ARTICLE IN PRESS

International Journal of Sustainable Built Environment (2017) xxx, xxx–xxx

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International Journal of Sustainable Built Environment

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Sustainability focused decision-making in building renovation

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Received 18 March 2017; accepted 1 May 2017

Abstract

An overview of recent research related to building renovation has revealed that efforts to date do not address sustainability issues comprehensively. The question then arises in regard to the holistic sustainability objectives within building renovation context. In order to deal with this question, the research adopts a multi-dimensional approach involving literature review, exploration of existing assessment methods and methodologies, individual and focus group interviews, and application of Soft Systems Methodologies (SSM) with Value Focused Thinking (VFT). In doing so, appropriate data about sustainability objectives have been collected and structured, and subsequently verified using a Delphi study. A sustainability framework was developed in cooperation with University of Palermo and Aarhus University to audit, develop and assess building renovation performance, and support decision-making during the project's lifecycle. The paper represents the results of research aiming at addressing sustainability of the entire renovation effort including new categories, criteria, and indicators. The developed framework can be applied during different project stages and to assist in the consideration of the sustainability issues through support of decision-making and communication with relevant stakeholders. Early in a project, it can be used to identify key performance criteria, and later to evaluate/compare the pros and cons of alternative retrofitting solutions either during the design stage or upon the project completion. According to the procedure of the consensus-based process for the development of an effective sustainability decision-making framework which was employed in this study, the outcome can also be considered as an outset step intended for the establishment of a Decision Support Systems (DSS) and assessment tool suited to building renovation context.

Keywords: Sustainability; Building renovation; Decision support; Knowledge management; Soft Systems Methodology (SSM); Value Focused Thinking (VFT)

1. Introduction

Today buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions in the EU (European Commission [EC], 2014). New buildings generally need less than 3–5 l of heating oil per square meter per year while older buildings consume about 25 l on average (EC, 2014). Some buildings even require up to 60 l. Renovation of buildings is currently achieving increased attention in many European countries (Buildings Performance Institute Europe [BPIE], 2011), the primary reason is that about 35% of the EU's buildings are over 50 years old (Joint Research Centre [JRC], 2015), and thus they grow less attractive, if not maintained thoroughly during life time

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Peer review under responsibility of The Gulf Organisation for Research and Development.

http://dx.doi.org/10.1016/j.ijsbe.2017.05.001
2212-6090/

Please cite this article in press as: Kamari, A. et al. Sustainability focused decision-making in building renovation. International Journal of Sustainable Built Environment (2017), http://dx.doi.org/10.1016/j.ijsbe.2017.05.001

(for the reasons such as insufficient indoor air quality and thermal comfort). In retrofitting context via enhancing the energy efficiency (Energy Efficiency Watch [EEW], 2015) the total EU energy consumption can be decreased by 5–6% as well as CO_2 emissions by about 5% (EC, 2014). However improving energy efficiency and carbon emission parameters are not the only goals in building renovation[1] context. Energy and resource-conscious architecture are known as environmental friendly issues. Considering just them for a project is not sustainable if it is non-functional, much costly and malformed. Historical value, identity, aesthetic, integrity, innovation etc. are all rich unmeasured proofs why people still emphasize and keep living in their existing buildings over time that needs to be included in alternative renovation solutions. It hence calls for major considerations in this context so as to create a high-performance building (to be in consistence with sustainability in its full sense) via application of a holistic and integrated design process (where different stakeholders are involved), which make sure all design goals are met. Over the last few decades different methods have been developed to implement and evaluate the renovation existing buildings from technical and not-technical perspectives (Ma et al., 2012). Jensen and Malesa (2015) discussed that these methods have a narrow environmental or energy focus. Therefore, it leads to insufficiently understand and examine the sustainability objectives fulfilment and their greater chain of effects in aforementioned context (Ministry of Climate, Energy and Building – Danish government [SBi], 2014).

1.1. Sustainability development paradigm

Sustainability development refers to a dynamic process from one state towards another which means there is no exact definition about it, in fact every societies and cities are evolving by passing the time in order to become more superior or inferior (United Nation [UN], 2013). Hence our goals including visions, ambitions and technical feasibilities are all subjects to change (Brophy, 2014). The sustainability (Williamson et al., 2003) can be described as incontestable development of society and economy on a long-term basis within the framework of the carrying inclusion of the earth's ecosystems (UN, 2013). Similarly, developing major retrofitting alternatives for existing buildings to include sustainability initiatives can decrease operation and maintain costs; reduce environmental impacts; and can increase building adaptability, durability, and resiliency within other views. Due to this the buildings may be less costly to operate, may growth in value, last longer, and contribute to a preferable, healthier, and more convenient environment to the occupants who lives and works in there. Enhancing indoor comfort quality, reducing moisture, and improving efficiency all can result in enhancing user's health and productivity (Bluyssen and Cox, 2002).

From sustainability perspective, there are factors that must be taken into the consideration all together in order to gain the ultimate goal which is known as "sustained prosperity" relevance to different stakeholders and so their various priorities. Hence, the optimal renovation solutions are a trade-off among a range of energy related and non-energy related factors that must be taken in account (Boeri et al., 2014). With sustainability moving up agendas across industry and government as well as enhancing sustainability awareness in public, being able to assess the sustainability impacts and opportunities of a project sounds crucial. Considering of where building design industry meets the sustainability solutions enables building designers to anticipate a larger demand for systematic strategies to upgrade existing building stock close at hand (Kamari et al., 2017b). Furthermore, the sustainability paradigm is based on the modern information and communication systems (Afgan and Carvalho, 2002). As such, it is of special interest to verify the need for the deep understanding of sustainability as the pattern with the agglomerated set of indicators defined by the respective criteria (Afgan, 2010). If human settlements are to carry out sustainability as a target, it is necessary to develop methods to set criteria, plan, design, and evaluation. It is also necessary having such methods as a scientific basis in terms of comparison between various projects (Nguyen and Altan, 2011), and for considering how they should be developed over time.

1.2. Rationalization of developing the decision-making support framework for sustainable retrofitting

The present paper, investigates the problem of knowledge management in building renovation corresponding to sustainability development paradigm. Otherwise, as a part of the RE-VALUE[2] research project (Value Creation by Energy Renovation, Refurbishment and Transformation of the Built Environment, Modelling and Validating of Utility and Architectural Value), this paper deals with its overall objective, which is to develop a holistic sustainability Value Map for building renovation purpose to support project development and to communicate the outcomes with the relevant stakeholders. The Danish research project RE-VALUE has been initiated to shed light on existing renovation methodologies, and the potential to further develop them into a model targeted retrofitting initiatives in Denmark. The aim is to make a full-scale demonstration of two renovation projects in areas with different residential compositions, and to study their effects

[1] In this paper, the term "building renovation" is used as the equivalent of "building retrofitting" in accordance with the "sustainable development paradigm". The authors' intent is to fill the gap, which exists between these two terms in existing literature.

[2] Participated by Brabrand Housing Association – with energy renovation in the Aarhus suburb of Gellerup – as well as DEAS, an administration company on the private rental housing market (for more info: http://www.revalue.dk).

as regards the reduction in energy consumption and the impact on health and well-being of users.

Up to now there is a significant spectrum of methods accessible for appraisement of sustainability concept (Haapio and Viitaniemi, 2008; Cole, 2005; Crawley and Aho, 1999). They have been expanded beside demands from the surroundings, primarily corresponding to environment as the main category so far, where the most recent tools attempted to evaluate environment, economy and social relations in an equal circumstances (Jensen and Maslesa, 2015). Many of the existing assessment methodologies and tools (Gohardani and Björk, 2012) have been developed for the design of the new buildings, but can be applied renovation projects as well, and some are particularly intended or adapted for building renovation context. BREEAM (by British Research Establishment), LEED (by US Green Building Council), ATHENA (by ATHENA Sustainable Material Institute in Canada), BEAT (by Danish Building Research Institute), DGNB (by German Sustainable Building Council) and EcoEffect (by Royal Institute of Technology in Sweden) are some examples of these methods. Furthermore, the figure and application of the evaluation tools in the building area has orderly been propounded (Poston, 2011). Sustainability has recently been being studied and addressed through more holistic perspectives such as the research which has been done by International Living Future Institute (2014) and called Living Building Challenge; or it also has been developed into a decision-making support frameworks such as SPeAR by Arup Group Limited Arup (2012) or Chris Butters' sustainability framework from Norwegian Architects for Sustainable Development (2014), in order to represent and evaluate sustainability in the form of a holistic Value Map. As part of these recently holistic approaches (Poston et al., 2010), the building's users have to be involved in the process (Yu et al., 2011; Sweeney et al., 2013), especially from early design stages in order to get the ultimate goal of sustainability in building renovation (Degan et al., 2015). People use buildings in unexpected ways. A deep and advanced renovated building with high energy standards may have an extreme energy consumption from day first if the building occupants misunderstand of their essential roles as a part of highly efficient system. As such, the learning, education and inspiration of the building occupants can also add values to the project and needs to be considered and included in the evaluation of the sustainability.

As part of the RE-VALUE research project, Jensen et al. (2017) have carried out a meta-synthesis of 7 existing sustainability assessment methodologies. For instance, Fig. 1 demonstrates the assessment of the DGNB-DK and how its indicators were analysed through different categories, including Social, Environmental, and Economic. Moreover, the process was also investigated through specific indicators.

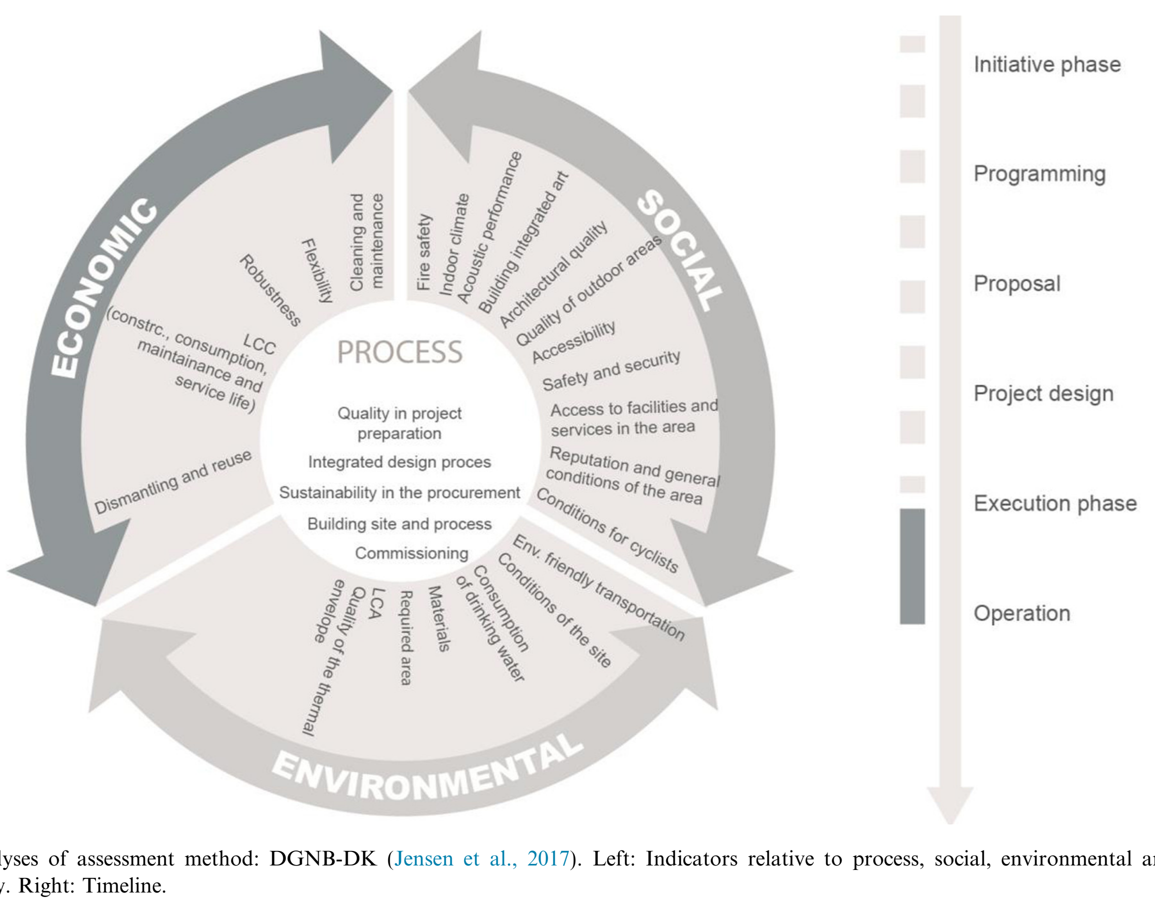

Fig. 1. Analyses of assessment method: DGNB-DK (Jensen et al., 2017). Left: Indicators relative to process, social, environmental and economic sustainability. Right: Timeline.

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The aim of the study was to compare the methodologies by examining which sustainability criteria they each attach importance to. The paper identified and positioned the criteria of each methodology relative to the traditional three-pillar-system of sustainability. This served to illustrate that the methodologies indeed attach importance to different sustainability indicators, which underlines that 'Holism' in sustainability is a relative term. Despite the fact that many of the methodologies are characterized as holistic by the developers e.g. (AktivHusDanmark, 2015; Schunck, 2011), not all methodologies address social, economic and environmental sustainability as well as process-related issues equally. As such, the models themselves represent a stance on sustainability, which may affect the decision-making process and ultimately the outcome of the renovation project. As discussed in previous section (see Section 1.2), the concept of sustainability is a dynamic process and therefor, many of the existing assessment methods are not applicable for different contexts (design of new buildings or renovation of the existing buildings), locals and regions. Alyami and Rezgui (2012) identified some of the factors that hinder the applicability of the existing assessment methodologies including:

- Climatic conditions.
- Geographical characteristics.
- Potential for renewable energy gain.
- Resource consumption (such as water and energy).
- Construction materials and techniques used,
- Building stocks.
- Government policy and regulation.
- Appreciation of historic value.
- Population growth.
- Public awareness.
- etc.

Furthermore, most of the methods and tools that mentioned above have a narrow environmental or energy focus (Jensen and Maslesa, 2015). In other words, the selection of indicators is often unsystematic in those methods. Important factors (specifically in connection to the society) are left out, and different kinds of indicators are sometimes jumbled together (Butters, 2014). Brophy (2014) states that assessment methods have-in the past-been seen as a driver for sustainability, however, both the methods and the context in which they operate, are changing rapidly. This is significant because it leads to misapprehend the correct intention of the sustainability objectives. By using the existing methods, users do not comprehend an overall picture of what the sustainability goals are, what is essential to be addressed, or what objectives are close at hand. In this perspective, the present paper primarily (see Section 2) gives information about the methodology adopted in this research; and later in Sections 3 and 4, it provides details about the development and application of a sustainability decision-making support framework and holistic Value Map for the building renovation. In Section 5, the paper will conclude by providing an overview of the framework and a short introduction about the possible future research works.

2. Methodology

2.1. Research design

A knowledge society is based on the need for knowledge distribution, access to information and the capability to convert information into knowledge (Afgan, 2010). Knowledge management is one of the crucial requirements of a knowledge society (Afgan, 2006). The issue of knowledge management in building renovation context, for the reasons that stated earlier, is a challenge (International Living Future Institute, 2014) that should not be downgraded. It is a complex system because it cannot be fully addressed without comprehension of the interconnections and interactions between its technical objectives and its society as well as the influences of the development impact on its environment and world (the neighbours and city that the building is located) as a whole. There are essential stages regarding to the problem of knowledge management in building renovation context in order to develop a new sustainability decision-making support framework which needs to be performed through a consensus-based process (Alyami and Rezgui, 2012; Cooper, 1999). Following these steps in a rational order, the overall methodology applied in present research project has been elicited from Neves et al. (2009). The authors (Neves et al., 2009) employed SSM (Checkland, 2000) beside Value Focused Thinking-VFT (Keeney, 1992) approach, in order to refine and structure the list of the objectives along with various perspectives regarding to the main evaluators identified in energy efficiency sector. They concluded (Neves et al., 2009), although there is no guarantee that the same problem analysed by another team or even by the same team in a different occasion would lead to the same results, the exhaustive learning catalysed by the SSM study, and then with the VFT approach, combined with the ex-post interviews with some experts, explicitly provided confidence about the completeness of the model. In this regard, the present research project has adopted a qualitative multi-method research approach through 7 stages which has been illustrated in Fig. 2.

The research methodology in the present research assumed conducting SSM with VFT through a consensus-based process. It was done through conducting two workshops and series of academic participant's meetings in the Department of Engineering-Aarhus University and in connection to RE-VALUE research project. The focus group included variety of participants including: architects (from architectural consultant companies), contractors, experts (in energy efficiency, indoor comfort, construction & management, civil engineering, health and human well-being), decision-makers, professors within different backgrounds (who participate with RE-VALUE

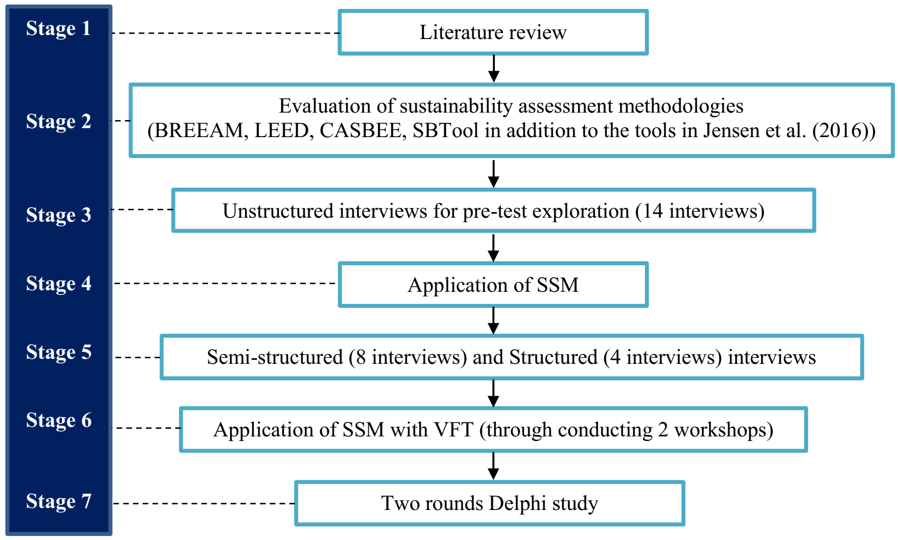

Fig. 2. The methodology adopted by the authors for developing and validating the data to create the sustainability decision-making framework.

project as well as supervise the Ph.D students in Department of Engineering-Aarhus University and Department of Architectures-University of Palermo), Ph.D. students (4 in total who works closely with RE-VALUE project), members of engineering union, and member of government associations (municipality of Aarhus city and Aalborg city in Denmark).

2.2. Data collection approaches

In order to ensure that the decision-making framework reflects sustainability best practice, primarily a number of other sustainability assessment methods and literature were reviewed. Added to what Jensen et al. (2017) explored as the part of the RE-VALUE project, the authors of the present paper have also analysed another existing sustainability assessment methodologies, including BREEAM[3] (by British Research Establishment), LEED[4] (by US Green Building Council), CASBEE[5] (by Japan Sustainable Building Consortium) and SBTool[6] (by Natural Resource Canada). The review concentrated on the strength and weaknesses, and also where they have been implemented successfully. These sources were referred to throughout; initially to identify the appropriate categories, then the appropriate criteria and subsequently in drafting the indicators (or sub-criteria). In this consideration, added to the literature studied in the precedent sections (i.e. Section 1.2), and in order to recognize and address some specific indicators, the following literature related to *Technical* (Baker, 2009; Burton, 2012; Building Performance Institute [BPI], 2013; PrEN 15203/15315 Energy performance of buildings (CEN, 2006), National Institute of Building Sciences [NIBS], 2014; Bluyssen, 2000), *Architectural* (Acre and Wyckmans, 2014; Salingaros, 2006, 1995), *Social* (Mofatt and Kohler, 2008), *Environmental* (Baker, 2009; Burton, 2012), *Cultural* (Behzadfar, 2008), *Financial* (Lutzkendorf et al., 2011), *Management* (NIBS, 2014), *Education* (Pilkington et al., 2011), *Regulations* (UN, 2008), and *Cost* (Wang et al., 2009; Page and Burgess, 2009; Krstić and Marenjak, 2012) have been studied.

Subsequently, individual and group interviews (Ali and Al Nsairat, 2009) were utilized in this research project, which is considered as the major path to gather and discuss the data from various stakeholders. To this end, the researchers went into the middle of the field, observed and met the different building occupants. The interview process, though, started by comprising of 14 unstructured interviews (with building occupants). In order to simplify the various demands from the building occupants, the first round SSM was applied. Next, the results were investigated using conversational guide and interview survey with other stakeholders in the field. Therefore, 8 semi-structured and 4 structured interviews among different types of stakeholder (from Academia, Government, and Industry) were carried out. It aimed, instead of collecting general knowledge about the retrofitting in practice, to recognize the areas where further research and development could lead to construct a difference and add value for retrofitting projects. The central aim of these stages was to provide information in order to feed into the complementary round use of (stage 6 – see Fig. 2) SSM.

2.3. Soft Systems Methodology (SSM)

SSM was developed by Peter Checkland in the late 60' s at the University of Lancaster in the UK (Checkland, 2000). Initially it was seen as a modelling tool, but by passing years it has become progressively as a learning and meaning development tool so far (Williams, 2005). It is a systems approach that is used for analysis and problem

[3] http://www.breeam.org.
[4] http://www.usgbc.org.
[5] http://www.ibec.or.jp/CASBEE/english/.
[6] http://www.iisbe.org/node/140.

solving in complex and messy situations. These situations are "soft problems" such as: How to improve building performance? How to perform a sustainable retrofitting? Checkland and Scholes (1990) distinguish between 'hard' and 'soft' systems thinking within the attempt to use system concepts to solve problems. Simonsen (1994) describes Hard Systems Thinking within Systems Engineering (as the traditional research strategy or design approach for engineers and technologists) and Systems Analysis (as the systematic appraisal of the costs and other implications of meeting a defined requirement in various ways). The author (Simonsen, 1994: p 2) discusses *Hard Systems Thinking has the starting point in 'structured' problems and the assumption that the objectives of the systems concerned are well defined and consistent;* unlike *Soft Systems Thinking has the starting point in 'unstructured' problems within social activity systems in which there is felt to be an ill-defined problem situation*. SSM exploits "systems thinking" in a cycle of action research, learning and reflection to help understand the various perceptions that exists in the minds of the different people involved in the situation (Maqsood et al., 2001). Checkland (1999) discusses this further where it can be used to analyse any problem or situation, but it is most appropriate where the problem "cannot be formulated as a search for an efficient means of achieving a defined end; a problem in which ends, goals, purposes are themselves problematic". It was reported as a viable alternative to use mapping-based problem structuring methods to help unveiling a set of objectives for structuring a multi-criteria decision analysis model (Neves et al., 2009). In particular, SSM is able to stimulate, debate and capture the required vision for the future of complex challenges; it is a considered appropriate methodology in appreciation and analysis of Social (social practices, and power relations), Personal (individual beliefs, meanings, emotions), and Material (physical circumstances) worlds (Mingers and Brocklesby, 1997). There are a lots of documented examples of the successful use of SSM in many different fields, ranging from ecology to business and military logistics.

Developing a new sustainability decision-making support framework in retrofitting context is ultimately a very complex (due to different decision maker), and multi-disciplinary task (within a sustainable perspective). Kamari et al. (2017a) discuss this issue which from many angles is similar to the problems known as messy/wicked problems. The phrase 'wicked problems' (Churchman, 1967) was originally used in the context of social planning, where it was used to demonstrate problems that were difficult or impossible to solve, because they address complex social interdependencies. Similarly, the characteristics of the problems in the retrofitting discipline involves many qualitative and quantitative factors and criteria that are provisional case to case. SSM in this situation functions as an interrogative device that enables debate amongst concerned parties (Checkland, 1999), it leads to catch the complexity of the existing issues from different perspectives among various stakeholders and later communicate the possible solutions. Such methods can be exploited to equip a basis for technical design and social intervention. In this perspective, the following model (see Fig. 3) was used to benefit from SSM in the present research project. It hence has been applied to explore the innovation and knowledge management in aforementioned context.

2.4. Value Focused Thinking (VFT)

The basis for the developing sustainable framework is where the right values should be the driving force for the decision-making process (Komiyama and Takeuchi, 2006). Keeney (1992) discusses that the relative desirability of decision-making's consequences is a concept based on values, and thus the fundamental notion in decision-making should be values, not alternatives. He describes further, the premise is focusing early and deeply on values when facing difficult problems which lead to more desirable consequences. Historically and theoretically, the concept of value is closely related to financial (monetary) productivity (Hansen, 2010). However, the complexity of building design, with its variety of stakeholders, calls for a broader understanding of the term (Madsen et al., 2015). Keeney (1992) states the principle of thinking about values is to discover the reasoning for each objective and how it relates to other objectives. Therefore, VFT essentially consists of two activities: first deciding what you want and then figuring out how to get it (Keeney, 1992). Once the list of objectives is reasonably complete, it is important to specify clearly what each objective includes. Since the main purpose of the present research is to develop a new decision-making framework to support sustainable retrofitting, the concepts presented in Keeney's VFT (Keeney, 1992) considered appropriate to structure the outcomes from the SSM study. Fig. 4 illustrates the advantages of the application of VFT in present research study.

2.5. Applying SSM beside VFT to building renovation

As stated before, building renovation context is a both highly multi and inter-disciplinary field and it involves a considerable number of stakeholders. Therefore, it covers domains which are identified in different ontological outsets; some sub-domains are focusing on quantifiable aspects, such as energy consumption and construction cost, whereas other domains are more concerned with qualitative aspects related to e.g. society (Estkowski, 2013). In addition, it should meet the sustainability development goals. To this end, the research based on the model developed in Fig. 3, primarily developed a Rich Picture (see Fig. 5) among different stakeholders in the workshops about RE-VALUE project. Next, it exploited CATWOE analysis and Root Definition (see Table 1) as well as developed the Conceptual Model (see Fig. 6).

The benefits of doing a sustainable retrofit are significant and it is not quite apparent in the minds of

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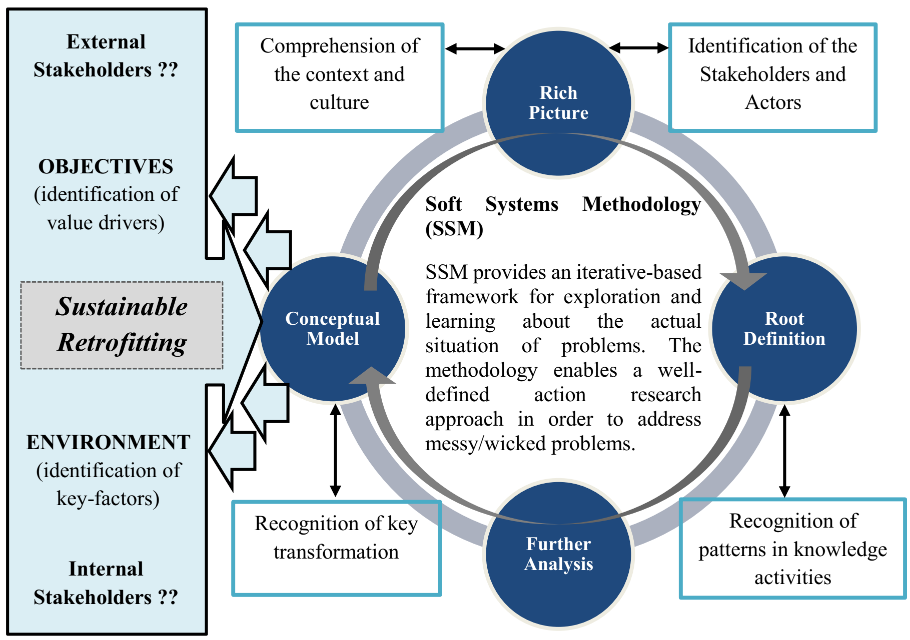


Fig. 3. Application of SSM to knowledge management in sustainable retrofitting.

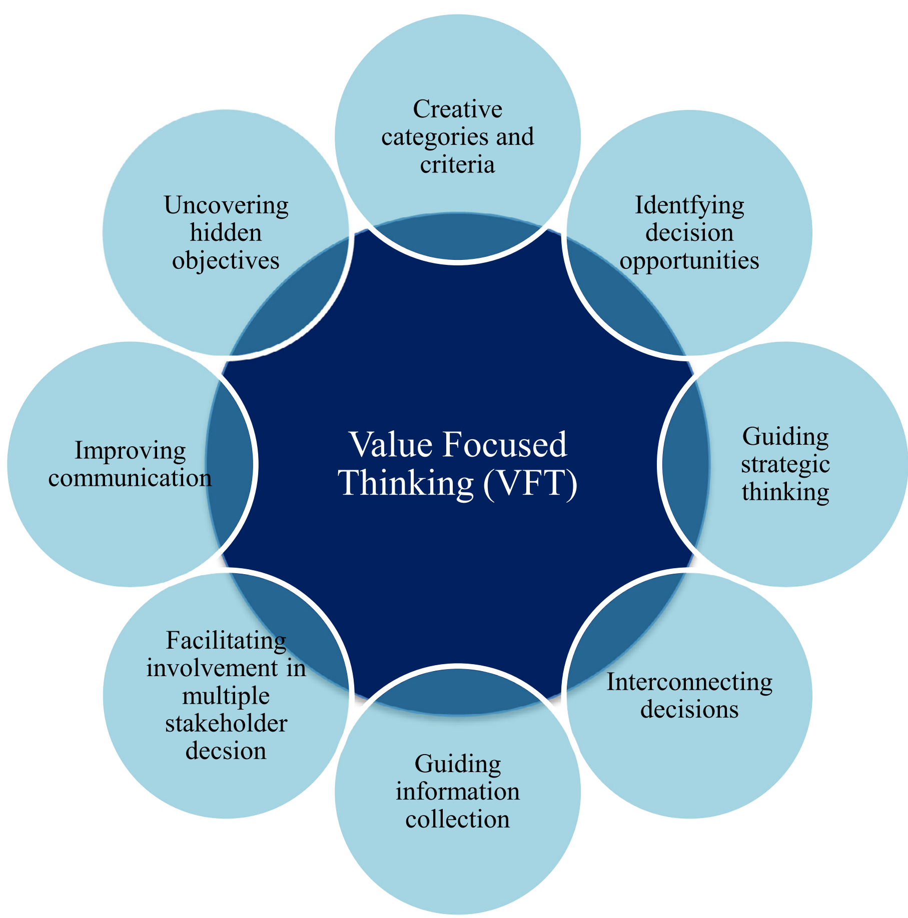


Fig. 4. Advantages of using VFT to knowledge management in sustainable retrofitting.

the different relevant stakeholders in the renovation process. This was identified while the Rich Picture was being developed that demonstrates the structure, processes and particularly the system of dialogues, requirements and perceptions of the stakeholders about the building renovation process. The thorough utilization of SSM (see Fig. 5, Fig. 6

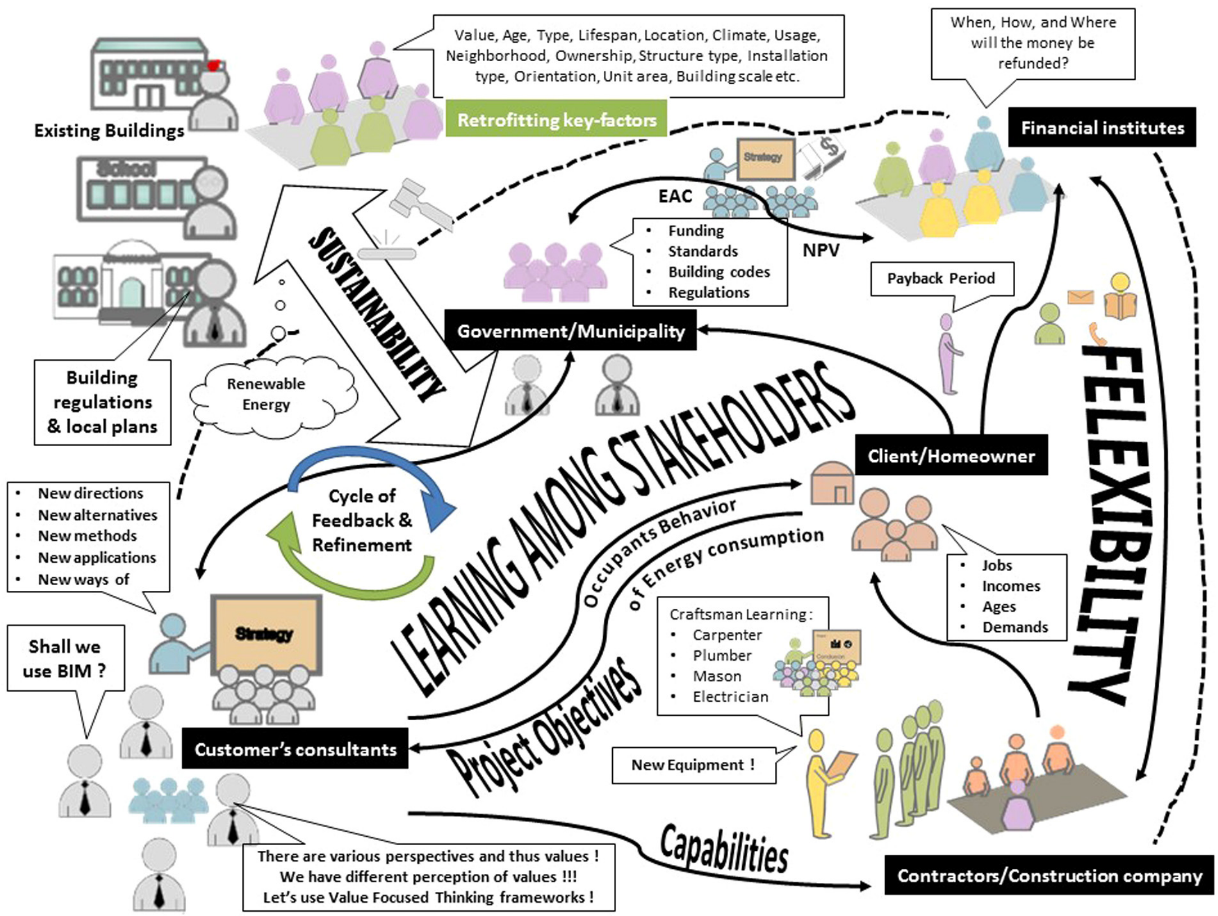


Fig. 5. Rich picture – The stakeholders and process of the building renovation.

Table 1
Root Definition and CATWOE analysis for building renovation context.

Root definition	CATWOE analysis
A system owned by project manager who together with Architect and Design Engineer, use knowledge, skills and experience to prepare and assess possible retrofitting alternatives through sustainable value oriented criteria that delivers the most appropriate solution for the retrofitting project. This is undertaken where all the different stakeholders specifically the consultant company have a well understanding of the process, objectives/goals, issues and challenges. The community expectation and behaviour for the design and construction of the project must be taken into the consideration	*Customer:* The client and the community. *Actors:* Client/Homeowner, Customer's consultants, Government/ Municipality, Financial institutes, and Contractors/Construction company *Transformation:* To use knowledge, skills and experience to proper and assess applicable retrofitting alternatives through the sustainable value oriented perspectives that delivers the most appropriate solutions in existing building stock. *Weltanschauung (why bother?):* To assess the feasibility of making a sustainable retrofitting we need a good/well understanding of the process, objectives/goals, and issues. *Owner:* Design team including Architect, Design Engineer and Engineering Manager *Environment:* Historical value of the existing building, Climatic zoon, Location etc

and Table 1) for building renovation, formalized the knowledge of the renovation process explicitly, highlighted problematic areas, and explored the requirements. It provided recommendations where the sustainability values can be identified and added in this context.

Present research endeavoured to investigate the common patterns among the decisions made by different stakeholders within building renovation circumstances that highly influence the other key members' decisions with different priorities. In this intervention, SSM played an important role proposing questions[7] to extract the list of value drivers in regard with the involved stakeholders. Hereafter, according to the guidelines in Keeney (1992), the framework of VFT was utilized to modify and structure the value drivers (see Fig. 7), turn them into the sustainabil-

[7] The list of the guidelines was used from Neves et al.,(2009). (2009: p 10 – table number 5).

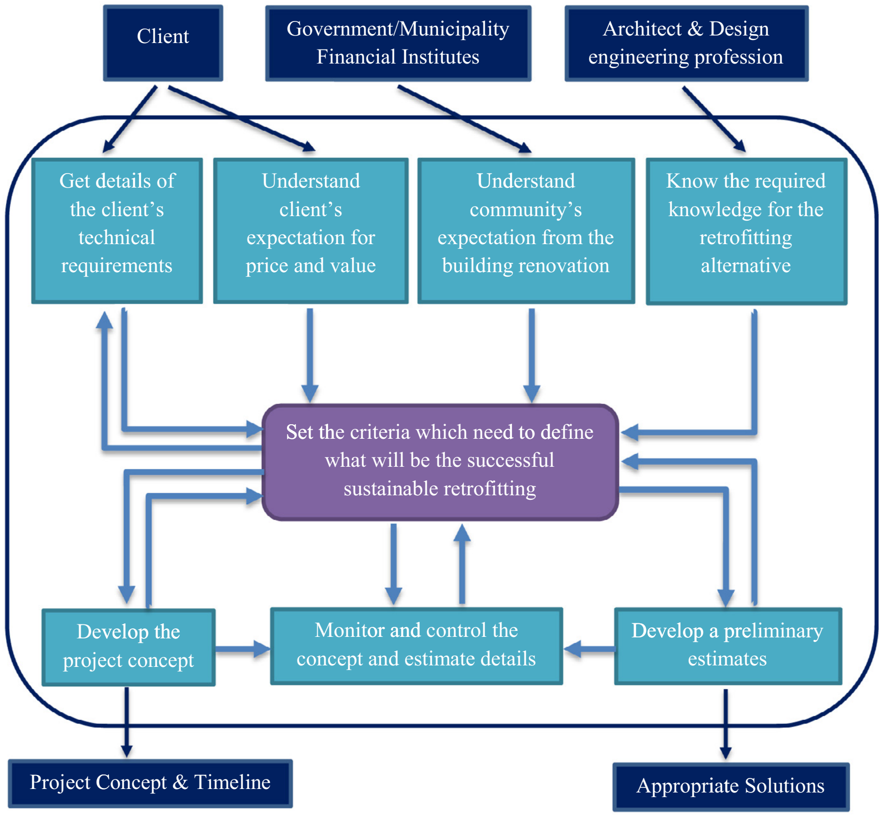


Fig. 6. Conceptual Model – Building renovation context.

ity objectives, and ultimately expand their relevant indicators in a consensus-based process. It was performed using two essential frameworks which is known as the hierarchy of fundamental objectives and the network of means-ends objectives. By developing the first one, it initially recognizes the values to use in the decision process while the second one leads to construct the alternatives to judge. This paper primarily focused on the primitive structure in order to identify the sustainability objectives. However, in order to distinguish the objectives and their sub-objectives, it was considered vital to identify the means objectives and end objectives. The list of objectives were hence analysed to identify which of them are end-objectives and which are means that lead to that end. It concluded the framework of fundamental objectives and sub-objectives. Later, they have been renamed as the criteria and indicators so as to develop the new sustainability decision-making framework which were represented in Table 2 and Table 3. The methods of SSM and VFT were though applied in sequence. Attaching the context of knowledge management including application of SSM with VFT to the scenario of building renovation augmented a new vigour, insight and framework in order to be comprehended by different stakeholders specially the design team.

It is worth noting that, application of SSM in building renovation mapped a research path to address one of the most popular barriers which is occurred in this area (the building renovation). It is called "Rebound effect" in which the post-retrofit energy consumption is higher than predicted, due to changes in occupant behaviour (Booth and Choudhary, 2013). The question that arises inevitably is how to involve different stakeholders and on the top of that building occupants (Eriksen et al., 2013) [and keep them involved] in the design process so as to promote and improve their learning about the sustainability, the sustainable retrofitting and the sustainable DIY (do-it-yourself). For this reason, Kamari et al. (2017b) have explored this concept within more comprehensive overview over the existing barriers and challenges in building renovation context and concluded a new Holistic Multi-methodology for Sustainable Retrofitting (HMSR). It has been developed through mixing certain SSM and Multiple Criteria Decision Making – MCDM (Wang et al., 2009) methods in order to promote an integrated design process implementation and evaluation for the building renovation so as to overcome the identified challenges (including Rebound effects). It is worth noting that the developed HMSR within the mentioned study might be considered as the most appropriate procedure to put the outcomes of the present paper (the new sustainability decision-making support framework for building renovation) into the practice.

3. Findings

The sustainability decision-making support framework developed in this paper should be able to represent if a building renovation has been successful at meeting an expected level of performance (in accordance with sustain-

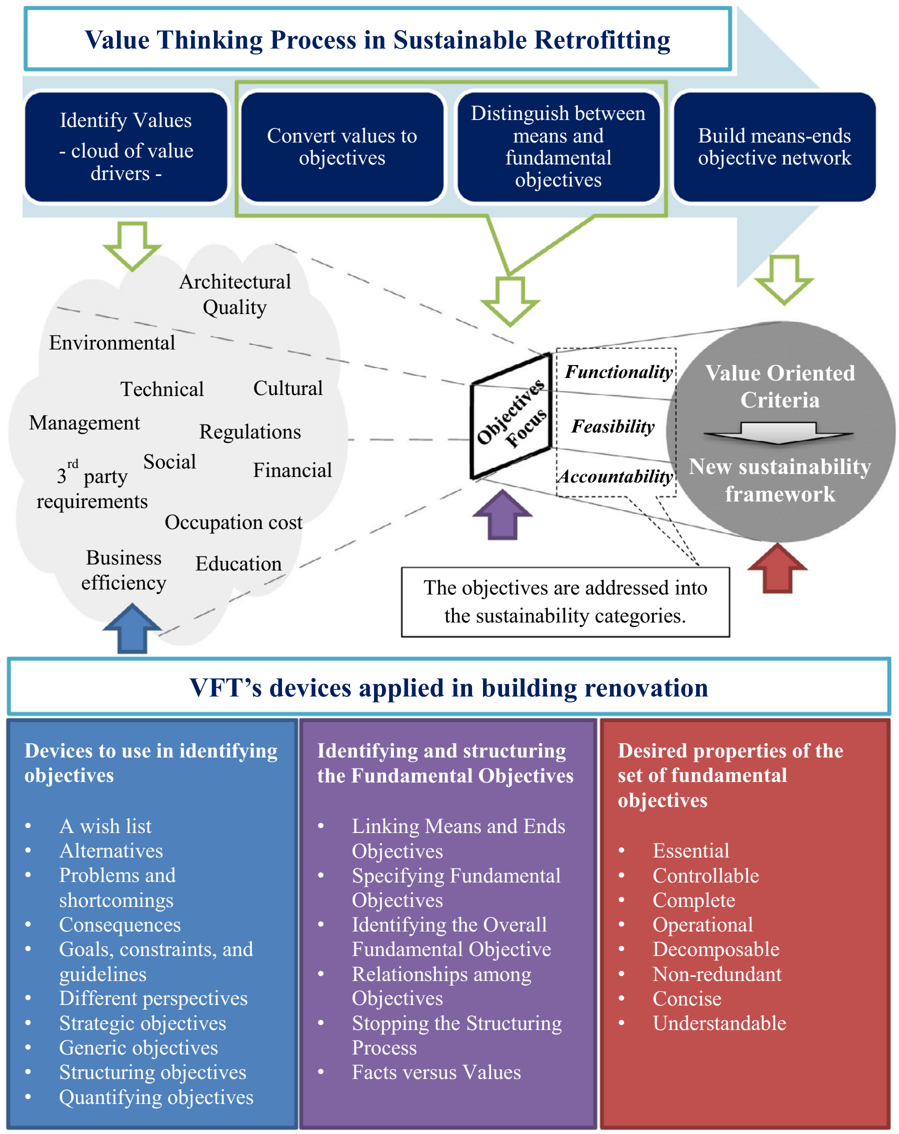


Fig. 7. Application of VFT to knowledge management in sustainable retrofitting.

ability in its totality) in a number of declared criteria. The sustainability matrix was created in response to the collected data within stages 1–7 of the applied research methodology (see Fig. 2). The outcomes concluded that the decision-making framework should bear the following characteristics:

- The framework must be able to be applied from the pre-retrofit or start-up stages in renovation design process.
- It should be comprehensive enough along with sustainability traditional pillars in order to address the building renovation performance from different aspects – environmental, social, and economical with respect to local, cultural and urban context.
- The sustainability framework should creatively be developed in order to be comprehended as simple as possible.
- The categories, criteria, and indicators of the developed framework should acknowledge the context of building renovation.
- The values about architectural quality must be included into the framework.
- The stakeholders' learning about the sustainability, the sustainable retrofitting and the sustainable living should be considered as a value and be included into the framework.
- The value of an efficient collaborative process should be a part of the framework.

3.1. Key factors in building renovation

The outcomes of stages 1–6 of the applied research methodology (see Fig. 2) identified and listed 30 key-factors which particularly must be considered for any

Table 2
List of the key factors for retrofitting projects during project set-up and pre-retrofit survey.

Value	Building type	Tenancy
Climate	Building story	Buy and Sell
Location	Unit area	Occupant's daily stay
Site	Structure	Occupant's monthly stay
Neighbourhood	Shape	Occupant's yearly stay
Building function	Ventilation	Occupant's consumption habits
Ownership	Material	Occupant's demands
Orientation	Installations	Occupant's income
Age	Retrofitted yet	Occupant's job
Lifespan	Balcony & Chimney	Additional consideration

Table 3
List of three different categories and their related sustainable value oriented criteria.

Functionality	Accountability	Feasibility
Indoor comfort	Aesthetic	Investment cost
Energy efficiency	Integrity	Operation & maintenance cost
Material & waste	Identity	Financial structures
Water efficiency	Security	Flexibility & Management
Pollution	Sociality	Innovation
Quality of services	Spatial	Stakeholders engagement & education

retrofitting case during pre-retrofit survey and project set-up (see Table 2). The result of the utilization of this stage in practice, indicates if there is potential for building renovation before taking any action. The intent concerns the overall exploration of the building as well as involvement of the building occupants and understanding both their demands of the renovation and their behaviour or special habits while living in the building. For each factor, a brief description has been provided in Appendix.

3.2. Categories and criteria

The three newly defined categories and totally 18 main sustainable value oriented criteria were addressed through the application of the research methodology stages 1–7 (see Fig. 2). On the top of that, SSM was considered effective, in order to analyse and uncover a "cloud of objectives/criteria" regarding different sustainability perspectives and relevant stakeholders' priorities in the building renovation design process. The outcomes of this step led to create three new categories in order to illustrate sustainability in the way that is more comprehensive and recognizable to the different stakeholders. The new categories were defined as,

- "Functionality" which refers to technical, environment and used resources (environment).
- "Feasibility" which encompasses financial, process, management, education and institutional indicators (economy), and
- "Accountability" which embraces municipal, architectural, cultural, human and community indicators (society).

But the 'cloud of objectives' still was unstructured. For this reason several VFT's devices (see Fig. 7) were employed to expand and refine the list of criteria achieved at the end of the second round SSM workshop. The central aim of the consolidated categories and criteria was to provide first round Delphi panel experts (from Academia, Government, and Industry) on checking and validating the outcomes. The panel of 16 experts, therefore, was activated as the point of departure in order to brainstorm and perform deliberative consideration, based on 'open ended solicitation of ideas' taking place in October 2015. It investigated the list of applicable criteria for the building renovation purpose in connection to 3 newly driven categories. In this stage, the goal was to examine the essential and relevance of the requirement specification and framework outline. As well, the initial draft of the possible indicators for each criteria was addressed. As the result of this contribution, each category was illustrated by 6 sustainable value oriented criteria (see Table 3).

3.3. Indicators (or sub-criteria)

The criteria which were developed in previous step, are attached to a certain number of indicators (Segnestam, 2002). The indicators (or sub-criteria) are the details that sit behind each criteria. Table 4 in the following represents the results of the data which were collected from literature review, investigation on existing assessments methodologies, interviews and group discussions and two rounds Delphi study. The further studies included consideration of some renovation cases in different stages in Denmark. In fact, the outcomes from the first round of the Delphi study (see Section 3.2), were reconsidered and expanded further in Aarhus University-Denmark. As such, based on the observations and consideration of the 5 renovating cases (all in Denmark), the addressed criteria were further reviewed and validated in the second round of the Delphi study with 19 participants (from Academia, Government, and Industry) taking place in November 2016. However the reason was to build a critical consideration of the sustainability framework (which will be argued in Section 4) and discussion of development of the indicators based on the collected information and to reconsider the outcomes regarding to the renovation cases before generating the last version of the framework. Accordingly, the indicators which were addressed for each criteria were checked and validated by 4 groups of the experts (19 participants with different area of expertise – see Section 2.1) during the RE-VALUE research project's workshop.

Table 4. Sustainability decision-making support framework's categories, criteria, and indicators – Column D in this table refers to the procedure which the indicator has

Table 4
Sustainability decision-making support framework's categories, criteria, and indicators – Column D in this table refers to the procedure which the indicator has been created from. In this regard, '1' refers to the indicator which was extracted from Literature Review; '2' refers to the indicator which was extracted from considering of the existing assessment methodologies (BREEAM, LEED, CASBEE, and SBTool in addition to the items considered in Jensen et al. (2017)), '3' refers to the indicator which was outlined from the Interviews, and '4' refers to the indicator which was resulted from the Group discussion.

Column A: Category
Column B: Criteria
Column C: Indicators or sub-criteria
Column D: Source of creation

A	B	C		D
Functionality	Indoor comfort	Indoor air quality		1, 2
		Lighting comfort (day and artificial)		2
		Thermal comfort		2
		Acoustic comfort		2
		Moisture comfort		2, 3
	Energy efficiency	Reduction of energy consumption	Heating	1, 2
			Hot Water System	
			Cooling	
			Cold water system	
			Air-conditioning	
			Ventilation	
			Lighting (interior & exterior)	
			Fans	
			Pumps and controls	
			Electricity consumption for external lighting	
			Other electrical equipment	
		Energy generation		1, 3
		Energy monitoring		1, 3
		Energy efficient saving		2, 3
	Material & waste	Material cycle	Environmental impact of the materials	1, 2
			Local materials	1, 2
			Recyclable material	1, 2
			Re-use of structural frame materials	1, 2
			Building fabric component (insulation)	1, 2
			Responsible source of materials	1, 2
			Use of finishing materials	1, 2
			Material efficiency over its life cycle (LCA)	1, 2
			Use of material that are designed to deal with future climate change	1, 2
			Material with high/low thermal mass (depends on the climatic zone)	1, 2
		Waste	Construction waste management	1, 2
			Solid waste treatment	1, 2
			Waste treatment	1, 2
			Recycling facilities	1, 2
			Recycling storages	1, 2
	Water efficiency	Water consumption		2
		Grey water recycling		2
		Rain water harvesting		2
		Water fixture & conservation strategy		2
		Irrigation system		2
		Water monitoring		2
	Pollution	CO_2 emissions		2
		NOx emissions		2
		Impact of refrigerant		2
		Light pollution (night light)		2
		Water pollution		1, 2
		Noise pollution		2
	Quality of services	Usability		1, 2
		Adaptability for future change		1, 2
		Durability and reliability		1, 2
		Controllability of system		1, 2
		Efficient infrastructure		1, 2
		Maintenance of performance		1, 2

(*continued on next page*)

Table 4 (*continued*)

Column A: Category
Column B: Criteria
Column C: Indicators or sub-criteria
Column D: Source of creation

A	B	C		D
Accountability	Aesthetic	Temperature	Intensity of perceivable details	1, 4
			Density of differentiations	1, 4
			Curvature of lines and forms	1, 4
			Intensity of colour hue	1, 4
			Contrast (amongst other colour hues)	1, 4
		Harmony	Reflectional symmetries on all scales	1, 4
			Translational and rotational symmetries on all scales	1, 4
			Degree to which distinct forms have similar shapes	1, 4
			Degree to which forms are connected geometrically one to another	1, 4
			Degree to which the colours harmonize	1, 4
	Integrity	Site protection – Cultural heritage privacy		1, 2
		Site protection – Natural privacy		1, 2
		Site protection – Prevent criminal threads		1, 2
		Mitigation ecological impact		1, 2
		Enhance site ecology		1, 2
		Land function		1, 2
		Infrastructure		1, 3, 4
		Pathways and accessibility		1, 3, 4
		Neighbourhood and lighting policy		1, 3, 4
		Pedestrian & cyclist safety		1, 3, 4
		Building density		1, 3, 4
	Identity	Natural identity (e.g. Desert town, Mountain town, Windward town etc.)		1, 3, 4
		Artificial identity (e.g. University city, Religious city, Touristic city, Industrial city etc.)		1, 3, 4
		Human identity (e.g. Attitudes, Traditions, Customs etc.)		1, 3, 4
	Security	Occupant health		1, 4
		Occupant safety (building scale)		
		Fire protection		1, 4
		Security for building occupants and assets (building scale)		1, 4
		Natural hazards mitigation		1, 4
	Sociality	View quality – Enclosure and peripheral density (configuration of the block that affects views)		1, 4
		Block physical boundaries (peripheral density and contour)		1, 4
		The height to width ratio (proportion) of internal block spaces (such as courtyards) and the sense of enclosure		1, 4
		Functions in the block, and built and human densities		1, 4
		Physical barriers between public and private spaces		1, 4
		Outdoor private spaces		1, 4
		The facade composition and permeability (changes in facade permeability and composition, such as the size of windows and dwelling entrances)		1, 4
	Spatial	View from the inside (private domain) to the outside (public domain) of dwellings and from outside to inside (visual privacy)		1, 4
		View quality by lighting distances between public and private domains		1, 4
		The articulation between space and its boundaries, and between adjacent spaces		1, 4
		The privacy within the dwelling (zoning considering different groups within the family)		1, 4
		Light (access of daylight, layout zoning, and sun orientation of openings)		1, 4
		Colour (types and effects in the space)		1, 4

(*continued on next page*)

Table 4 (*continued*)

Column A: Category
Column B: Criteria
Column C: Indicators or sub-criteria
Column D: Source of creation

A	B	C		D
Feasibility	Investment cost	Design		1, 3
		Construction		1, 3
		Procurement	Building equipment (e.g. door, window, materials, furniture etc.) MEP equipment Structural equipment	1, 3
		Replacement	Building equipment (e.g. door, window, material, furniture etc.) MEP equipment Structural equipment	1, 3
		Repair	Building equipment (e.g. door, window, materials, furniture etc.) MEP equipment Structural equipment	1, 3
	Operation & maintenance cost	Statutory periodic inspections		1, 3, 4
		Costs of replacing degraded materials and elements		1, 3, 4
		Costs of periodic works and repairs		1, 3, 4
		Costs of reactive maintenance		1, 3, 4
		Operational costs		1, 3, 4
	Financial structures	Payback period		1, 3, 4
		Net Present Value (NPV)		1, 3, 4
		Affordability of residential rental		1, 2
	Flexibility & Management	Commissioning		2, 4
		Consultation		2, 4
		Collaboration		2, 4
		Construction planning		2, 4
		Construction site impacts		2, 4
		Perform proper building operations and maintenance		2, 4
	Innovation	Building form		1, 4
		Building envelop		1, 4
		Passive design (lighting and ventilation)		1, 4
		Building structure		1, 4
		Interior design		1, 4
		Built area		1, 4
		HVAC system		1, 4
	Stakeholders engagement & education	Environmental strategy/design & features	Sustainable urban drainage systems Air source heat pump Photovoltaic Low-E Glass	1, 3, 4
		Operational instructions	General Electrical Plumbing	1, 3, 4
		Sustainable DIY (do-it-yourself)	Fixings Certified materials Paints & finishes	1, 3, 4
		Energy consumption		1, 3, 4
		Water use		1, 3, 4
		Home information guide alternative formats		1, 3, 4
		Alarm information		1, 3, 4
		Recycling and waste system and collection		1, 3, 4

been created from. In this regard, '1' refers to the indicator which was extracted from Literature Review; '2' refers to the indicator which was extracted from considering of the existing assessment methodologies (BREEAM, LEED, CASBEE, and SBTool in addition to the items considered in Jensen et al. (2017)), '3' refers to the indicator which was outlined from the Interviews, and '4' refers to the indicator which was resulted from the Group discussion.

4. Developing sustainability decision-making support framework for building rneovation

4.1. General features

The new sustainability framework has been developed using the results from previous sections. It has been divided into the two parts (see Fig. 8). The *External* part (the Char-

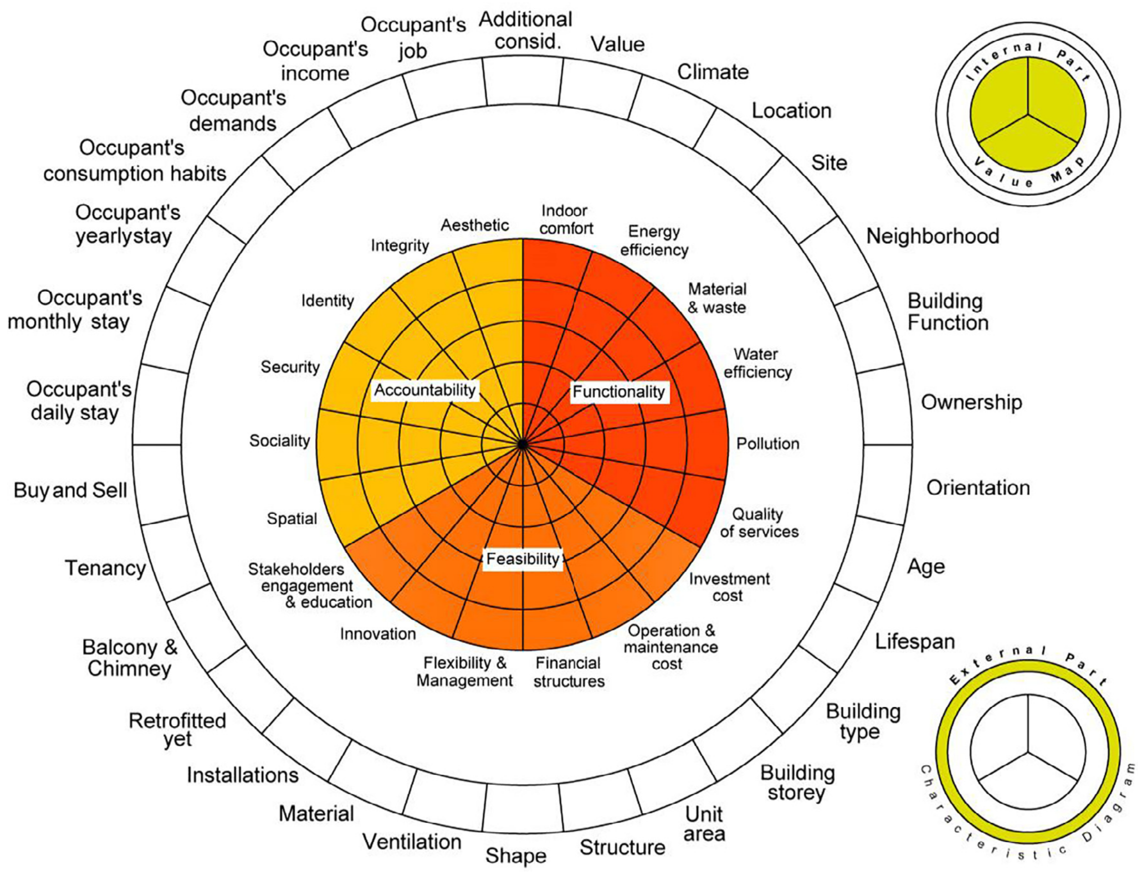


Fig. 8. Holistic sustainability decision-making support framework for building renovation.

acteristic Diagram) which can be used for the collection of the required data on pre-design or start-up phase of the retrofitting projects; and the *Internal* part (that is the main part of the developed framework) works as Value Map (see next section for the application). The main 4 inherent principles of the such framework can be described as:

- *External part (Characteristic Diagram for Building Renovation)*
  (1) The renovation key-factors on external part of the framework must be considered initially before making any decision on retrofitting case

- *Internal part (Value Map)*
  (2) The Value Map (internal part) is separated into three equal parts and each one belongs to the three newly driven sustainability categories;
  (3) The value score is outwards and therefore the best renovation alternative corresponds to largest star;
  (4) The divisions are utilized instead of compass points in order to illustrate values by assigning a visually correct geometrical weighting.

The purpose of developing this framework has been to represents a new simplified sustainability decision-making framework for building renovation to support project development and communicate outcomes with stakeholders. An adjacent counterpoising of the different criteria in the Value Map that some methods try to carry out, should not be performed. It predominantly seems essential that the three pillars of *Functionality*, *Feasibility* and *Accountability* have to be given even portion visually. Doing so represents the relative effect of various possibilities to the users. For each renovation project, the priorities are quite vary from case to case and therefore the counterpoising of the criteria is interdependent consistently. A renovation strategy can clearly be considered far better than another, even without calculation of a value precisely. Precise scores matters less than the process to make the final decisions.

4.2. The application

The decision-making support framework developed during the research activity is not just to evaluate if one solution (among possible retrofitting options) is preferable than the other, but it also can be utilized in early design stages to characterize essential areas and initiatives to achieve a holistic building renovation. The collected data relating to the key-factors (application of the external part of the framework), provides a basic and general knowledge about the renovation project, and further in a bigger picture, indicates if there is potential for the building to be renovated. The internal part of the developed decision-making framework, functions as a Value Map (see Fig. 9) which visual-

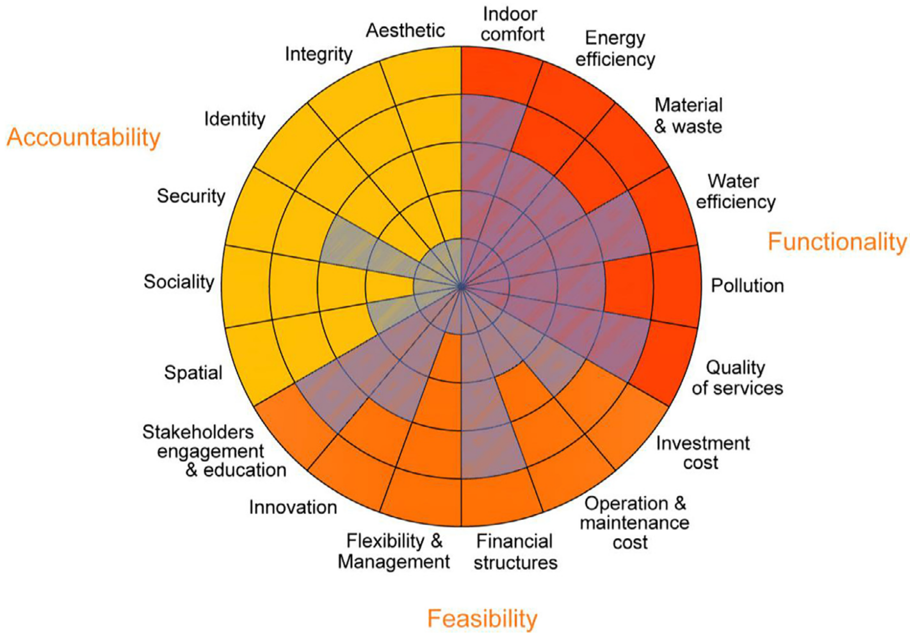


Fig. 9. Holistic sustainability decision-making support framework for building renovation (Internal part: the Value Map).

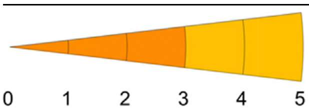
izes the main objectives for sustainable retrofitting. It does not offer guidelines for sustainable design, rather it focuses on multi-criteria appraisal, and can be used together with consultant sustainability services. The intent is an optimum of all requirements, not maximization of some. For this reason, a comprehensive data gathering needs to be performed. Literature reviews, site visits, desktop study, review meetings, and participation with relevant stakeholders are the possible ways of data gathering. Further, the data need to be examined to ensure that it has been collected methodologically and statistically sound. The results can be utilized in order to observe, audit and assess the renovation case performance (to be in accordance with sustainability in its totality) and support decision-making during the project's lifecycle. It can be utilized to perform a baseline appraisal, investigation on the possible gaps within and on intersections of the key risk areas, or recognize and set up key performance criteria and indicators during early design stage. It can also be utilized to guide decision-making and stakeholder participation. In addition, the pros and cons of each alternative renovation solutions can be compared so as to identify their particular significance, which effect differently from case to case due to related various circumstances. It can also be utilized to undertake assessment after the execution processed or during operation phases that can lead to organizational learning and identification of efficient approaches to latter cases. In addition, it might be used for the regions that do not yet offer rating and certification among existing assessment methodologies, or where a client wants to test readiness for certification (e.g. DGNB-DK[8]) and enhance performance of the building renovation. Hence, it can be underlined that the developed framework can be considered not only as an abstract framework while a project is being developed, but a bound method of the design and planning process as well as assessment and comparison within building renovation context.

4.3. The scale of the criteria

The sustainability decision-making support framework's performance rating system (in accordance with sustainability in its totality) for criteria has represented in Table 5. It demonstrates a graduated rating system from a range of 1–5. In this framework, value 1 indicates sub-standard quality while value 2 means "normal practice" or features expected about recently retrofitted buildings and solutions. Value 3 corresponds a results well above today's practice, and value 4 means application of exceedingly advanced solutions. Value 5 which is the maximum value in this framework refers to what we presently may contemplate as more or less "fully sustainable retrofitting" – for instance a near-zero energy renovated projects (Morelli et al., 2012). There are very few projects in around the world which may reach this outward ambience at more than two or three scores. In a full assessment of each criteria – in addition to the indicators provided for each criteria (see Table 4) – most might require further detailed breakdown including sub-indicators, for instance the different factors regarding to Human Identity. Therefore, for each one of the 18 criteria, indicators can be expanded more in detail and as such, the evaluation can be performed either in a detailed format or/and simple procedure. During the appraisal, those are the indicators that are evaluated using the holistic sustainability decision-making support framework's performance rating. The privileged

[8] http://www.dk-gbc.dk/.

Table 5
The sustainability decision-making support framework's performance rating system – e.g. of the indicator: Durability.



Durability	Value	Standards	Ratio	Example
	1	Sub-standard	Low	5–10 years
	2	Minimum standard	Reasonable	10–15 years
	3	Good practice	Moderately	15–20 years
	4	Best practice	High	20–25 years
	5	Exemplary	Very high	More than 25 years

and insecure cases will be identified for each indicator. Further the assessment items are deployed from the indicators through running a comprehensive set of essential questions. In order to aid the user while considering the questions, extra information such as some figures and more explanation can be provided. These questions can be utilized by design team to estimate the specific rating that each indicator has to obtain. The assessment items (questions) have to be assessed in turn and assigned a score. A short description have to be provided for the justification of the scores. To this end, scores should be allocated based on topic experts and building renovation contractors. It needs to be critically done where there are especially regulatory requirements that needs to be met. Hereafter, an initial appraisal based on aggregation of the indicators and sub-indicators' scores can be estimated and subsequently the averages of these scores will be assigned to the criteria. Doing so leads to both collect and later assess the required data about the renovation project comprehensively.

4.4. Qualities and quantities

Depends on the type of the criteria which were developed in this paper, they can be categorized as soft or hard, subjective or objective, and qualitative or quantitative inherently. Factors corresponding to *Functionality* in the Value Map are quantifiable mostly; it can be considered as the main reason why many architects or design engineers often used to narrow their design on sustainability to the a few factors including energy efficiency, lifespan or investment costs, which can be measured in an adequately objective way. Factors regarding to *Accountability* or *Feasibility*, in the other side, are not quantitative but qualitative. And it means they need to be assessed or appraised qualitatively. They have to be met and designed at the drawing board stage. It compulsorily needs to be performed, however the outcomes are to a far larger degree relevant to stakeholders' perceptions. Keeney (1992) states that the values must be identified and defined precisely; it can then be articulated through this meaning qualitatively by stating objectives, and, if desirable, it can be embellished with quantitative value judgments. Wandahl et al. (2006) discuss difficulty of measuring a value grounded in at least two factors, the subjectivity of value, and the difficulty in making the value statements explicit – you cannot measure something you do not know. In this regard, developing such decision-making support framework can overcome the second issue; and corresponding to the first one, evaluation should be post-occupancy, using sociological methods such as the approaches which were being developed in Systems Thinking (Checkland, 1999) and Theory domains and have been used broadly. Consequently for renovation projects to be in accordance with sustainability in its full sense, it seems essential to focus on the interactions and interdependences of quantitative and quantitative aspects corresponding to the objective and subjective values during the project life cycle. As Butters (2014) states the sustainability is not something that can be delivered. Nor can it be evaluated once and for all. It is a condition that must be considered over time.

5. Conclusion and further studies

5.1. Conclusion

This paper included the development of a new simplified holistic sustainability decision-making support framework which applies to the structures of the built environment for renovation of the existing buildings. It can both be utilized as a holistic sustainability framework to audit, develop and assess building renovation performance, and support decision-making during the project's lifecycle. It is a holistic sustainability decision-making framework to support the development of renovation projects and communicate the outcomes with relevant stakeholders. In order to develop the framework, the research employed a multi-dimensional research strategy that involves a variety of approaches including literature review; exploration of some well-known existing assessment methodologies; conducting individual and focus group interviews; and eventually it included the application of SSM with VFT to problem of knowledge management in building renovation, as a complex issue, challenging from case to case and difficult to act upon. The outcomes were validated using two rounds Delphi study. As the result of developing this new framework through series of interviews, workshops, meetings, conferences and reviewed literature, it might be concluded that present takes on sustainability objectives fulfilment in this area (the building renovation) is not holistic enough and not examining the greater chain of effects. Intelligibly there is a lack of systems thinking in this context, though, we need to examine new thinking approaches to illustrate it more holistic with much more integrity and awareness of different stakeholders and their priorities within a building renovation. It is the roadmap to overcome such complex problems which can be obtained only if we succeed in amplifying

Please cite this article in press as: Kamari, A. et al. Sustainability focused decision-making in building renovation. International Journal of Sustainable Built Environment (2017), http://dx.doi.org/10.1016/j.ijsbe.2017.05.001

cross-disciplinary or multi-disciplinary perspectives. So the focus in this context must be shifted from a technical evaluation to sustainability – from eco-technology to the whole picture. As such, if the goal is further sustainable development paradigm, therefore, it entails developing integrated design processes and assessment methodologies besides holistic decision support frameworks.

5.2. Further studies

According to the procedure of a consensus-based process for the development of an effective sustainability decision-making framework that applied in this research project, this study also provides an outset step intended for the establishment of a sustainability decision support and assessment tool suited to building renovation context. It therefore needs further developments including the assessment items and benchmarks (Lee, 2012; Lee and Burnett, 2008) as well as software. The next step of this research project, therefore, will be to conduct a study based on development of a Sustainable Retrofitting Framework by introducing 3 levels of Integrated Design Process Implementation and Evaluation[9]. It concentrates specifically on the development of two different frameworks alongside two different types of decision-making methods. Each framework will be divided into the three stages of integrated design process including *Exploration*, *Assessment* and *Scientific Decision-making*. The *Exploration* stage is designed to respond the essence of various stakeholders and building conditions in time of renovation; the *Assessment* stage is formulated to address the trade-offs or correlations between the sustainability criteria upon varies renovation strategies; and finally during the last stage, the selection of the most efficient renovation scenarios can be finalized using an approach is named *Scientific Decision-making*. It is worth noting that there is a huge potential in order to consider and develop such a decision-making framework further into the areas including Generative Design Systems, Computational Design, Performative Architecture, Decision Support System (DSS), and ultimately Building Information Modelling (BIM) as cutting edge technologies today (Ahmad and Thaheem, 2017; Jalaei and Jrade, 2014; Whalley, 2005).

Acknowledgment

The authors of the paper would like to show their gratitude to the Danish Innovation Foundation for financial support via the project “RE-VALUE”, as mentioned in the Section 1.2, and to the onsite design and execution teams for kindly assisting the authors in order to run the interviews, workshops and collection of the required data.

[9] The outcome of this stage of the present research study as a separate paper [which has been written by the same authors] has been submitted to the PLEA 2017 conference, Edinburgh, UK. It is under review at the time of submission of the present paper. It will be published on July/2017.

Appendix A

A brief description about the existing key factors in building renovation context:

- ***Value****:* Does the property have historical or cultural value?
- ***Climate****:* What is the dominant climate or related climatic zone of the area? (e.g. cold and dry)
- ***Location****:* Does the building located in rural area or urban sector?
- ***Site****:* What are the specific characteristic of the site the property situated? (e.g. proximity to crowded spaces)
- ***Neighbourhood****:* What is the neighbourhood status of the building? Does the building working or connected with other buildings?
- ***Building function****:* What is the function of the property? (e.g. residential, commercial, hospital etc.)
- ***Ownership****:* What is the status of the building’s ownership and occupants? (e.g. the owner is government and the flat has been rented as a 100 years inhabitancy schema)
- ***Orientation****:* What is the orientation status of the building?
- ***Age****:* What is the age of the property?
- ***Lifespan****:* Has the building been planned (from construction to demolition) for a certain period? (e.g. municipalities outreach plans)
- ***Building type****:* What is the type of the building? (e.g. multi-story building, single flat building etc.)
- ***Building story****:* What is the scale of the building? (e.g. the number of the floors and units in a multi-story and unit apartment)
- ***Unit area****:* What is the area of the units? (e.g. the size of the units in a multi-unit apartment)
- ***Structure****:* What is the structure and envelope type of the property? (e.g. metal and brick)
- ***Shape:*** What are special things about the shape of the building? (e.g. a curvy shape)
- ***Ventilation:*** What is the ventilation system of the building?
- ***Material:*** What are the types and specialty of the existing material?
- ***Installations****:* What is the installation (heating, cooling and electrical systems) type of the building? Have they divided privately between the units or they are common between the units? (e.g. central heating system in a multi-story building)
- ***Retrofitted yet****:* Has the property been renovated so far? When?
- ***Balcony and Chimney****:* Is there balcony or chimney in the building?
- ***Tenancy****:* How late is the property under rent? (e.g. the property has been rented for 2 years till January/2017)
- ***Buy and Sell****:* Is the owner going to sell the property? When? (e.g. owner is going to renovate the building in order to immediate sell)

- ***Occupant's daily stay**:* How many hours are the occupants staying at unit/flat? (e.g. day and night except 7 am to 2 pm)
- ***Occupant's monthly stay**:* How many hours are the occupants staying at unit/flat? (e.g. day and night except 7 am to 2 pm)
- ***Occupant's yearly stay**:* How many month are the occupants staying at unit/flat? (e.g. all of a year except July)
- ***Occupant's consumption habits**:* What is the occupant's energy consumption habits? (e.g. opening the windows from 5 pm to 7 pm during the day)
- ***Occupant's demands**:* What is the occupant's demands of retrofitting? (e.g. no changes in the building but insulation)
- ***Occupant's income**:* How much is the occupant's income level?
- ***Occupant's job**:* What jobs type are the occupants doing?
- ***Additional consideration**:* In some special cases there is possibility of adding question to this list (e.g. is the building suffering from special fungus, insects etc.?)

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Please cite this article in press as: Kamari, A. et al. Sustainability focused decision-making in building renovation. International Journal of Sustainable Built Environment (2017), http://dx.doi.org/10.1016/j.ijsbe.2017.05.001

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