.	“Significant energy savings” (abstract)  “The measured energy consumption for heating and domestic hot water before and after renovation was 139.1 kWh/m <sup>2</sup> /year and 95.6 kWh/m <sup>2</sup> /year, respectively...” (abstract)
(Hongisto et al. 2015) Satisfaction with sound insulation in residential dwellings - The effect of wall construction	“Subjective acoustic conditions were investigated in two types of multi-storey residential buildings.” (p. 319)  Field measurements for verification purposes (limited to “...one measurement in each building under test”) (p. 319)  Questionnaire (594 respondents)  Comparison of two independent groups through statistical analysis.	<u>Measures described in isolation</u> “...with different wall constructions with a similar weighted sound reduction index R <sub>w</sub> ”: Heavy construction (monolithic concrete walls) and Light construction (staggered double walls).” (abstract)  “...with either Heavy or Light walls between the dwellings.” (p. 311).	Finland “...two types of residential multi-story buildings which both fulfilled the Finnish Building Code regarding sound insulation (airborne sounds: R <sub>w</sub> ≥55 dB, impact sounds: L <sub>n,w</sub> < 53 dB).” (p. 319)  Study conducted in four (Building type Heavy) and two (Building type Light) buildings from after 2000 with concrete floor.  Group equality test: No significant effects of group differences on the main results.	“The satisfaction with sound insulation did not differ between the two building types. All neighbour noise sources were rated equally disturbing in both building types. The building types did differ from each other with respect to the effects of noise on sleep.” (abstract)  “Wakenings due to neighbour noise were significantly more frequently reported in building type Heavy. However, the reported frequencies in wakenings were at a moderate level in both groups.” (p. 316)  Indications of influence of noise from neighbors in the night-time on sleeping. This is articulated as a potential health risk.	-	-

Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
<p>(Juntti and Lundy 2017)</p> <p><i>A mixed methods approach to urban ecosystem services: Experienced environmental quality and its role in ecosystem assessment within an inner-city estate</i></p>	<p>Mixed methods applied to case study:</p> <p>Scientific ecosystem assessment</p> <p>Literature review, review of study area using land cover maps and site walk-over (two visits).</p> <p>Qualitative data collection:</p> <p>“...qualitative interview and visual data from the residents...” (abstract) (10 participants)</p> <p>App for the participants to express features of the estate which they like or dislike. Semi-structured interviews.</p>	<p>Focus on exterior spaces.</p> <p>Not articulated as alteration measures but as bio-physical structures and ecosystem services (ES).</p> <p>“Packages”</p> <p>Regeneration of neighborhood landscaping including new ownership and apartment types</p> <p>“...the new buildings, paths and greenspaces” (p. 18)</p> <p><u>Elements described in “isolation”</u></p> <p>Parks and gardens</p>	<p>UK</p> <p>Woodberry Down Estate (London, UK). Inner-city neighborhood.</p> <p>Built in the 1940’s.</p> <p>“At the time of the project (2014-2015), redevelopment was well advanced; several tower blocks had been replaced (including the development of a ‘private tower block’) and the landscaping of several blue-green area, with a stark juxtaposition between old and new components apparent within the estate.” (p. 12)</p> <p>“The redevelopment involves replacing 1981 homes with 5561 new ones of which 41% are allocated for social renting and shared ownership with the remainder available as private luxury apartments.” (p. 12)</p>	<p>Focus on: Experienced environmental quality and ecosystem services (ES).</p> <p><u>Safety</u></p> <p>(+) Subjective feelings of safety: “... where a green area will be accessed by some, others may be much more reluctant to enter because of the threat that they assign to the place for reasons of previous experience/knowledge.” (p. 17)</p> <p><u>Negative de-territorialisation</u></p> <p>-“I’m very happy with the regeneration. It’s much better. But I’m not the proper beneficent and I should be, because I’ve lived here for over 30 years.” (p. 19)</p> <p><u>Alleviate stigma</u></p> <p>+ “constitute (material) access routes and (expressive) features that are constructed as benefits that alleviate this stigma because they are believed to attract visitors and passers-by, rendering the estate ‘less enclosed’...” (p. 18)</p> <p>Participants express that the estate is more inviting/approachable to visitors. The authors link this to “pride/a positive identity”.</p> <p><u>Social interactions</u></p> <p>+ “...meeting places that bring the community together” (p. 18)</p>	-	<p>Yes. Articulated as ecological potentials, e.g. “storm protection” and “micro and local climate regulation”. See table 3.</p>
	<p>(Kasemets et al. 2019)</p> <p><i>Turning a landscape into a suburban community and the realization of a sense of place</i></p>	<p>Comparative case study (two cases)</p> <p>“...semi-structured interviews were conducted in 2009 during two periods with sixteen people.” (p. 39)</p> <p>“...micro-level perspective, by examining how people experience the landscape in their everyday practices.” (p. 38)</p>	<p>Focus on regeneration of areas, including landscape transformation</p> <p><u>Measures mentioned in isolation:</u></p> <p>Existing pinetrees</p> <p>Densification of area</p> <p>Water pond</p> <p>Mixed dwelling types.</p>	<p>Estonia</p> <p>Two settlements in the post-socialist Urban Region of Tallinn, Estonia, in a former military area and in a former gardening cooperative that have been turned into permanent living spaces.</p> <p>Mixed typologies:</p> <p>“Of the respondents, one lived in a soviet-built apartment block, the others in detached houses, semi-detached houses or terrace houses.” (p. 39)</p>	<p>Focus on community building</p> <p>“On examining the natural conditions, it appeared how the natural environment was important for the residents initially from the general aesthetic point of view, where the pine forest has been a significant natural element when choosing a place to live.” (p. 42)</p> <p>At the cost of parts of a pine forest.</p> <p>“An important natural landscape element in the settlement was a pond, which created a public space for the settlement.” (p. 44)</p> <p>“In one interview, the way the soviet buildings were known as “garbage houses” was expounded (Fig. 3). These houses were inhabited, yet the occupants were apparently not participating in the community arrangement.” (p. 41)</p>	-



Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
(Darby 2017) Coal fires, steel houses and the man in the moon: Local experiences of energy transition	<p>“...interviews and observations with low-income householders and their energy Advisers” (abstract)</p> <p>Study carried out in 2000-2001</p> <p>Only findings from the paper focusing on more recent renovation effort have been included in this review.</p>	<p>General focus on “energy transitions”.</p> <p>Examples of interventions: New heating system New windows</p> <p>Focus on the importance of energy advisers (middle-actors) in assisting in implementation of interventions, informing residents about how to utilize systems and add a sense of control over the resident’s own situation.</p> <p>Further, the paper mentions a tenant expressing contentment with being able to buy his flat.</p> <p>As non-physical initiatives, this is not included in this review.</p>	<p>“...a district of central Scotland whose economy had depended on coal and paraffin shale mining for over a century” (abstract)</p> <p>Unspecified typology. Yet, included due to mentioning of residents living in apartments.</p> <p>Deprived area.</p>	<p>Increased comfort (in this review interpreted as thermal comfort)</p> <p>Reduced costs for heating (in some cases helping residents stay in their apartments)</p> <p>Importance of external funding to make it possible to implement interventions (which many residents otherwise could not afford).</p> <p>Process value: “Tenancy could induce frustration, resignation and gratitude towards the landlord in varying degrees.” (p. 124)</p>	<p>Focus on fuel bills.</p>	<p>Yes. Focus on “energy transition”</p>
(Weber and Wolff 2018) Energy efficiency retrofits in the residential sector – analysing tenants’ cost burden in a German field study	<p>Literature review</p> <p>“This article compares calculated theoretical heating energy consumption for prior to and after retrofit with actual consumption data after retrofit.” (abstract)</p> <p>Semi-structured interviews with residents after renovation.</p>	<p>Energy renovation in general</p> <p>Some flats have been merged.</p>	<p>Southern Germany</p> <p>“...10 apartment buildings built between 1931 and 1966, which have been subject to energy efficiency retrofitting...” (p. 683)</p> <p>The renovation took place 2012-2014.</p> <p>Rental (social housing).</p> <p>The average income and the education is below the average in Germany.</p>	<p>“...despite the very high reductions in energy consumption, for more than half of the households the savings in energy consumption cannot offset the rent increase subsequent to the energy efficiency measures. This result is especially dramatic, because in the case study the allocated costs added onto the rent are below the average compared to other energy-related retrofit costs from reported studies. In consequence, this could lead to households being displaced by the increased costs, an issue which is known as energetic gentrification.” (p. 686)</p> <p>Risk of “energetic gentrification.”</p>	<p>The paper focuses on the impact of energy retrofits on rent level.</p> <p>“...the actual rent increase implemented by the housing association lies between 6 and 13.20 € per square metre and year.” (p. 684)</p> <p>“...all households (...) profit from the retrofit in terms of heating energy costs” (p. 684)</p>	<p>“The measured average reduction of energy consumption amounts to 69%, thus, from an energetic point of view, the energy-related modernisation of these buildings has been successful.” (p. 684)</p>
(Rose et al. 2019) Refurbishing blocks of flats to very low or nearly zero energy level – technical and financial results plus co-benefits	<p>Two case studies.</p> <p>Calculated and measured energy use for heating and domestic hot water before and after renovation.</p> <p>Measurements of indoor temperature and ventilation rate after renovation.</p> <p>Questionnaire after renovation (only in Traneparken, since Seems have was a transformation from dormitories etc. to apartments – this information was information retrieved through e-mail correspondence with the author of the paper)</p>	<p><u>Packages</u> (Traneparken)</p> <p>Windows and doors replaced.</p> <p>New balanced mechanical ventilation systems with heat recovery.</p> <p>Automatic switch-off controls with presence detectors added in common areas.</p> <p>Photovoltaic-system added on roof.</p> <p>Reinsulation of exterior walls and roof + new brick façade.</p>	<p>Traneparken and Seems Have housing areas (only results related to Traneparken included here, due to questionnaires only being carried out here)</p> <p>Social housing</p> <p>Hvalsø municipality, Denmark.</p> <p>From 1969. Three blocks of flats.</p> <p>Renovated in 2012.</p>	<p>“Co-benefits for the tenants.</p> <p><u>Building quality</u> Warm surfaces and no draught allow for a furnishing that fully utilizes the apartment area. Less noise from outside.</p> <p><u>Direct economic benefits</u> Reduced energy costs and lower vulnerability to fluctuating energy prices.</p> <p><u>User comfort</u> Improved thermal comfort provides a direct increase in well-being and thereby fewer days of sickness. The improved air quality is an advantage for everyone, but for people suffering from allergy, the air quality can be of almost invaluable importance.” (Table 1, p. 2)</p> <p>“1. Improved indoor climate 2. Increase of livable area due to warmer surfaces (outer walls and windows) 3. New balconies 4. Aesthetically beautiful buildings” (p. 6)</p>	<p>An account of rent increase and savings due to energy optimizations.</p> <p>On a societal level, the economic impact is articulated as “direct economic benefits.”</p> <p>Further, examples of the economic value of specific intervention measures are presented:</p> <ul style="list-style-type: none"> <li>• Insulation added to the exterior wall.</li> <li>• Replacing windows.</li> </ul> <p>For instance, the value of increased useful floor area.</p>	<p>Yes. Focus on reduced energy consumption, reduced CO2 emissions through energy renovation, and potentials for limiting material consumption by refurbishing rather than demolishing and building from new.</p>



## ADDED REFERENCE

Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
(Nørgaard and Rudå 2021) Fysisk omdannelse i udsatte boligområder - En undersøgelse om at styrke beboernes tryghed og forebygge kriminalitet	Study performed "a few years" after completion of the renovations: 'Mixed methods' Observation and registration, street interviews and in-depth interviews with residents and other central stakeholders.	2 social housing areas: Rosenhøj and Egedalsvænge. Here we focus on findings from Rosenhøj (see p. 24f.)  <i>Packages:</i> Larger renovation, including façade transformation	2 social housing areas: Rosenhøj and Egedalsvænge. Here we focus on findings from Rosenhøj.  4 story building blocks  Rosenhøj: (Built 1967-70, 27 identical concrete blocks in 4 stories). Description of infrastructural conditions (see p. 24)	+ More residents feel more proud of the area after renovation.	-	Environmental value (energy optimization) is only mentioned indirectly in the description of the renovation of Egedalsvænge.
	(See p. 17ff.)	<i>Measures mentioned in "isolation":</i> Clear pathways and improved lighting. Cutting trees and bushes.	Discussion of socio-economic and organizational factors (e.g., p. 20, 42 and 83).	+ "...for which reason most people feel safe, when moving in the housing area, also after dark." (p. 82 translation by the author) However, there are still places, where residents avoid going, because they feel unsafe.		
		Balconies		+ "...the residents tell that the new balconies have increased the contact between the residents, who are using the balconies at the same time." (p. 40, translation by the author).		
		"...windows and balconies in housing blocks with closed gables and in other places, where the view is limited" (p. 82f.)		+ "The study thus shows that adding windows and balconies in housing blocks with closed gables and in other places, where the view is limited, has a positive impact on the residents' feeling of safety." (p. 82f.)		
		Video surveillance		+/- Positively influences the sense of safety of some residents; however, other residents feel that it is annoying.		



## ADDED REFERENCE

Reference	Methodology	Alteration measure	Context	Social value creation (Resident well-being)	Economic value creation	Environmental value creation
(Stender and Bech-Danielsen 2019) Bridging social gaps: Transforming disadvantaged areas by linking them to the city	Desk research on plans, written sources etc. Initial field visit and tour of the area.	Three different approaches:	Three Danish disadvantaged social housing areas:	Study focusing on linking disadvantaged areas to the remaining city.	-	-
	Interviews with key actors. Qualitative interviews with selected tenants and users. Survey among tenants and other users (people moving through the area) Registrations of urban life plus ethnographic field reports documenting patterns of use and other observations.	<i>"Infrastructural changes"</i> ( <i>"Destination-strategy"</i> ) (Mjølnerparken itself has not yet been renovated)	Mjølnerparken/ Superkilen (built 1984–1987, 559 flats, 4-storey blocks)	+/- <i>"Here the spectacular urban design and new facilities have succeeded in attracting different people, who use the area in various ways. ... There is still a very manifest border – physically and socially – between Mjølnerparken's estate and Superkilen's urban space, and even neighbours living very close to Mjølnerparken are hesitant to move inside the estate."</i> (p. 48)		
		<i>"...introducing new functions and public services"</i> Care home and day care institutions ( <i>"everyday-route-strategy"</i> )	Gyldenrisparken (built 1964, 4-storey blocks and one high-rise building, 477 flats plus several one-storey buildings for commercial lease)	+ <i>"It thus seems that the renewal of Gyldenrisparken has been successful in creating a vivid and mixed life in between the blocks, partly due to the new functions in the area, but also due to its location between a main street and several residential neighbourhoods."</i> (p. 47).  + <i>"...though the remaining green areas are smaller than before, most of the tenants perceive them as safer and more comfortable."</i> (p. 47).		
	<i>"Implementing a greater variety of flats in order to establish a diverse group of residents."</i> (see more p. 39f.)	Finlandsparken (built 1967–1971, 530 flats, 4-storey blocks).	See pp. 40-42 for socio-economic and building-physical description.	+ <i>"Thus, the tenants in the new penthouses do not necessarily engage much in their local environment. Still, the diversification of both housing stock and tenants might have a beneficial effect on the area's overall reputation. Also, the new types of housing may allow tenants to climb up the ladder of the housing career without leaving the area"</i> (p. 51)  General comments: +/- <i>"...spatial proximity does not necessarily reduce social distance."</i> (p. 53)  - Risk of gentrification (p. 53)		

# Appendix E

## QUANTITATIVE AND QUALITATIVE DATA

**Table E.1.** Showing the residents' satisfaction with the built environment (lived gestures) (horizontally - left and middle) and the residents' general perception of their health (horizontally - right). All values are n (%). Only data from the heating season is included. In relation to health, all data is shown as a total sum due to small values. Results > 33% are displayed with bold. Only quotes related to themes with which >33% express dissatisfaction are included in order to elaborate on/nuance the results. All cells with less than five respondents are summarised as "<5" due to the protection of personal data (Sundhedsdata-styrelsen 2018).

 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health	
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES	
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)	Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
<b>Daylight</b>									
Living room	Very satisfactory/satisfactory	97 (80)	7 (47)	42 (89)	48 (81)			43 (81)	14 (70)
	Neither/nor	9 (7)	<5	<5	<5			<5	<5
	Very unsatisfactory/unsatisfactory	14 (12)	<5	<5	7 (12)			6 (11)	<5
Bedroom	Missing	<5			<5			<5	
	Very satisfactory/satisfactory	90 (74)	10 (67)	30 (64)	50 (85)			39 (74)	14 (70)
	Neither/nor	9 (7)	<5	6 (13)	<5			<5	<5
Children/spare rooms	Very unsatisfactory/unsatisfactory	20 (17)	<5	10 (21)	6 (10)			9 (17)	<5
	Missing	<5		<5	<5			<5	<5
	Very satisfactory/satisfactory	74 (61)	6 (40)	25 (53)	43 (73)			31 (58)	10 (50)
Kitchen	Neither/nor	12 (10)	<5	5 (11)	6 (10)			5 (9)	<5
	Very unsatisfactory/unsatisfactory	16 (13)	<b>5 (33)</b>	6 (13)	5 (8)			<5	<5
	Missing	19 (16)	<5	11 (23)	5 (8)			13 (25)	<5
	Very satisfactory/satisfactory	87 (72)	10 (67)	30 (64)	47 (80)			35 (66)	15 (75)
	Neither/nor	19 (16)	<5	9 (19)	7 (12)			10 (19)	<5
	Very unsatisfactory/unsatisfactory	14 (12)	<5	8 (17)	<5			7 (13)	<5
	Missing	<5			<5			<5	

"I think it is really nice. Sometimes I would like to complain that there is too little [daylight], but then it is just because the sun is not shining."

(Female resident, Gellerupparken)

"I do not turn on the light until 22-22.30, because it is nice and bright."

(Female resident, Gellerupparken)

"It is nicer to have a lot of light and then block it than to sit in darkness."



(Male resident, Gellerupparken)

**Too bright in rooms for sleeping**

"I get light in from very early in the morning. During summertime, I cannot sleep after 7, if the sun is shining. Light is not a problem. My entire long side consists of windows. I pull the curtain, if I need to sit and work by the computer, and it is not worse than that."

(Male resident, Toveshøj)





 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health		
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
<b>The temperature during the non-heating season</b>										
Living room	Too cold/cold	<5	<5	<5				<5		
	Pleasant	58 (48)	6 (40)	22 (47)	30 (51)			27 (57)	22 (42)	8 (40)
	Too hot/hot	53 (44)	<b>5 (33)</b>	<b>21 (45)</b>	<b>27 (46)</b>			17 (36)	25 (47)	<b>11 (55)</b>
	Missing	8 (7)	<5	<5	<5			<5	<5	<5
	Too cold/cold	<5	-	<5	-			<5	<5	<5
Bedroom	Pleasant	59 (49)	6 (40)	28 (60)	25 (42)			25 (53)	24 (45)	9 (45)
	Too hot/hot	50 (41)	<b>5 (33)</b>	13 (28)	<b>32 (54)</b>			18 (38)	23 (43)	<b>9 (45)</b>
	Missing	9 (7)	<5	<5	<5			<5	<5	<5
	Too cold/cold	<5	-	<5	<5			<5	<5	<5
Children/spare rooms	Pleasant	56 (46)	5 (33)	25 (53)	26 (44)			27 (57)	20 (38)	8 (40)
	Too hot/hot	43 (36)	<b>5 (33)</b>	10 (21)	<b>28 (47)</b>			15 (32)	20 (38)	<b>8 (40)</b>
	Missing	20 (17)	5 (33)	11 (23)	<5			<5	12 (23)	<5
	Too cold/cold	5 (4)	<5	<5	<5			<5	<5	<5
Kitchen	Pleasant	70 (58)	5 (33)	31 (66)	34 (58)			31 (66)	28 (53)	10 (50)
	Too hot/hot	38 (31)	<b>5 (33)</b>	10 (21)	<b>23 (39)</b>			10 (21)	19 (36)	<b>9 (45)</b>
	Missing	8 (7)	<5	<5	<5			<5	<5	<5
	Too cold/cold	5 (4)	5 (4)	5 (11)			<5	<5	<5	<5
Hallway	Pleasant	81 (67)	7 (47)	33 (70)	41 (69)			35 (74)	34 (64)	11 (55)
	Too hot/hot	26 (21)	<5	6 (13)	16 (27)			7 (15)	12 (23)	<b>7 (35)</b>
	Missing	9 (7)	<5	<5	<5			<5	5 (9)	<5
	Too cold/cold	6 (5)	<5	5 (11)			<5	<5	<5	<5
Bathroom	Pleasant	87 (72)	7 (47)	35 (74)	45 (76)			35 (74)	39 (74)	12 (60)
	Too hot/hot	20 (17)	<5	5 (11)	12 (20)			6 (13)	8 (15)	6 (30)
	Missing	8 (7)	<5	<5	<5			<5	<5	<5

Too hot during summer

"When it is really hot, it is impossible to sit in the kitchen. Then we go out here [the balcony]." [...] "In the afternoon, it is unbearable on the balcony [...] Then we go to the living room and make draught through, regulate the temperature." (female resident, Toveshøj)

"During summertime, it is difficult to get rid of the heat if there is no wind. I cannot create draught through. (Male resident in single-room apartment, Toveshøj).





 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health		
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
<b>Dampness in the apartment? How is the air?</b>										
Too dry/dry	17 (14)	<5	8 (17)	7 (12)			<5	10 (19)	5 (25)	
Pleasant	74 (61)	7 (47)	28 (60)	39 (66)	<b>Moist in the bath-room</b>		33 (70)	30 (57)	11 (55)	
Too damp/damp	30 (25)	<b>6 (40)</b>	11 (23)	13 (22)			12 (26)	13 (25)	<5	
Missing										
<b>Air circulation</b>										
A lot of draught/little draught	77 (64)	<b>9 (60)</b>	<b>29 (62)</b>	<b>39 (66)</b>			28 (60)	36 (68)	<b>12 (60)</b>	
pleasant	28 (23)	<5	9 (19)	16 (27)	<b>Experi-ence of draught</b>		13 (28)	10 (19)	5 (25)	
very still air/a little still air	15 (12)	<5	9 (19)	<5			5 (11)	7 (13)	<5	
missing	<5			<5			<5			
<b>Air quality (Is there enough fresh air?)</b>										
Very good/good	42 (35)	5 (33)	15 (32)	22 (37)			19 (40)	21 (40)	<5	
Neutral	50 (41)	6 (40)	23 (49)	21 (36)			19 (40)	22 (42)	9 (45)	
Very bad/bad	29 (24)	<5	9 (19)	16 (27)			9 (19)	10 (19)	<b>9 (45)</b>	
Missing										




### Experience and satisfaction with the built environment (experienced gestures)



### General perception of one's own health

 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health		
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
Do you need more ventilation?										
	A lot/ a little	81 (67)	11 (73)	27 (57)	43 (73)			28 (60)	37 (70)	15 (75)
	No	37 (31)	4 (27)	18 (38)	15 (25)			17 (36)	16 (30)	<5
	Don't know	<5		<5	<5			<5		<5
	Missing					Issues with the current extra-ction devices in the bathroom and kitchen  Too hot during summer-time	The resident expresses that there is an extraction device, which does not work: "When I cook, it doesn't extract, and when I don't cook, it does." (female resident in Gellerupparken)  "He says that he can feel that there is an old ventilation system [in the bathroom]. So it is relatively poor. He says that they have heard that they are going to change it [in the renovation] because it is an old ventilation system." (Male resident, Toveshøj via interpreter)  See quotes under "temperature"			



 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))					QUANTITATIVE DATA (number (%))		
		AREAS					GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
Have you felt bothered by one or more of the mentioned smells/conditions within the latest 12 months?									
Stuffy smell	Weekly/sometimes	55 (45)	6 (40)	22 (47)	27 (46)	21 (45)	24 (45)	10 (50)	
	Never	65 (54)	9 (60)	24 (51)	32 (54)	25 (53)	29 (55)	10 (50)	
Mould-like smell	Missing	<5	-	<5	-	<5			
	Weekly/sometimes	24 (20)	<5	5 (11)	15 (25)	10 (21)	9 (17)	<5	
Earth-like smell	Never	97 (80)	11 (73)	42 (89)	44 (75)	37 (79)	44 (83)	16 (80)	
	Missing	-							
Tobacco smell	Weekly/sometimes	16 (13)	5 (33)	5 (11)	6 (10)	5 (11)	8 (15)	<5	
	Never	105 (87)	10 (67)	42 (89)	53 (90)	42 (89)	45 (85)	18 (90)	
Other	Missing	-							
	Weekly/sometimes	63 (52)	9 (60)	18 (38)	36 (61)	21 (45)	28 (53)	13 (65)	
	Never	58 (48)	6 (40)	29 (62)	23 (39)	26 (55)	25 (47)	7 (35)	
	Missing	-							
	Weekly/sometimes	41 (34)	<5	14 (30)	24 (41)	15 (32)	19 (36)	6 (30)	
	Never	66 (55)	5 (33)	32 (68)	29 (49)	25 (53)	29 (55)	12 (60)	
	Missing	14 (12)							
	Weekly/sometimes		7 (47)	<5	6 (10)	7 (15)	5 (9)	<5	
	Never								
	Missing								

"If someone in another apartment is cooking strong/spicy food, you can smell it through the extraction device in the kitchen." (Male resident, Gellerupparken).

"I air out when I cook. Sometimes I have to shut the windows because my upstairs neighbor is smoking hash because it travels right down to me. But it isn't every day." The resident also expresses that he has neighbors who cook very spicy food, but he just finds that cozy. (Male resident, Toveshøj)

"Someone on the Xth floor. She always opens the door, so it stinks of food in my apartment, because the smell travels up here." (female resident, Gellerupparken)

Smells from other apartments

 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health			
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES			
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Tovehøj and Gellerup (n=8)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)	
Openness - how do you experience your apartment in relation to the surroundings?		Too public	20 (17)	<5	<5	15 (25)		8 (17)	7 (13)	5 (25)	
		Public	20 (17)	<5	7 (15)	9 (15)		7 (15)	10 (19)	<5	
		Neither/nor	23 (19)	6 (40)	9 (19)	8 (14)		9 (19)	9 (17)	5 (25)	
		Private	56 (46)	<5	27 (57)	25 (42)		23 (49)	26 (49)	6 (30)	
		Too private	<5			<5					<5
		Missing	<5			<5				<5	
Bedroom		Too public	24 (20)	<5	8 (17)	15 (25)		9 (19)	10 (19)	5 (25)	
		Public	22 (18)	<5	<5	15 (25)		5 (11)	13 (25)	<5	
		Neither/nor	20 (17)	7 (47)	6 (13)	7 (12)		8 (17)	9 (17)	<5	

Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))					QUANTITATIVE DATA (number (%))		
		AREAS					GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvngangen (n=47)	Gellerup B4 (n=59)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
	Private	53 (44)	<5	28 (60)	21 (36)	25 (53)	21 (40)	6 (30)	
	Too private	<5			<5			<5	
	Not relevant	<5			<5			<5	
	Missing								
Children's room/spare room	Too public	14 (12)	<5	<5	12 (20)	7 (15)	<5	<5	
	Public	16 (13)	<5	<5	12 (20)	5 (11)	8 (15)	<5	
	Neither/nor	21 (17)	6 (40)	9 (19)	6 (10)	11 (23)	8 (15)	<5	
	Private	45 (37)	<5	23 (49)	19 (32)	19 (40)	19 (36)	6 (30)	
	Too private	<5			<5		<5	<5	
	Not relevant	16 (13)	<5	9 (19)	5 (8)	<5	9 (17)	<5	
	Missing	7 (6)	<5	<5	<5	<5	5 (9)	<5	
	Too public	19 (16)	<5	<5	14 (24)	6 (13)	9 (17)	<5	
	Public	22 (18)	<5	5 (11)	15 (25)	7 (15)	11 (21)	<5	
	Neither/nor	27 (22)	8 (53)	9 (19)	10 (17)	12 (26)	11 (21)	<5	
Kitchen	Private	50 (41)	<5	29 (62)	18 (31)	21 (45)	21 (40)	7 (35)	
	Too private	<5			<5			<5	
	Missing	<5			<5	<5	<5		
	Too public	28 (23)	<5	<5	22 (37)	10 (21)	11 (21)	7 (35)	
	Public	26 (21)	<5	14 (30)	8 (14)	11 (23)	11 (21)	<5	
	Neither/nor	20 (17)	6 (40)	5 (11)	9 (15)	7 (15)	9 (17)	<5	
	Private	28 (23)	<5	13 (28)	14 (24)	11 (23)	14 (26)	<5	
	Too private	<5			<5			<5	
	Not relevant	12 (10)	<5	7 (15)	<5	<5	6 (11)	<5	
	Missing	6 (5)	<5	<5	<5	<5	<5	<5	
The open balcony*	Too public	28 (23)	<5	<5	22 (37)	10 (21)	11 (21)	7 (35)	
	Public	26 (21)	<5	14 (30)	8 (14)	11 (23)	11 (21)	<5	
	Neither/nor	20 (17)	6 (40)	5 (11)	9 (15)	7 (15)	9 (17)	<5	
	Private	28 (23)	<5	13 (28)	14 (24)	11 (23)	14 (26)	<5	
	Too private	<5			<5			<5	
	Not relevant	12 (10)	<5	7 (15)	<5	<5	6 (11)	<5	
	Missing	6 (5)	<5	<5	<5	<5	<5	<5	
	Too public	14 (12)	<5	<5	12 (20)	7 (15)	<5	<5	
	Public	16 (13)	<5	<5	12 (20)	5 (11)	8 (15)	<5	
	Neither/nor	21 (17)	6 (40)	9 (19)	6 (10)	11 (23)	8 (15)	<5	

No statements related to the openness of open balconies and/or terraces on ground floor.

\*Note: Potential misclassification as some people in G and T have replied "not relevant" even if all apartments in these housing departments have at least a shallow, open balcony.





General perception of one's own health



QUALITATIVE DATA



QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS



Toveshøj and Gellerup (n=8)



 <b>Experience and satisfaction with the built environment (experienced gestures)</b>		QUANTITATIVE DATA (number (%))					QUALITATIVE DATA		 <b>General perception of one's own health</b>	
		AREAS					QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES	
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
The closed balcony*	Too public	8 (7)	<5	<5	<5			<5	<5	
	Public	<5	<5					<5	<5	
	Neither/nor	7 (6)	5 (33)		<5			<5	<5	
	Private	10 (8)	<5	<5	6 (10)			5 (11)	<5	
	Too private									
	Not relevant	80 (66)	<5	36 (77)	43 (73)			27 (57)	36 (68)	17 (85)
	Missing	13 (11)	<5	9 (19)	<5			7 (15)	5 (9)	<5
		21% for whom it is relevant ("Not relevant" subtracted)								
		Too public if "not relevant" are subtracted								
		*Note: The number of missing responses in S and G (together with the high number of "not relevant responses") may reflect that there is not a closed balcony in the included apartments. In general, in S and G, all other responses than "not relevant" can be considered a misclassification.								
Terrace on ground floor*	Too public	7 (6)	<5	<5	5 (8)			<5	<5	
	Public	<5	<5	<5				<5	<5	
	Neither/nor	<5	<5		<5			<5	<5	
	Private	10 (8)	<5	5 (11)	<5			<5	<5	
	Too private									
	Not relevant	90 (74)	11 (73)	35 (74)	44 (75)			32 (68)	41 (77)	17 (85)
	Missing	10 (8)		6 (13)	<5			5 (11)	<5	<5
		50% for whom it is relevant ("Not relevant" subtracted)								
		33% for whom it is relevant ("Not relevant" subtracted)								
		*Note: A relatively high percentage of missing responses, which may reflect that residents have chosen not to answer the question rather than using the option "not relevant."								







 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health	
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES	
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)		Good (n=47)	Excellent/really good (n=53)
<b>How do you experience the acoustics/sound in your apartment?</b>									
Living room	Very satisfactory/satisfactory	77 (64)	10 (67)	35 (74)	32 (54)	See quotes below.	26 (55)	39 (74)	12 (60)
	Neither/nor	23 (19)	<5	8 (17)	14 (24)		11 (23)	8 (15)	<5
	Very unsatisfactory /unsatisfactory	20 (17)	<5	<5	12 (20)		10 (21)	5 (9)	<5
	Missing	<5		<5				<5	
Bedroom	Very satisfactory/satisfactory	75 (62)	9 (60)	34 (72)	32 (54)		27 (57)	38 (72)	10 (50)
	Neither/nor	25 (21)	<5	10 (21)	14 (24)		13 (28)	7 (13)	5 (25)
	Very unsatisfactory /unsatisfactory	20 (17)	<b>5 (33)</b>	<5	13 (22)		7 (15)	8 (15)	<5
	Missing	<5		<5					<5
Children's room/spare room*	Very satisfactory/satisfactory	81 (67)	10 (67)	37 (79)	34 (58)		29 (62)	39 (74)	13 (65)
	Neither/nor	24 (20)	<5	8 (17)	15 (25)		11 (23)	9 (17)	<5
	Very unsatisfactory /unsatisfactory	16 (13)	<5	<5	10 (17)	7 (15)	5 (9)	<5	
	Missing								
Kitchen	Very satisfactory/satisfactory	77 (64)	9 (60)	36 (77)	32 (54)	28 (60)	38 (72)	11 (55)	
	Neither/nor	26 (21)	<5	9 (19)	15 (25)	10 (21)	10 (19)	6 (30)	
	Very unsatisfactory /unsatisfactory	18 (15)	<5	<5	12 (20)	9 (19)	5 (9)	<5	
	Missing								
Hallway	Very satisfactory/satisfactory	73 (60)	9 (60)	34 (72)	30 (51)	27 (57)	36 (68)	10 (50)	
	Neither/nor	29 (24)	<5	9 (19)	17 (29)	11 (23)	12 (23)	6 (30)	
	Very unsatisfactory /unsatisfactory	19 (16)	<5	<5	12 (20)	9 (19)	5 (9)	<5	
	Missing								
Bathroom	Very satisfactory/satisfactory	69 (57)	6 (40)	34 (72)	29 (49)	25 (53)	34 (64)	10 (50)	
	Neither/nor	30 (25)	<5	10 (21)	17 (29)	11 (23)	14 (26)	5 (25)	
	Very unsatisfactory /unsatisfactory	22 (18)	<b>6 (40)</b>	<5	13 (22)	11 (23)	5 (9)	5 (25)	
	Missing								

 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health		
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)			Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
<b>Noise in the apartment</b>										
	<i>Irritatingly hard/hard</i>	29 (24)	<5	10 (21)	17 (29)			12 (26)	12 (23)	<5
	<i>Pleasant</i>	91 (75)	13 (87)	37 (79)	41 (69)		Quotes are not included as the quantitative results are <33%.	34 (72)	41 (77)	16 (80)
	<i>Irritatingly dead/dead</i>	<5			<5			<5		
	<i>Missing</i>									
<b>Are you bothered by noise from the neighbors?</b>										
	<i>No</i>	49 (41)	<5	17 (36)	28 (47)			23 (49)	19 (36)	7 (35)
	<i>Yes/sometimes</i>	72 (60)	11 (73)	30 (64)	31 (53)	<b>Noise from neighbors</b>	The resident expresses that sounds travels. "It is not to a degree where it bothers me, but you can clearly hear if people are arguing, and you can hear children running around next door. You cannot really tell if it is next door or downstairs, but it is easy to tell that there are other people living here." (female resident, Gellerupparken). "Besides the evident traffic noise from Edwin Rahrs vej, then it is a noisy neighborhood. There are many young men on mopeds or in big cars, who drive around day and night and make noise. They will park and honk at three in the morning if they are picking up someone." (Male resident in Toveshøj). The resident expresses that she can hear noise from the construction site. (Female resident, Gellerupparken via interpreter).	24 (51)	34 (64)	13 (65)
	<i>Missing</i>					<b>Traffic noise (vandalism)</b>				
<b>How do you experience the materials, which are used in the apartment?</b>										
	<i>Very satisfactory/satisfactory</i>	51 (42)	<5	23 (49)	24 (41)	<b>State of materials</b>	"...But we lived here for 25 years, so it doesn't look as good as it did 25 years ago." (Female resident, Toveshøj).	23 (49)	21 (40)	7 (35)
	<i>Neither/nor</i>	17 (14)	<5	8 (17)	6 (10)			7 (15)	7 (13)	<5
	<i>Very unsatisfactory/unsatisfactory</i>	52 (43)	8 (53)	15 (32)	29 (49)			17 (36)	24 (45)	10 (50)
	<i>Missing</i>	<5		<5	<5				<5	

 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health			
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES			
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)			Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)	
How do you experience the ability to arrange/furnish your apartment?	Living room	Very satisfactory/satisfactory	90 (74)	10 (67)	38 (81)	42 (71)	Individual upgrades  "He thinks that it is unfair that when they move out, they have paid for the total value of the kitchen, but they cannot bring it with them [...]. So that is a bad thing (male resident in Toveshøj via interpreter)"  The resident states that the apartment is old now, but still in a nice state – it works. (Female resident, Gellerupparken).	38 (81)	39 (74)	13 (65)	
		Neither/nor	9 (7)	<5	<5	6 (10)		<5	5 (9)	<5	
		Very unsatisfactory/unsatisfactory	22 (18)	<5	7 (15)	11 (19)		8 (17)	9 (17)	<5	
	Bedroom	Missing									
		Very satisfactory/satisfactory	80 (66)	7 (47)	38 (81)	35 (59)		33 (70)	36 (68)	11 (55)	
		Neither/nor	14 (12)	<5	5 (11)	7 (12)		<5	8 (15)	<5	
	Children's room/spare room*	Very unsatisfactory/unsatisfactory	26 (21)	<b>6 (40)</b>	<5	17 (29)		12 (26)	9 (17)	<5	
		Missing	<5		<5					<5	
		Very satisfactory/satisfactory	58 (48)	5 (33)	27 (57)	26 (44)		27 (57)	22 (42)	9 (45)	
		Neither/nor	17 (14)	<5	6 (13)	8 (14)		<5	10 (19)	<5	
	Very unsatisfactory/unsatisfactory	26 (21)	<b>5 (33)</b>	5 (11)	16 (27)	11 (23)	11 (21)	<5			
	Missing	20 (17)	<5	9 (19)	9 (15)	6 (13)	10 (19)	<5			
						Washing machine and tumble dryer  "If I could do magic, just on a small scale, I would like my own washing machine and tumble dryer. The laundry tends to pile up, and it is inconvenient. I have my own washing machine in storage in Alborg, and a tumble dryer in the same place." (Male resident, single-room apartment, Toveshøj).					
						Accessibility  "There will be an elevator in the first stairway, not in ours. I am a little disappointed with that. That is the most important thing for me. More important than the bathroom." (Female resident, Toveshøj)  "Maybe the bathroom is too small. It was good enough, but now that M has problems washing himself, there is not enough room for two people." (Female resident, Toveshøj)					



 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health		
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)		Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
Kitchen	Very satisfactory/satisfactory	66 (55)	5 (33)	31 (66)	30 (51)	Please refer to "thermal comfort."  The resident states that the last two summers, there have only been three nights, where she could sit on the balcony, "It is too windy because I live in the gable. When the weather is nice, I sit out there." (Female resident in Gellerupparken).  "The balconies are small. To narrow to be useful." The resident states that it would be better if it was a little bigger, but that it would influence the façade expression. "But it means that I cannot use it a lot. However, I am pleased to have it." [...] "Couldn't they just have given it 20 cm more? Then one could pass the chair. Or make a bigger opening from within the apartment – e.g. double door, so you could sit inside. But, then you would have to move a radiator. But just a little bit bigger opening." (Male resident, Gellerupparken).  "I then put up a demand for a broom cupboard" [...]. "Because, otherwise it is not implemented. And damn, you always have a broom and a vacuum cleaner, which has to be somewhere." (Female resident, Gellerupparken).	29 (62)	29 (55)	8 (40)	
	Neither/nor	25 (21)	5 (33)	7 (15)	13 (22)		7 (15)	14 (26)	<5	
	Very unsatisfactory/unsatisfactory	30 (25)	5 (33)	9 (19)	16 (27)		11 (23)	10 (19)	8 (40)	
Hallway	Missing									
	Very satisfactory/satisfactory	62 (51)	5 (33)	30 (64)	27 (46)	27 (57)	27 (51)	8 (40)		
	Neither/nor	26 (21)	<5	7 (15)	16 (27)	5 (11)	15 (28)	6 (30)		
Bathroom	Very unsatisfactory/unsatisfactory	32 (26)	7 (47)	9 (19)	16 (27)	15 (32)	10 (19)	6 (30)		
	Missing	<5		<5			<5			
	Very satisfactory/satisfactory	55 (45)	<5	29 (62)	23 (39)	26 (55)	22 (42)	7 (35)		
Bathroom	Neither/nor	27 (22)	<5	9 (19)	14 (24)	8 (17)	12 (23)	7 (35)		
	Very unsatisfactory/unsatisfactory	39 (32)	8 (53)	9 (19)	22 (37)	13 (28)	19 (36)	6 (30)		
	Missing									



 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))					QUALITATIVE DATA			 General perception of one's own health		
		AREAS					QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS			GENERAL HEALTH CATEGORIES		
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)			Toveshøj and Gellerup (n=8)	Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)	
<b>Ability to influence conditions</b>												
Sound/ acoustics	Very satisfactory/satisfactory	56 (46)	<5	29 (62)	23 (39)		See quotes under "noise from neighbors"	18 (38)	29 (55)	9 (45)		
	Neither/nor	28 (23)	<5	10 (21)	15 (25)			12 (26)	10 (19)	6 (30)		
	Very unsatisfactory/unsatisfactory	35 (29)	<b>8 (53)</b>	7 (15)	<b>20 (34)</b>			15 (32)	14 (26)	5 (25)		
	Missing	<5	<5	<5	<5			<5				
Daylight	Very satisfactory/satisfactory	92 (76)	11 (73)	38 (81)	43 (73)		Quotes not included as the quantitative results are <33%.	36 (77)	40 (75)	16 (80)		
	Neither/nor	15 (12)	<5	6 (13)	8 (14)			6 (13)	7 (13)	<5		
	Very unsatisfactory/unsatisfactory	14 (12)	<5	<5	8 (14)			5 (11)	6 (11)	<5		
	Missing											
Openness towards surroundings	Very satisfactory/satisfactory	90 (74)	12 (80)	38 (81)	40 (68)		Quotes not included as the quantitative results are <33%.	36 (77)	39 (74)	14 (70)		
	Neither/nor	20 (17)	<5	8 (17)	9 (15)			6 (13)	10 (19)	<5		
	Very unsatisfactory/unsatisfactory	11 (9)	<5	<5	10 (17)			5 (11)	<5	<5		
	Missing											
Temperature	Very satisfactory/satisfactory	64 (53)	6 (40)	17 (36)	41 (69)		<b>Ability to influence temp.</b> "During summertime, it is difficult to get rid of the heat if there is no wind. I cannot create draught through. (Male resident in single-room apartment, Toveshøj)."	26 (55)	27 (51)	11 (55)		
	Neither/nor	7 (6)	<5	<5	<5			<5	<5	<5		
	Very unsatisfactory/unsatisfactory	50 (41)	<b>8 (53)</b>	<b>26 (55)</b>	16 (27)			17 (36)	24 (45)	<b>8 (40)</b>		
	Missing											
Air quality	Very satisfactory/satisfactory	85 (70)	13 (87)	32 (68)	40 (68)		<b>Ability to influence individual</b> The resident expresses that there is an extraction device, which does not work: "When	31 (66)	41 (77)	12 (60)		
	Neither/nor	15 (12)	<5	<5	10 (17)			7 (15)	5 (9)	<5		
	Very unsatisfactory/unsatisfactory	20 (17)	<5	11 (23)	8 (14)			9 (19)	7 (13)	<5		

 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health			
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES			
		All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)			Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)	
Air circulation	Missing	<5			<5	-ly influence air circulation and vent. in general	Toveshøj and Gellerup (n=8)			<5	
	Very satisfactory/satisfactory	56 (46)	7 (47)	21 (45)	28 (47)		I cook, it doesn't extract, and when I don't cook, it does." (female resident in Gellerupparken)		26 (55)	22 (42)	8 (40)
	Neither/nor	14 (12)	<5	6 (13)	<5		"It would be nice if it was something you could control a little [the ventilation]" [...] "It is difficult for me to figure out if you could have a system, where I can control how much it ventilates without affecting the others." (male resident, Gellerupparken)		7 (15)	5 (9)	<5
	Very unsatisfactory/unsatisfactory	51 (42)	<5	20 (43)	27 (46)		See quotes under "temperature" and "ability to influence temp."		14 (30)	26 (49)	10 (50)
	Missing						The resident states that they themselves put a new floor on top of the existing one, and they think that it is very unfair that it should be removed when they move out during the renovation. They do not feel that it is fair that they have to pay for laying the flooring and removing it again. "It doesn't make any sense". They really like the flooring and do not want a new wooden floor (Female resident in Gellerupparken via interpreter).		23 (49)	26 (49)	9 (45)
Dampness	Very satisfactory/satisfactory	58 (48)	<5	24 (51)	31 (53)	Ability to retain individual upgrades	Now we have been talking about it [broom cupboard] for 12 years" [...] "you have to remember to say it every time. Because now we are at the third inspection, I think, since we started talking about it – and all of a sudden, they never heard about... this and that." (female resident, Gellerupparken)		9 (19)	11 (21)	5 (25)
	Neither/nor	25 (21)	6 (40)	6 (13)	13 (22)				15 (32)	15 (28)	5 (25)
	Very unsatisfactory/unsatisfactory	36 (30)	5 (33)	17 (36)	14 (24)					<5	<5
	Missing	<5	<5		<5	Ability to influence design decisions					
<b>Expression of building</b>											
	Very appealing/appealing	47 (39)	<5	33 (70)	13 (22)	Expression			19 (40)	19 (36)	9 (45)
	Neither/nor	26 (21)	<5	9 (19)	15 (25)		"It is, like, very standard. Not so nice. However, if it had been first class, then they probably could not afford to live here." (Male resident in Toveshøj via interpreter).		10 (21)	12 (23)	4 (20)
	Very unappealing/unappealing	48 (40)	12 (80)	5 (11)	31 (53)				18 (38)	22 (42)	7 (35)
	Missing										





 <b>Experience and satisfaction with the built environment (experienced gestures)</b>			 <b>General perception of one's own health</b>			
QUANTITATIVE DATA (number (%))			QUANTITATIVE DATA (number (%))			
AREAS			GENERAL HEALTH CATEGORIES			
	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
<b>Ability to get chatting with your neighbors or other residents</b>						
Very satisfactory/satisfactory	79 (65)	34 (72)	40 (68)	35 (74)	29 (55)	14 (70)
Neither/nor	23 (19)	8 (17)	11 (19)	7 (15)	12 (23)	<5
Very unsatisfactory/unsatisfactory	19 (16)	5 (11)	8 (14)	5 (11)	12 (23)	<5
Missing						
<p>QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS</p> <p>Toveshøj and Gellerup (n=8)</p> <p>"You nod and say hello" (Male resident, Gellerupparken)</p> <p>The resident explains that he often helps the neighbors with small things. "They know that they can just come knocking if there is anything they need help with – also if it is in the middle of the night." [...] "The husband cannot really walk, but he does not want to move out. He tells some good stories, so I am happy to have them." (Male resident, Toveshøj)</p> <p>"We can be four to five people. Officially, we are three people living here. So, it is a group home". (Female resident, Gellerupparken)</p> <p>"...it [the football training field] is located by the common house, "Laden," where I spend a lot of time. We have communal eating every Friday and have had it for 1,5 years by now." (Male resident, Toveshøj)</p> <p>The resident explains that she is part of a club, the "the Ghetto bitches" [Ghettokællingerne]. They meet at festive seasons – Easter, Whitsun, Christmas, and so on. And they have summer barbecues in the garden. "We are 12-14 girls who get together. Some who have lived here for a very long time." (Female resident, Gellerupparken)</p>						
<b>Sense of safety</b>						
Very safe/safe	87 (72)	39 (83)	40 (68)	31 (66)	40 (75)	15 (75)
Neither/nor	20 (17)	<5	12 (20)	7 (15)	10 (19)	<5
Very unsafe/unsafe	13 (11)	<5	7 (12)	8 (17)	<5	<5
Missing	<5	<5		<5		
<p>Quotes not included as the quantitative results (in terms of dissatisfaction) are &lt;33%.</p>						
<b>When arriving at the building block</b>						

 Experience and satisfaction with the built environment (experienced gestures)		QUANTITATIVE DATA (number (%))				QUALITATIVE DATA		 General perception of one's own health	
		AREAS				QUOTES AND DERIVED THEMES FROM QUALITATIVE INTERVIEWS		GENERAL HEALTH CATEGORIES	
Outside the entrance door to the apartment	Very safe/safe	All (N=121)	Toveshøj (n=15)	Søvangen (n=47)	Gellerup B4 (n=59)	Toveshøj and Gellerup (n=8)	Good (n=47)	Excellent/really good (n=53)	Less good/poor (n=20)
	Neither/hor	19 (16)	<5	<5	12 (20)		7 (15)	8 (15)	<5
	Very unsafe/unsafe	93 (77)	9 (60)	40 (85)	44 (75)		34 (72)	42 (79)	16 (80)
		8 (7)	<5	<5	<5		5 (11)	<5	
Missing	<5	<5				<5			
<b>Narrative of the area</b>									
The resident states that it is a lovely place – a nice area, where a lot of good things happen, which never come out. "Generally, only the negative things take up space, but that's not what I know. So many sweet and nice people live out here. We get along, and it doesn't matter if it is Somalis, Iranians, Danes – the people I know out here are lovely people. Then there are a few scamps, but they can be found everywhere. And they ruin it for the others." (Female resident, Gellerupparken).									
"When people hear that I live in Brabrand, then "ugh!". Then I get angry with them" [...] Because they think that it is the worst, black people who live in Brabrand." (Female resident, Toveshøj)									
"Sometimes the police come if there is trouble in the bazaar... There is peace and quiet here. Many say that it is dangerous to live in Brabrand, but we have nice neighbors" (Female resident, Toveshøj).									
<b>Uncertainties and concerns related to the process</b>									
"How will we survive? It will be a tough period for." (Female resident, Toveshøj)									

The illustrations were previously published in the paper (Kamari et al. 2021a).

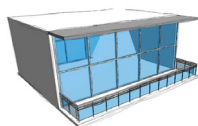
# Appendix F

## PAPER PROTOTYPES

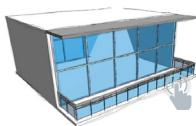
This appendix includes the paper prototypes presented in a user group interview in relation to Objective 3.

### EXERCISE // PAPER PROTOTYPE NO. 1

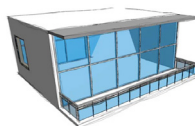
scenarie 1 - eksisterende



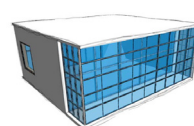
scenarie 2



scenarie 3



scenarie 4



energi/forbrug  klik for mere info B

miljøpåvirkning  klik for mere info C

anlægsudgifter

bygbarhed

overophedning

dagslys

ventilation

sundhed

udkig

privativ

energi/forbrug

miljøpåvirkning

anlægsudgifter

bygbarhed

overophedning

dagslys

ventilation

sundhed

udkig

privativ

energi/forbrug

miljøpåvirkning

anlægsudgifter

bygbarhed

overophedning

dagslys

ventilation

sundhed

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bygbarhed

overophedning

dagslys

ventilation

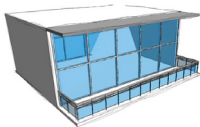
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udkig

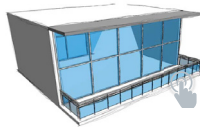
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## EXERCISE // PAPER PROTOTYPE NO. 2

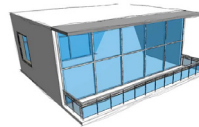
scenarie 1 - eksisterende



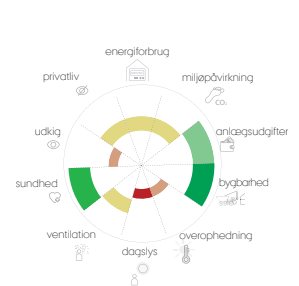
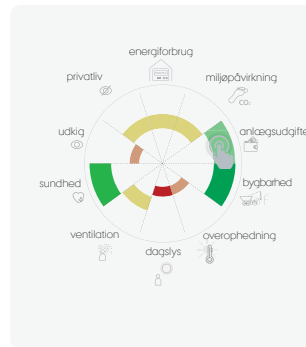
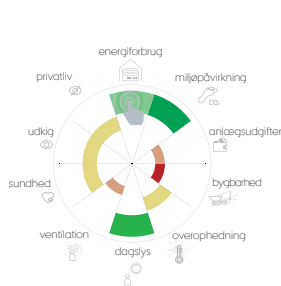
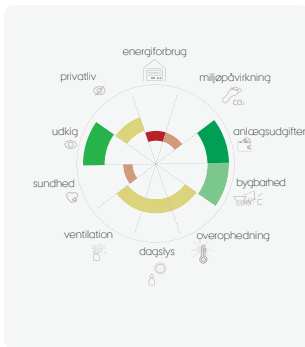
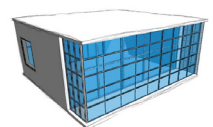
scenarie 2



scenarie 3

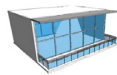


scenarie 4

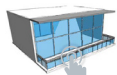


## EXERCISE // PAPER PROTOTYPE NO. 3

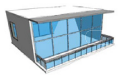
scenarie 1 - eksisterende



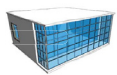
scenarie 2



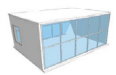
scenarie 3



scenarie 4



scenarie 5



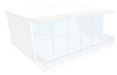
scenarie 6



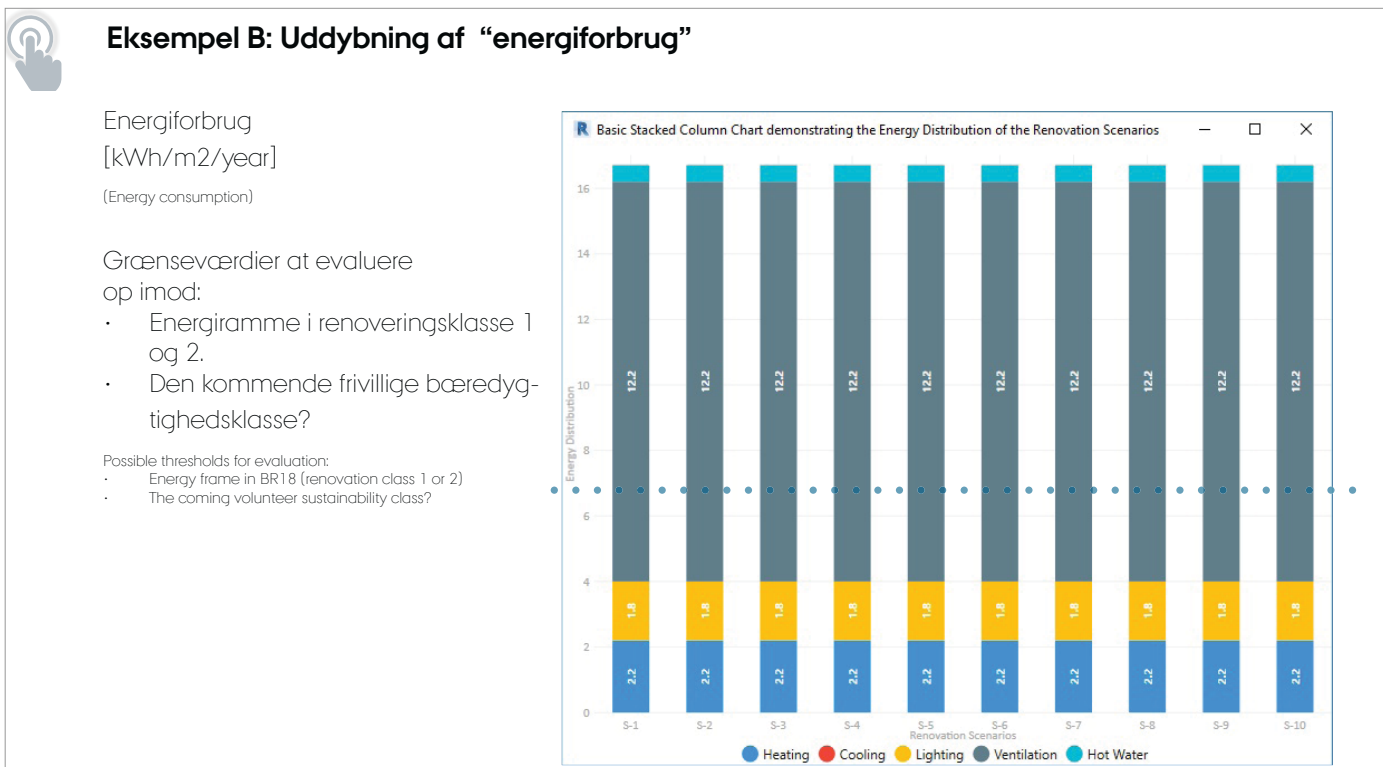
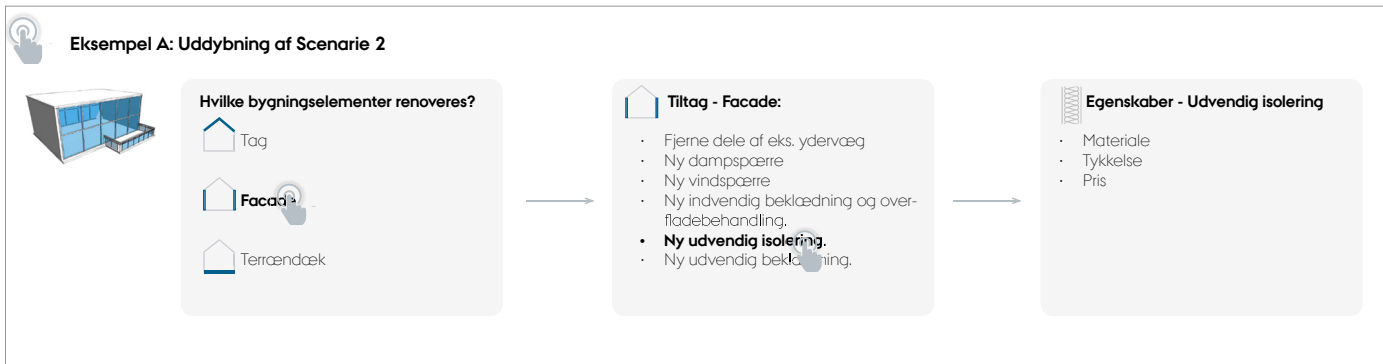
scenarie 7



scenarie 8



	scenarie 1 - eksisterende	scenarie 2	scenarie 3	scenarie 4	scenarie 5	scenarie 6	scenarie 7	scenarie 8	
energiforbrug	orange	green	green	green	green	green	green	orange	potentier
miljopavirking	orange	orange	orange	orange	green	green	orange	orange	green
anlægsudgifter	white	green	orange	red	red	red	red	red	yellow
bygbarhed	white	yellow	yellow	green	yellow	yellow	yellow	yellow	orange
overophedning	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	udfordringer
dagslys	yellow	yellow	yellow	red	green	yellow	yellow	yellow	yellow
ventilation	green	green	green	green	green	green	green	green	green
sundhed	green	orange	green	green	green	green	green	orange	green
udkiq	orange	orange	orange	orange	orange	orange	orange	orange	orange
privatliv	yellow	orange	orange	green	yellow	yellow	yellow	green	green







### Eksempel C: Uddybning af "Anlægsudgifter"

Anlægsudgifter [DKK]

