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Article

Unveiling the Process of Sustainable Renovation

Liane Thuvander [1,*], Paula Femenías [1], Kristina Mjörnell [2] and Pär Meiling [1]

[1] Department of Architecture, Chalmers University of Technology, Sven Hultins Gata 6, Göteborg SE-412 96, Sweden; E-Mails: femenias@chalmers.se (P.F.); par.meiling@chalmers.se (P.M.)

[2] Energy Technology, SP Technical Research Institute of Sweden, Borås SE-501 15, Sweden; E-Mail: kristina.mjornell@sp.se

* Author to whom correspondence should be addressed; E-Mail: liane.thuvander@chalmers.se; Tel.: +46-31-772-1000; Fax: +46-31-772-2485.

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Abstract: Renovation processes are complex and there is a risk of underestimating architectural, cultural, and social values in favor of exterior and interior upgrading, energy efficiency and financing. A synthesized, systematic process is needed for making decisions about renovation measures. The aim of this paper is to survey decision-making procedures aimed for sustainable renovation. We inventory existing tools and methodologies based on (a) a literature review and (b) results from a workshop with participants from the Swedish buildings sector, academia, and other stakeholders. Our results show that there are many tools available but few seem to have reached acceptance in renovation. None of the more established methods and tools addresses a complexity that balances material and immaterial values and they are often too specific. There is a need for simplified tools, especially for evaluating more intangible, experienced values. Instead of one comprehensive tool preferably a methodology for renovation should be developed with references to different tools. In the building sector, renovation should be considered a service-minded process rather than a merely technical one as often is the case in new construction. There is a need to clarify the process and the meaning of the terms, and that need is even more urgent when it comes to the values that are more difficult to define.

Keywords: building assessment; tools and methodologies; decision-making support; sustainable renovation

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1. Introduction

1.1. Background

The built environment is often the focus of discussion in the efforts to fight climate change. Activities related to the built environment constitute 40% of the total societal energy use and a major part of the EU's greenhouse gas and carbon dioxide emissions [1]. Considering that the building stock in Europe is being renewed at a rate of only 1%–1.5% per year, there is a large potential to carry out energy saving measures in the existing building stock [1,2]. These facts have pushed Europe to take actions to reduce energy use and carbon dioxide emissions in the building sector and the built environment. In 2002, the European Energy Performance of Buildings Directive (EPBD) adopted a set of minimum efficiency standards for both new and existing residential and commercial buildings [3]. In 2009 a recast and strengthened directive [4] stated that all new and renovated buildings must comply with tough energy-performance standards and supply a significant share of their energy requirements from renewable sources after 2020. The European directive states that "major renovations must increase energy-savings if doing so is technically, functionally and economically feasible" [3]. The Swedish governmental policy concerning energy efficiency in the built environment is aiming at a 20% reduction in energy use by 2020 and a 50% reduction by 2050 compared to 1995 levels [5]. Further, by 2020 a reduction of 40% of greenhouse gases should be reached, and at least 50% of the total energy use should be based on renewable energy sources [6]. Thus, upcoming strengthened EU directives and national regulations will put pressure on property managers and owners to take action.

Due to the age distribution of the building stock and related refurbishment needs, construction activities are increasing in the field of maintenance, renovation, and transformation. In Sweden, about 56% of all investments in housing are related to building activities in renovation [7]. Yet it is new construction that is highly normative in determining routines and procedures in construction as well as in the training and postgraduate training of architects and engineers [8], and if they want to survive as independent professions, they have to adopt new skills, relevant contextual knowledge, and new, consistent value systems [9]. Despite the growing attention to the existing building stock, most of the regulations and instruments still aim at achieving sustainable *new* construction [10], and there is a lack of standardized routines, policies, and regulations that focus on the renovation process [11].

Renovation may often be preferable to demolition and new construction as means of reducing total energy use. Studies have shown that the actual life of buildings exceeds the estimated service life [12,13], and in terms of resource use and environmental impact including both production and operation, there is a preference for renovation over demolition [14,15]. However, narrower studies that focus on, for example, climate impact can result in strategies that favor new construction [16]. The built environment is an important part of Europe's cultural heritage, a national and regional identifier, and a hub for socio-economic development [17]. It is estimated that 37% of global tourism has a cultural motivation [18].

Renovation processes are complex and more uncertain in terms of decision-making, planning, and execution than the process of new construction [2,19–21]. The qualities and the deficiencies of the existing building need to be known. A lack of knowledge risks the loss of inestimable values when, for

example, elements of high material, technical, or artistic value are replaced by industrial, low quality products with a shorter life-span. There is also a risk that architectural, cultural and social values might be neglected in favor of energy and economic performance metrics. Further, these immaterial values of the built environment are often perceived as fuzzy and difficult to handle. More knowledge and supporting tools are needed in order to make systematic, synthesized decisions in renovation projects that will enable us to balance various desires, needs, and values with respect to a number of important aspects such as energy, environmental, technical, and economic performance as well as social, cultural, and architectural aspects.

According to Swedish law, managers of rental properties must receive at least 50% of the tenants' consent prior to actions that will raise the apartment standard and consequently lead to increased rent [22]. An updated Swedish law that regulates the activity of public housing companies [23] states that these companies shall operate according to commercial principles and "normal" requirements for the return on investment of capital [24]. This legislation implies that social issues might be more difficult to include in renovation by public municipal housing companies, which indicates a need to reconsider which complementing regulations and measures are needed in order to deal with different problems in the housing market [25]. Prior to this updated law, large renovation projects initiated by public municipal housing companies in Sweden often included actions to tackle social issues.

1.2. Aim and Scope

The aim of this work is to understand the current decision-making processes for renovation in order to come up with suggestions on how it can be improved to better handle significant sustainability aspects. Key questions are: What actors are involved and at what stages of the process? What tools exist to potentially support a more multi-faceted approach taking into consideration a higher number of sustainability aspects? We have identified a lack of sources that describe the decision-making process of renovation. In order to get a picture of current processes, a survey of decision-making procedures and existing decision support tools used by stakeholders in relation to renovation of existing buildings was done. The results of this survey are a necessary starting point to identify needs for further development of such tools and methodologies.

Additionally, we reflect on new ways of conducting research, development, and innovation using a transdisciplinary arena in which a broad range of stakeholders from building industry, society, and academia collaborate on the definition of problems, challenges, and opportunities and on data collection and knowledge generation.

Renovation is addressed from a broad perspective, including both residential and commercial buildings owned and managed by private or municipality owned companies. The emphasis is on the preliminary investigation phase, *i.e.*, the phase in which the main direction and goals for renovation are defined and decided. Furthermore, we focus on decisions about major renovations.

1.3. Approach

A survey of existing tools and methodologies was carried out and based on (a) a limited literature review and searches on the Internet and (b) results from a workshop with stakeholders from the Swedish

building industry, academia, and other societal organizations. In the literature review, a mapping of existing tools and methodologies that could be used to make decisions in the process of renovation based on environmental building assessment was made. Among these, a number of internationally well-established tools and methodologies together with a number of Swedish approaches have been discussed. Some of these methods were then further investigated with respect to sustainable building aspects such as environmental, technical, architectural, cultural, social, and economic.

The workshop with property owners (private and public municipal housing), architects, consultants, contractors, representatives of the Swedish Union of Tenants, the Gothenburg City Planning Office, the Gothenburg City Museum, the Regional Heritage Administration of Western Sweden (Västarvet), and the Västra Götaland regional administration was organized in order to get a picture of the current decision-making procedures used by property owners and other stakeholders involved in the renovation process. The empirical material derived from the workshop was analyzed in order to reach an understanding of the decision-making process used today by various organizations.

2. Terminology and Concepts

2.1. What do We Mean by Renovation and Sustainable Renovation?

There is no general definition to describe building changes, but a large variety of partly overlapping terms are in use. Among the common terms are alteration, adaptation, renovation, rehabilitation, refurbishment, retrofitting, restoration, reconstruction, retro-commissioning, modernization, transformation, tune-up, see for example [21,26–29]. The use of a diverse terminology is due to the varied type and scale of buildings, the large range of actions, and the variety of reasons and motivations for making an intervention, e.g., preservation, technical, functional or social obsolescence [30,31]. Changes to buildings can range from minor repairs or re-fit with a minimum of interventions to major renovations with larger changes of the original building. At one end of the scale we find preservation or conservation which only arrest decay, usually in attempts to preserve the original building [27,32], and at the other end we find clearance and reconstruction or replacement of an entire building [33,34]. While some terms are rather unanimously used, for example preservation, conservation, modernization or rehabilitation, other terms have a larger span of interpretation. Some authors use the term renovation to indicate a minimum of interventions [30] while others find the term to indicate more consistent upgrading [34]. Some authors use the term retrofit to emphasize the act of improving a building to a higher standard [28,35], for example in respect to objectives for sustainable building [19].

The new Swedish Planning and Building Act published in 2011 [36] uses the more general term alteration to indicate changes of a building's structure, function, use, appearance or cultural historical value [37]. Alteration includes both new additions to a building and changes where a significant or a more limited part of an existing building is significantly altered. Alteration is not defined by the size of the interventions but by the consequences of the same. There is no sharp limit between alterations or maintenance where the latter can for example have consequences for the exterior characteristics of the building (e.g., changed roof material). Regarding the regulation, the altered part of the building is subject to the same technical and energy efficiency requirements as a new building. However, non-compliance with the regulation is negotiable regarding the extent of the changes, specific

pre-requisites and in relation to requirements in the Planning and Building Act for cautious alteration (in Swedish varsamhetskravet) and prohibition to distortion (in Swedish förvanskningsförbudet). Considering the lack of universally agreed definitions, we are using the commonly used term renovation, which we define to include middle range to major interventions.

Our focus is sustainable renovation, which refers to ambitions to fulfill the dimensions of environmental, social and economic sustainability in changes to buildings. In the sustainability debate, improvement is often related to energy savings and environmental issues. When dealing with existing housing, the social dimension representing the residents and their connection to the site becomes more important. Energy conservation actions are often influenced by municipal policy and economic return (reduced operation and maintenance costs) [38,39]. However, major renovation of the building envelope to reach energy efficiency is more scares as this is associated with high cost and low return of investment due to a number of factors including the market value of the property, the slow increase of energy prices, and difficulties to transfer the costs upon rent [11]. Energy improvements *per se* are seldom the main motivation for initiating a major renovation but one of several coinciding needs. In fact, our observations are that even today many renovations are carried out without specific attention to achieve energy efficiency. Earlier studies have shown that one main driver behind European renovation activities is the goal of increasing comfort levels (mostly maintenance, repair and modernization aimed at extending component service life, increasing comfort or replacing components) [10]. Social deterioration has also been a strong motivation for larger interventions in existing housing [40]. In later years, energy efficiency and other environmental considerations have been combined with social improvements in existing housing areas as an attempt to address sustainable renovation in a more comprehensive way [26]. Due to the complexity of sustainable renovation in which multifaceted values and objectives should be dealt with, there are in fact few examples where optimal results have been reached regarding all dimensions of sustainability. Some studies point to non-achieved objectives in the social dimensions regarding for example equity, integration and democracy [26,41].

There is also a need for quality assurance in the renovation process to assure that the initial requirements are fulfilled throughout the renovation process as well as in the operation phase [42,43].

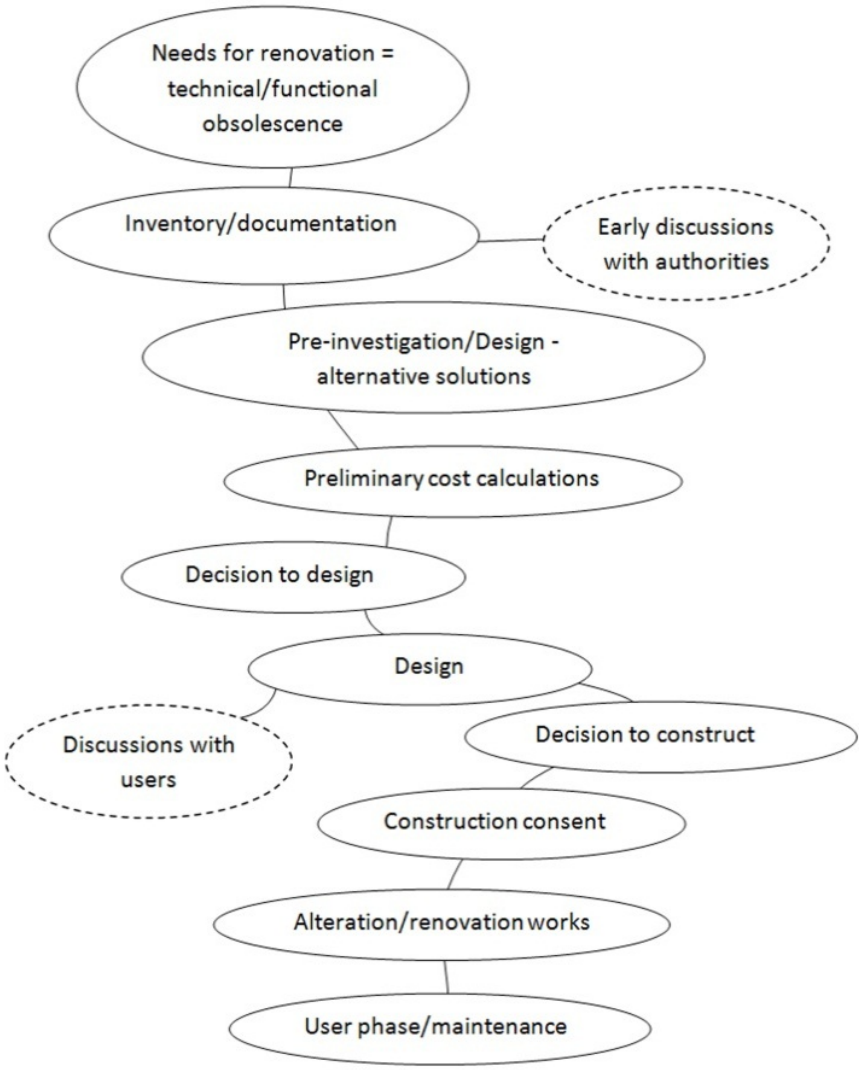
2.2. Renovation Process and Preliminary Investigation

In general, a renovation process has more or less the same phases as the process of new construction (pre-design/preliminary investigation or programming, design, construction, commissioning, and occupancy or use). However, in renovation more emphasis should be laid on the preliminary investigation phase in terms of time and resources to achieve good results [19]. In this context it should be added that renovation processes often start with poor documentation of building conditions.

The focus of this paper is on the preliminary investigation phase as this is the phase in which the main direction and goals for a renovation are defined and the most significant decisions are taken (Figure 1). What then do we mean by preliminary investigation in renovation? When a property owner or construction client has identified a need for a major renovation, usually a preliminary investigation is carried out in order to survey and investigate special issues and to establish a relevant documentation. The preliminary investigation is an important part of renovation and alteration projects.

In Sweden, the local planning and building committee can require a preliminary investigation if this is not submitted by the property owner.

Figure 1. Schematic overview of a renovation process. Adapted from [44].



Thorough preliminary investigation is a broad term that includes the collection of various types of information, an inventory of the status of the building, and the establishment of a documentation of the building prior to an alteration. According to Nordling and Reppen [44], undertaking a preliminary investigation is prescribed by Swedish law. Nordling and Reppen [44] also argue that a preliminary investigation should include surveys of the building and its environment (the local context, general impressions, technical status, maintenance status), documentation of user requirements, documentation of property data, contracts that concern the building, history (building year, previous renovations/alterations, users, previous color schemes), and drawings and pictures (construction drawings, historical drawings, sketches, photographs). Also, a preliminary investigation should be objective and not include subjective evaluations.

According to BPIE [2], the building owner's decision-making process for undertaking renovation differs a lot depending on the reason that gave rise to starting the process. In many cases it is a question of immediate maintenance for which the decisions are taken based on the appraisal of options

under time constraints whereas in cases of non-urgent maintenance cost benefit analyses are performed based on a certain payback horizon also valuing ancillary benefits. If the reason for renovation is to improve the buildings or apartments, in terms of stand-alone measures, the decision factors are basic information, trustworthy advice and a willingness to act, but consequential improvements on the other hand are decided based on competing investments whereas for whole building renovation, the decision factors are professional expertise, quality contractors and finance.

3. Literature Review of Existing Tools and Methodologies

3.1. Framework for Description

The literature review aims at looking into which existing tools potentially could be used for a more multifaceted approach in the decision-making process of renovation. It is divided into two parts, a literature review regarding previous articles that study and compare building assessment tools, and a comparison of the tools according to a framework proposed by Thuvander, Femenías and Meiling [45]. This framework describes a number of values with a division into architectural, social, cultural historical, technical, environmental, and economic values together with process quality. We have reviewed and discussed the literature based on this framework and in light of how the different values are addressed. Our focus is on tools and methods for renovation. However, since only a few methods have been developed for renovation, we have also studied tools and methods that were developed for new construction but have the potential to be adapted to renovation. Our point of departure is building environmental assessment methods.

3.2. What Tools and Methods Are There to Support Decision-Making for Sustainable Renovation?

In the literature, there is a wide range of international and national tools and methods for assessing or classifying buildings from an environmental or sustainability perspective. Some are being used globally; others concentrate on local, regional or national specifics. The most established and widespread assessment methods are, among others, BREEAM (the Building Research Establishment Environmental Assessment Method, the first commercially available environmental assessment tool for buildings, introduced in 1990 in the UK), the American LEED (Leadership in Energy and Environmental Design), CASBEE (the Comprehensive Assessment System for Built Environment Efficiency, widely used in Japan), DGNB (the German certification for sustainable buildings, Deutsche Gesellschaft für Nachhaltiges Bauen), EPIQR (Energy Performance Indoor Environment Quality Retrofit), or the Green Building Tool. On the EU level, there are two ongoing projects in the seventh framework program, SuPer-Buildings [46] and OPEN HOUSE [47]. In Sweden, we can find the more internationally known methods and tools such as EcoEffect, the Swedish environmental rating tool, (in Swedish Miljöbyggnad) [48] and the Nordic eco-label Svanen [49].

The building environmental assessment field has been reviewed since the early 1990s [50], and since then these kinds of tools have been compared in a number of studies [50–61] Todd, Crawley *et al*. [51] describe specific elements of selected assessment systems, such as building type, criteria, and scoring/weighting/reporting results. Forsberg and von Malmborg [52] make an overview of the status of quantitative environmental building assessment methods developed in Northern

Europe, the ambitions for the object analyzed, and methodological aspects. Cole [54] discusses assessment methods and tools that include performance issues and structural features that differentiate them from earlier methods. Haapio and Viitaniemi [56] analyze and categorize sixteen internationally well-known environmental assessment tools for buildings and Ding [55] summarizes and describes the characteristics of twenty assessment methods. SuPerBuildings [57] reviews existing building evaluation tools based on three pillars of sustainability—environmental, economic, and social issues—and analyzes them for the availability of indicators and their degree of common understanding. Essig, Fischer *et al*. [58] review the current status of the development of international standards (e.g., TC59/SC 17 [62], CEN/TC 350 [63]), global initiatives (e.g., SB Alliance, iiSBE), and international methodologies (e.g., LEED, DGNB), targeting the assessment of sustainable buildings at national, European, and international levels. Malmqvist, Glaumann *et al*. [59] compare special characteristics of the Swedish environmental rating tool, which has been developed for existing buildings, with other well-known environmental assessment/rating tools. Blaviesciunaite and Cole [61] compare LEED and CASBEE regarding embedded cultural values .

In the OPEN HOUSE project, a large list of sustainability indicators emerged [58], which then provided the basis for selecting the indicators and developing the structure of the OPEN HOUSE methodology [64]. Sidwell, Clark *et al*. [53] review retrofit methods (EPIQR, MEDIC, TOBUS, *etc*.) and identify the most common criteria for building retrofit tools. The reviewed tools are seldom related to construction management or procurement methods, which are paramount for project delivery due to the uncertainty in renovation projects [53].

Other European methods of interest with special focus on renovation and not included in the above-mentioned studies are, for example, the Swiss Retrofit advisor, the more theoretical framework ADE, or the Swedish "Million Homes" knowledge base. Retrofit advisor [65] is an Excel-based tool supporting the building owner in the decision-making process for comparing different possible retrofitting measures. The tool makes predictions about different retrofit scenarios (light, extensive, and full). ADE-Renewal, or Architecturally Diverse, Energetic Renewal, is a theoretical method for renewal/preservation that combines landmark preservation principles with enhancement of energy efficiency and energy performance [66]. ADE-Renewal has been developed for modernist buildings as a model solution. The Million Homes tool (in Swedish Miljonhemmet), developed by the Swedish construction firm Skanska, is a knowledge base for renovation of buildings constructed in 1961–1975. It contains documentation from work practices, checklists, analyses, calculations, evaluations, and research. The Million Homes knowledge base covers economic, environmental, and social factors. It also works actively to create a dialogue among the stakeholders involved in the rebuilding process, such as owners, contractors, residents, and local politicians [67].

3.3. Analysis of the Results

So, how are the above-mentioned tools and methods relevant for our purpose? Which of the values of most interest to us are addressed, *i.e*., architectural, social, cultural historical, technical, environmental, and economic values? In this section tools and methods are compared according to our framework and with the purpose of testing their usability in renovation processes in Sweden.

All the assessment methods were developed to serve the specific requirements of the context in which they are used. They are designed for different types of buildings, emphasize different phases of the life cycle, and the structure of the information sources is not neutral and can profoundly influence the outcome [50,56,59,68] and cultural differences influence the priorities of building environmental assessment methods [61]. The context may refer to culture, legislation, and traditions, as well as geographic and climatic conditions [59]. However, by comparing the sustainability indicators and assessment methods in each of the different evaluation tools, we can draw conclusions both about those indicators that are not covered by the tools and thus may need elaboration, and about those indicators that are covered by most tools but that may need some harmonization [57]. Also, to carry out a successful renovation project, all risks need to be identified [53].

Most of the national methods address new construction, some of them address existing buildings and some address renovation, as for example, BREEAM (Domestic Refurbishment), LEED (major renovation), BNB/DGNB (large-scale renovation of office buildings), Valideo (office buildings renovation), CASBEE (renovation, renovation–brief version), Klimataktiv Gebäudestandard (residential buildings, houses/passive houses–refurbishment), Green Star, Nabers, Million Homes (a knowledge base for renovation),EPIQR (renovation multi-family buildings) [69], TOBUS (office buildings) [70]. Related to the development of EPIQR are INVESTIMMO, a tool to help make appropriate decisions regarding maintenance and energy efficiency for existing buildings, and XENIOS, a tool for diagnosing conditions and choosing renovation strategies for hotels [71].

SuPer Buildings [57] presents tables with a comprehensive and detailed review of a number of national existing building evaluation methods. Based on these tables and our own searches, Table 1 has been developed to display the most comprehensive methods, *i.e.*, the methods that address several values (as described in [45]) and address renovation or can be adapted to renovation. All methods address technical issues and are therefore not explicitly described in Table 1.

Table 1. Compilation of selected building assessment methods and values addressed.

Methods	**Addressed values**				
	Economic	**Environmental**	**Social**	**Architectural**	**Cultural historical**
BREEAM [57]	Value management *-Planning/preparation* *-Management* Whole life costs Ease of maintenance	Primary energy consumption (operational) Materials Construction phase Land use and ecology Water Waste Management and risk LCA indicators *-Global warming potential* *-Ozone depletion potential*	Comfort and Health * Building safety assessment User well being Accessibility *-Physical impaired people* *-Green and open spaces* *-Public services/amenities* Access to transport Social and ethical responsibility	Building esthetics and context	-

Table 1. *Cont.*

Methods	Addressed values				
	Economic	**Environmental**	**Social**	**Architectural**	**Cultural historical**
LEED [57]	Asset Value *-Building adaptability*	Primary energy consumption (operational) Materials Construction phase Land use and ecology Water Waste	Comfort and Health * Building security Accessibility *-Public services/amenities*	Building adaptability	-
DGNB [57]	Value management *-Planning/preparation* *-Management* Whole life costs Asset Value *-Building adaptability* Ease of maintenance	Primary energy consumption (operational) Materials Construction phase Land use and ecology Water Management and risk LCA indicators *-Global warming potential* *-Ozone depletion potential* *-Acidification potential* *-Eutrophication potential* *-Photochem. oz. creation potential*	Comfort and Health * Building safety assessment User well being Accessibility *-Physical impaired people* *-Green and open spaces* *-Public services/amenities* Access to transport	Building esthetics and context	-
CASBEE [57]	Value management *-Service life* Asset Value *-Building adaptability* Ease of maintenance	Primary energy consumption (operational) Materials Construction phase Water Waste Management and risk LCA indicators *-Global warming potential*	Comfort and Health * User well being	Building adaptability	-
EPIQR [72]	Refurbishment cost	Heating/cooling energy requirement and energy saving potential	Occupants and indoor environment quality	-	-

Table 1. *Cont.*

Methods	Addressed values				
	Economic	**Environmental**	**Social**	**Architectural**	**Cultural historical**
OPEN HOUSE [64]	Building-related Life Cycle Costs (LCC) Value stability	Primary energy consumption Energy efficiency Biodiversity Light pollution Materials Water and waste water Waste LCA indicators *-Global warming potential* *-Ozone depletion potential* *-Acidification potential* *-Eutrophication potential* *-Photochem. oz. creation potential*	Comfort and Health * Operation comfort Safety and security Service quality Electro-magnetic pollution Accessibility *-Barrier-free* *-Public* *-Bicyclecomfort*	Quality of the design and urban development of the building and site	-
Retrofit Advisor [65]	Investment costs Management costs Rent income Asset Value -Building adaptability	Energy characteristic values Eco-indicator (points/sqm) construction and management	Accessibility *-Physical impaired people* *-Green and open spaces* Places for meeting and social contacts *-Mixture of apartments* *-Common facilities*	Building adaptability Architectural quality Architectural integration neighborhood	Identity and re-recognition Existing building fabric
ADE-renewal [66]	Renovation costs	Energy efficiency Materials	-	Architectural concept	Existing building fabric Original color concept

*: includes visual comfort, thermal comfort, acoustic comfort, indoor air quality, water quality

Table 1 show that many of the values of interest to us are handled in existing methods, but there are also gaps. Architectural values (mostly treated as esthetics) are only covered in some of the methods, and cultural historical values are more or less absent. Looking into more detail, environmental and technical values are covered quite well and described by a larger set of indicators, whereas economic and social issues are not well developed—they are often addressed by only a few indicators. Retrofit covers all values, however, the architectural and cultural values are handled in a very general and aggregated way.

3.4. Discussion and Conclusions from the Literature Review

The field of building assessment in the context of sustainability has been developing successively in recent decades. Assessment methods have extended in scale and scope in terms of objects (from products to buildings and neighborhoods), phases (new construction, existing buildings, renovation, *etc*.), types of buildings (residential buildings, office buildings, *etc*.), issues

(environmental, economic, social), purpose of tools and methods (awarding a medal, label or certificate, or supporting decision making), or object of concern (building as such, stakeholder).

In the literature, the building environmental assessment tools and methods are also discussed in terms of generations, *i.e*., first generation, second generation, or next generation [50,54,73,74]. The second generation makes use of the first's experiences and may struggle with areas of building performance assessment that were previously either ignored or poorly defined [50,54,73]. These previously neglected areas may include the ability to offer different levels of assessment output; the ability to acknowledge regionally specific environmental criteria; the use of different measurement scales for different criteria sets; the weighting of criteria; the ability to be used as design tools; the ability to link with other performance issues; *etc*. [73].

The first and second generation of assessment methods as described above focus mainly on the environmental part of building assessment, the technical issues, and mostly overlook management and process issues [75]. Recently, we can see a transformation from environmental buildings assessment to sustainability assessment, toward including economic, social aspects as well as process issues, and increasing the system level to include aspects on a neighborhood level. As recently as 2008, Haapio and Viitaniemi [56] believed that this transformation seemed to be far off. Lützkendorf, Hajek *et al*. [74] judge the development more positively in 2011, and argue that assessment systems for buildings are currently in a phase of transition. From their perspective, the first generation of assessment and certification systems followed a bottom-up approach and concentrated on topics such as energy efficiency and environmental and health issues that would support the planning design, construction, and marketing of green buildings. Now, the development is moving towards a new generation of assessment systems that follow a top-down approach and encompass the three dimensions of sustainability: the environmental, the economic, and the social [74]. All methods described in Table 1 address the three dimensions in one way or another, even if the economic and social aspects still are in the beginning with few indicators. Also, there is a need for the development of new, reliable, and functionally sustainable building concepts and services for building refurbishment [76].

A number of tools are available today to support the building owner in making decisions, but most of them focus on specific aspects such as environmental, economic, or social issues. Few are adapted to handle architectural or cultural historical issues, and none of the more established methods such as BREEAM, LEED, DGNB, *etc*. addresses a complexity that balances technical, environmental, economic, architectural, cultural, and social values. The Retrofit Advisor, ADE, and OPEN HOUSE cover most aspects. OPEN HOUSE will be used to assess existing buildings, but it will probably be too comprehensive and hence costly to use to evaluate each renovation option. Retrofit Advisor is probably too aggregated, especially for the intangible values, and there is not much transparency of how the evaluation is made which makes it difficult to estimate the value of the results. ADE lacks the social aspects. These methods could, however, form an entirely relevant basis for the development of a simplified decision support framework that focuses on the evaluation of renovation options in the early phase.

There is a shift from environmental buildings assessment to sustainability assessment and a top-down approach is recommend for the further development of sustainability assessment systems [74], which will enable an understanding of the system structure and provision of indicators of relevance to the stakeholders. This in turn requires a larger involvement in the development process by all stakeholders [54,76]. Also, stakeholders can integrate either the assessment process itself (and related

processes) or the assessment results into their decision-making, and for that a suitable adaptation and differentiation of assessment results and their presentation is necessary [74].

What about guidelines and checklists *versus* assessment tools? Different stakeholders use tools for different purposes and need different levels of result aggregation. Simple self-assessment tools and comprehensive assessment tools are often used, however, with a slight preference for the simple self-assessment tools when academics and/or researchers are excluded. Short checklists and third-party certification are also used. Partial aggregation is seen as the optimal level of detail of representations of results [77]. Stakeholder-friendly ways of presenting assessment results are important [74].

In summary, there is an ongoing transformation from environmental to sustainable building assessment methods and tools and a shift from a purely bottom-up approach to a combined top-down approach (subject of concern). The existing methods still need to be improved: economic and social values are addressed but only by a few indicators. The architectural and cultural historical perspectives are still missing in most of the existing methods and need to be further developed and integrated when carrying out a renovation. Finally, broader applications and increased stakeholder involvement are needed in order to achieve user-friendly designs and methods that are relevant for property owners to apply in the decision-making process.

With this in mind, a workshop was organized with a broad range of stakeholders in the buildings sector.

4. The Workshop

The workshop that we refer to is a part of a co-operation between two research projects, Renobuild and Rebo. Both these projects aim to develop tools (methodologies, checklists, guidelines) that support decision-making processes for sustainable renovation and to bridge the gaps between the socio-cultural, environmental, and economic aspects of renovation. The research projects are carried out in local, transdisciplinary arenas in which stakeholders from buildings sector, academia and others societal actors collaborate. A workshop is a typical arena activity.

4.1. Preparation and Execution

The workshop, entitled "Methods and Tools for Decision Making in Renovation," was carried out in May 2011. The aim of the workshop was to get a better understanding of the decision-making procedures in the different organizations, what kind of tools and methodologies that are used today, but it was also to identify the need of improvement of the existing tools or development of new tools covering all aspects of sustainable buildings. Questions of interest were: What investigations are carried out before decisions are taken? What methods or tools are used by the property owners, and what is offered by the consultants, builders, and other organizations?

All together twenty-five stakeholders participated, representing sixteen different companies and organizations (Table 2). All the stakeholders are part of the above-mentioned transdisciplinary research projects. The workshop lasted about 5.5 hours, including lunch, and was led by the research team. Before the start of the workshop all participants were asked to prepare individual homework: to answer the questions presented in Tables 3 and 4. The entire workshop was recorded. A summary of the workshop and the results was sent out to all participants for review.

Table 2. Participants of the workshop.

Type of stakeholder company (Number of participating representatives)	Main business area	Type of ownership	Nr. of employees	Main field of work
Property owner and manager A (1)	Local, inside growth region	Municipally owned parent company of 10 subsidiary municipal property companies	940	Strategic development of property 70.000 apartments 4.413.000 square meters 560.000 square meters of commercial premises
Property owner and manager B (1)	Local, inside growth region	Municipally owned	260	Under umbrella of A. 23.000 apartments 1.410.000 square meters
Property owner, manager and developer C (1)	Local, inside growth region	Municipally owned	40	Urban developer, management of 77 buildings 376.000 square meters
Property owner and manager D (1)	Local, inside growth region	Municipally owned	110	Management of 9.800 apartments 635.000 square meters
Property owner and manager E (1)	National, inside growth region	Privately owned	260	23.500 apartments 1.640.000 square meters
∑ Homework presentations: 6 *				
Architect A (2)	International	Employee owned	660	Architecture, urban planning, landscape architecture, environment and architecture, design, interior design, project management, visualization
Architect B (1)	Local, inside growth region	Privately owned	7	Architecture, research and development
∑ Homework presentations: 2				
Technical consultant A (2)	International	Private (foundation)	9.000	Engineering, design and consultancy
Technical consultant B (2)	National, mainly inside growth region	Privately owned	300	Technical consultancy: HVAC, energy and environment, BMS, fire and risk, technical administration
∑ Homework presentations: 3				
Construction company A (2) ∑ Homework presentations: 1	International	Privately owned	15.000	Infrastructures, construction, residential developer
Organization A (1)	National, regional	Member organization	850	Tenants' interests
Organization B (1)	Local	Public	60	History of Göteborg, referral body
Organization C (1)	Local	Public	260	Urban planning, building permissions
Organization D (1)	Regional	Public	270	Heritage administration
Organization E (2)	Regional	Public	50.000	County Council (health, work, education, culture, *etc*.)
∑ Homework presentations: 2				
Research Organization A(3)	Local	Foundation		University of Technology
Research Organizations B (2)	National	State owned		Technical Research Institute
∑ Homework presentations: -				
In total: 25 Participants, 16 Companies, 14 Homework presentations				

*: One of the partners joined the project after the workshop. The homework was carried out and presented at a following Rebo project workshop in August 2011.

Table 3. Homework questions for property owners/managers.

(i) About the process—decision about preliminary investigation
• Describe briefly what a renovation process looks like in your company.
• What leads to a decision to carry out an investigation/preliminary investigation about any renovation?
• Who makes the decision?
(ii) Thorough preliminary investigations
• What investigations do you carry out before starting a renovation?
• Which investigations do you carry out by yourself within the company? Which do you procure from outside the company?
• Who participates in these investigations (division in your organization, tenants/users, *etc*.)?
(iii) Evaluation of renovation options
• Do you develop different renovation options? When, in the preliminary investigation?
• Who evaluates different renovation options?
• What methods or tools do you use?
• What methods do your consultants use?
• Do the methods deviate between preliminary investigation and design?
(iv) Decision on action
• Who decides to go forward with the planning?
• Who decides to carry out the renovation?
• How is the renovation financed?
• Are the decisions based on the results of the evaluation of renovation options?

Table 4. Homework questions for consultants and other stakeholders (Preliminary investigation).

• Are you usually involved in preliminary investigations?
• What kind of investigations do you provide during a renovation project's preliminary investigation phase?
• What tools/methods do you use to conduct preliminary investigations for renovation projects?

The workshop was divided into two parts. During the first part of the workshop the homework was presented and discussed, and during the second part the needs for improving the existing tools or developing new ones were discussed in groups. The emphasis was on the preliminary investigation phase, when the main direction and goals for a renovation are defined.

Two different templates for the homework presentations were prepared by the research team in order to capture the characteristics of each stakeholder group. One of the templates was directed to the property owners and the other was directed to the group of consultants and other stakeholders. The homework was sent out three weeks prior to the workshop. The property owners were asked to reflect upon the steps in a typical renovation process within their organizations in order to illuminate what kind of investigations they carry out in support of their decisions, how they evaluate various renovation options, and how they make decisions (Table 3). The consultants and other stakeholders were asked to reflect upon their role in the preliminary investigation or pre-design phase of projects (Table 4).

The second part of the workshop day was dedicated to group discussions about improvements or development of the decision-making process and tools used in renovation projects (Table 5). The participants were divided randomly into three groups and given three questions to discuss. Each group presented a summary of the best ideas to all at the end of the workshop. The workshop was rounded off by a general reflection of each participant.

Table 5. Questions for the group discussion in the workshop.

- What can be improved in the decision-making process for renovation projects?
- Is there a lack of tools or methods?
- If yes, how should those tools or methods be designed?

4.2. Analysis and Results

After the workshop, we analyzed the data it generated: The presentations and discussions of the homework, notes of the discussions taken during the workshop by the researchers, and the audio recordings from the workshop. We compiled the data related to the first part of the workshop in a matrix containing all the questions from the homework (see Tables 3 and 4), answers per company or organization specified in the homework presentation slides, and input from the homework discussions.

Property owners. A typical decision to start an investigation or preliminary investigation process is often taken on the CEO-level, by the management team, or by district personnel, depending on the extent of the renovation. The motives for renovations are normally based on the age of the building, technical or performance deficiencies such as mold or high energy use, or high costs. Tenants' needs and requirements and analysis of the surrounding environment can also have an influence on the decision to start a renovation process. However, more than anything else, the range of potential actions available to property owners in renovations is limited by current laws and regulations that govern, for example, accessibility, energy use, rent setting, and tenants' approval. Property owners' actions will also be influenced to a high degree by their manager/owner's directives and business plan, by local policy, the latter especially in the case of public municipal housing companies [39,78], and by urban development and land allocation agreements [79].

One private developer declared the possibility of investing in actions that are not directly commercial if these are in line with the company's broader business plans. This kind of investment decision seems more difficult to take for public municipal housing companies that find themselves impeded by Sweden's New Act on Public Municipal Housing Companies.

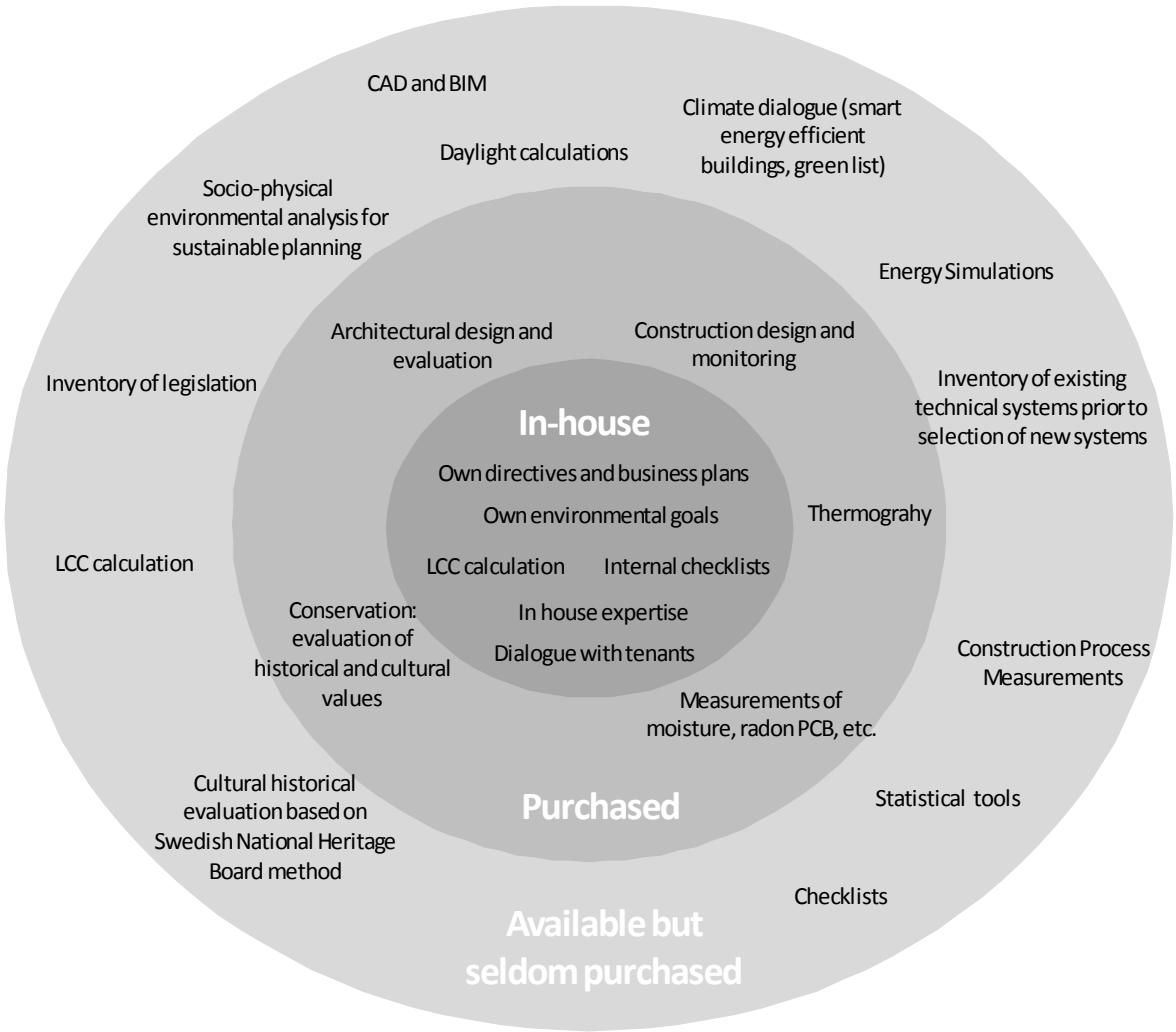
In the preliminary investigation phase, usually a number of alternative solutions are discussed, and sometimes even alternative processes are discussed, such as whether to combine several measures in one renovation package. What economic changes are acceptable for tenants? Does a specific measure imply an added value for the tenants? Alternatives might range from minimum actions prompted by technical deficiencies, to profitable improvements that imply increased comfort for tenants and that reduce energy costs, to complete renovation involving upgrading of the building's envelope and heating and ventilation system. Alternative solutions are evaluated from an economic perspective, for their impact on revenue, from a life-cycle perspective, and for the value they add to the area, but they are also evaluated based on expert assessments of costs and technical performance.

Examples of the tools/methods used in the preliminary investigation phase include life-cycle cost (LCC) calculations, market analyses, cash-flow calculations, cost-of-capital discounting, more general discussions on the basis of comprehensive data, investigations by consults, and dialogue with the tenants, but interestingly also "gut feelings" based on professional experience.

Other stakeholders. Examples of investigations carried out for clients in the preliminary investigation phase include assessment and selection of technical systems based on LCC, energy and environmental studies, certifications, design, management control, technical inspections, preliminary investigations by antiquarians, cultural historical evaluations, foot-traffic analyses (in Swedish gåtur), and sociological studies using empirical inquiry or sociotop maps. The tools and methods used include energy calculation software, building information modeling (BIM), and energy simulation tools, as well as methods developed within a company for design (see Figure 2 for more examples).

The material from the second part of the workshop, the group discussions, has been compiled in thematic topics as a result of the discussions: design and construction process, economy, involvement of tenants, and architecture and conservation. More general questions, questions of special interest, and comments have been highlighted.

Figure 2. Examples of decision-making tools and methods used (own) or purchased by housing managers and offered by other stakeholders in the preliminary investigation phase.



Regarding the *design and construction process*, the participants pointed out that all actors should be involved earlier in the process, which in turn (hopefully) can contribute to better economy and final results. More overall guidelines are desired, on both the municipal and regional levels, but also for the companies' management, so that these issues can be integrated from the beginning on and influence the whole organization. The workshop participants would also appreciate a better coordination of the large number of existing methods and tools for making decisions. At present it is not really clear how the tools are integrated into the process for quality control, for example. To achieve a better overview and long-term perspective, the participants preferred to adopt an object-based view or program, *i.e.*, with the focus on buildings, rather than a project-based view.

Not surprisingly, the topic *economy* is the dominant one. Financing of maintenance and renovations is an important question and to some extent also a political issue. For public municipal housing companies it is not possible to establish a maintenance fund as it is for tenant-owned housing. During the discussion it was also pointed out that there are several different economic calculation tools. Still it seems to be difficult to carry out an accurate calculation with comparable input data. As economy dominates how decisions are made, the participants of the workshop emphasized that it is important to ensure that different kinds of values other than technical get a regular place in the decision-making process.

The *involvement of tenants* and, as a part of that, a well-established tenant dialogue is important for a successful renovation process because in accordance with the Rent Act 50% or more of the tenants must approve a standard-increasing and thus rent-increasing renovation before property managers can take action. Some other questions that were highlighted by the workshop participants are: How to determine what results the client (tenant) would like to see fulfilled before making a decision? Is it possible to act like a developer, defining a base price for a property and then adding a possibility to select a number of extra services/upgrades?

There is a need for a better integration of *architecture and conservation* and a need for more simplified methods to make an inventory of these values early in the process. Existing methods, such as the Swedish National Heritage Board's "cultural historical evaluation" are complex and more or less unknown to most of the workshop participants. However, the participants discussed the potential for a simplified tool to get familiar with this topic before engaging an expert for further details. As antiquarians seem to be underutilizeded resources, with a very small share of the consulting market, there should be opportunities to develop these ideas.

4.3. Workshop Discussion and Conclusion

On an overarching level, the workshop showed how stakeholders handle a renovation and the related decision-making process. The homework presentations generated an overview of what methods and tools are applied today in connection with a preliminary investigation by property managers, consultants, builders, and other organizations involved in the Renobuild and Rebo research projects.

Results from the workshop show that the motives for renovations often are based on technical or performance deficiencies, but tenants' needs and requirements are also important. Property managers are not very pro-active about renovation but rather reactive to urgent technical problems or user complaints. This confirms results from earlier studies about the major motivation for renovation being the goal of increasing comfort levels [10]. Property managers have maintenance plans but no

renovation plans or long-term plans for their stock. They often appoint external consultants for technical investigations whereas they carry out their own profitability calculations. Whether external consultancy services for technical investigations or social studies are purchased (or considered) or not depends on the in-house competence. Often a large number of stakeholders are involved in preliminary investigations; however, stakeholders such as the Union of Tenants and the City Museum that have cultural historical expertise point out that they are not involved as much as they would like to be. Consultants and construction companies would like to be integrated into the process at earlier stages, which in turn could contribute to better economic and final results as potential problems can be avoided.

Regarding factors that will be of importance when evaluating renovation alternatives, finance will be significant. The financial values of the property (largely affected by location) and the possibilities to transfer costs upon rent will be decisive. Other influencing factors are owner and management directives, and business plans, and in the case of municipal housing company objectives and policy prioritized on the municipal level. But owner directives, at least for municipally owned housing companies, are not very explicit regarding maintenance and renovation activities. More overall guidelines are desired, on both the municipal and regional levels, but also for corporate management teams, so that the importance of different kinds of values and long-term management are integrated in the owner's directives and/or business plan which will influence all decisions.

5. Towards a Sustainable Renovation and Decision-Making Process

From the literature studies we can conclude that none of the available methods or tools for sustainable renovation addresses all the values of interest to our study, while being not too advanced to be neither practicable nor open enough to be adapted to specific cases. The methods listed can nevertheless form the basis for a simplified decision support tool for the evaluation of renovation options.

From the workshop we can conclude that the stakeholders use a wide range of methods. However, there is a need for a better integration of especially the architectural and cultural historical values, and a need to make an inventory of these values early in the process. There is also a need for more simplified methods in general. The integration of different stakeholders is perceived as either insufficient or initiated too late in the process.

One question that arises is: Whose values are described and who describes them? The workshop, which included a broad range of different stakeholders, illustrated that stakeholders have diverse ideas about what the important values are, *i.e.*, it depends very much on what perspective and professional role an actor has and, of course, who is making the decision. It is not always obvious where in the decision-making process the integration of social, architectural or cultural historical values is taking place. Decision-making support towards sustainable renovation should *invite* a dialogue between stakeholders, but also facilitate communication between practitioners from varying expert areas and (decision-makers among) property owners, which is necessary in order to identify and balance all the values.

In the preliminary investigation phase, the different values need to be studied one by one, but often they must also be balanced one against another within certain economic frames. In order for all the different values to really be addressed in the preliminary investigation phase, they must be anchored in the organization's policy documents and a budget for them allocated. The different material and

immaterial values also need to be integrated into processes for construction management, project delivery and not at least in risk management regarding, for example, potential loss of property value as a result of alterations of the original architecture.

Some property managers take care of the social investigation in a renovation process and the interaction with the tenants. Are property managers aware of the external consultant services that can provide expertise relevant to their contact with the current tenants and the local community? The results from the workshop indicate that there are unused resources available, both among professionals in the buildings sector (consultants and building contractors) and representatives of building authorities and tenants associations.

Looking forward, a robust methodology is needed to support discussion and subsequent decision-making. Such a methodology should enable the establishment of (a) an initial inventory and description of all values and (b) a basis for the evaluation of a number of measures based on defined goals for a renovation project. We suggest the use of a framework including a variety of flexible tools. An evaluation of different measures and their impact on the various values can be designed according to the renovation objectives of individual buildings. Such a checklist will highlight different renovation options and also support motivation and argumentation for a decision, a discussion of what measures to select and why.

Hájek, Lupícek, and Pavlu [77] suggest that the optimal level of detail of representations of assessment results, *i.e*., grade of complexity, is partial aggregation. This is in line with the results from the workshop.

6. Conclusions

The main aim of this paper is to initiate an inventory of the renovation process, its actors, methods and tools in use, and the need for decision-making support. In the continuation of the research, as support for comprehensive decision-making in renovation, respecting sustainability and multifaceted objectives, will be developed, the decision-making processes and knowledge integration in renovation will be further studied through case studies, observations and in-depth interviews of stakeholders. This paper surveys the evaluation tools currently available to help building owners make decisions. It identifies the need for the further development of tools and methods to support integrated decision-making in sustainable renovation.

There are many tools to support the transition to more sustainable building, and the use of these is increasing regarding new construction. However, few have gained acceptance in renovation, especially in renovation of existing housing. We see a need for a wider integration of knowledge areas in sustainable renovation to address a multitude of objectives and values and thus a need for support to handle these sometimes conflicting values and knowledge areas. Such support will probably on the one hand be a further developed renovation process to contain and handle these different knowledge fields. On the other hand there is a need for operational tools to support the integration of a larger spectrum of issues in the renovation process, not at least in the important early phases. Such tools should have a high degree of acceptance and should be applied by a large range of stakeholders involved. We see a need for more simplified tools, especially for evaluating architectural, cultural, and social values which are difficult for property managers to handle as they strive to manage various conflicts. One suggestion

is to develop more rough tools for the early stages of a renovation process and for emerging aspects, which should be easy to modify and to develop further.

Regarding management and policy issues, we recommend that a wider spectrum of values and objectives should be addressed when developing policies, owner directives, business plans, *etc*. in order to increase the mandate of including such considerations in renovation.

There is a large potential in working with a transdisciplinary arena in order to address the complexity of sustainable renovation as a means to develop practice through raising discussions, point to emerging aspects that should be handled, bring in larger spectra of knowledge, and establish a common understanding, as a basis for decision making. The workshop as an arena activity is a good seedbed for discussions and for establishing a common understanding, which is fundamental in all transdisciplinary work, especially work aimed at generating actionable knowledge. Finally, asking participants of a workshop to prepare homework assignments in advance is a helpful and efficient way to support workshop discussions and to collect empirical research data. It also leads to well-prepared and engaged workshop participants.

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Conflict of Interest

The authors declare no conflict of interest.

References and Notes

1. EC. *Energy-Efficient Buildings PPP, Multi-Annual Roadmap and Longer Term Strategy*; European Commission: Brussels, Belgium, 2010.
2. BPIE. *Europe's Buildings Under the Microscope. A Country-by-Country Review of the Energy Performance of Buildnings*; Building Performance Institute Europe (BPIE): Brussels, Belgium, 2011.
3. EC. Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. *Off. J. Eur. Commun.* **2002**, *L1*, 65–71.
4. EC. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast). *Off. J. Eur. Union* **2010**, *L153*, 40–43.

5. SOU. *Nationellt Program för Energieffektivisering och Energismart Byggande (National Programme for Energy Efficiency and Energy-Smart Construction)*; Government Official Reports; SOU: Stockholm, Sweden, 2005; Volume 2005/06, p. 145.
6. Swedish Government. *Government Bill 2008/09:163*; Stockholm, Sweden, 2009.
7. Sveriges Byggindustrier. *Fakta om Byggandet*; Sveriges Byggindustrier: Stockholm, Sweden, 2005.
8. Femenías, P.; Johansson, E.; Schulz, S.; Dyrssen, C. *Kunskapsöversikt över Utbildning inom Kulturhistoriska Byggnader och Miljöer*; Chalmers University of Technology: Göteborg, Sweden, 2011.
9. Kohler, N.; Hassler, U. The building stock as a research object. *Build. Res. Inf.* **2002**, *30*, 226−236.
10. Meijer, F.; Itard, L.; Sunikka-Blank, M. Comparing European residential building stocks: Performance, renovation and policy opportunities. *Build. Res. Inf.* **2009**, *37*, 533–551.
11. Femenías, P.; Lindén, A.-L. Sweden: Integrated strategies to overcome market barriers. In *Energy Efficiency in Housing Management: Policies and Practices in Eleven Countries*; Niebor, N., Tsenkova, S., Gruis, V., van Hal, A., Eds.; Earthscan Publishing: London, UK; New York, USA, 2012; pp. 16–37.
12. Kohler, N.; Yang, W. Long-term management of building stocks. *Build. Res. Inf.* **2007**, *35*, 351–362.
13. van der Flier, K.; Thomsen, A. Life cycle of dwellings and demolition by Dutch housing associations. In *Sustainable Neighbourhood Transformations*; Visscher, H., Gruis, V., Kleinhans, R., Eds.; Delft University Press: Delft, The Netherlands, 2006.
14. Thomsen, A.; van der Flier, K. Replacement or renovation of dwellings: The relevance of a more sustainable approach. *Build. Res. Inf.* **2009**, *37*, 649−659.
15. Itard, L.; Klunder, G.; Visscher, H. Environmental impacts of renovation: The Dutch housing stock compared with new construction. In *Sustainable Neighbourhood Transformations*; Gruis, V., Visscher, H., Kleinhans, R., Eds.; IOS Press: Amsterdam, The Netherlands, 2006.
16. Rønning, A.; Vold, M. What is best for the climate, refurbishment or replacement of buildings? In *Proceedings of the International Sustainable Building Conference*, Helsinki, Finland, 18–21 October 2011.
17. COE. *Council of Europe Framework Convention on the Value of Cultural Heritage for So*ciety; CETS No. 199; Council of Europe: Faro, Portugal, 2005. Available online: http://conventions.coe.int/Treaty/Commun/QueVoulezVous.asp?NT=199&CM=8&DF=04/01/2012&CL=ENG (accessed on 9 January 2012).
18. Archimedes. Actions to Regenerate Cities and Help Innovative Mediterranean Economic Development Enhancing Sustainability. In *Culture as a Socio-Economic Development Factor*; EUROMED: Venice, Italy, 2007. Available online: www.med-pact.com/Download/Archimedes/11%20Introduction%20Paper%20Cultural%20Heritage%20and%20Ec%20Dvlpmt.pdf (accessed on 21 June 2011).
19. Femenías, P.; Fudge, C. Retrofitting the city: Re-use of non-domestic buildings. *Int. J. Urban Des. Plan.* **2010**, *163*, 117–126.
20. Revers, J. The assessment of risk in conservation refurbishment projects. *Struct. Survey* **2001**, *19*, 238–244.

21. Rosenfeld, Y.; Shohet, I.M. Decision support model for semi-automated selection of renovation alternatives. *Autom. Constr.* **1999**, *8*, 503–510.
22. SABO. *Ombyggnad på Hyresgästernas Villkor*; SABO Rapport; SABO: Stockholm, Sweden, 2005.
23. SFS. *Lag om Allmännyttiga Kommunala Bostadsbolag* (Public municipal housing companies act); Swedish Parliament: Stockholm, Sweden, 2010.
24. Swedish Government. *Government Bill 2009/10:185: Allmännyttiga Kommunala Bostadsaktiebolag och Reformerade Hyressättningsregler* (The Bill on Public Municipal Housing Companies and Reformed Rent Setting Rules); Swedish Government: Stockholm, Sweden, 2009.
25. Lind, H.; Lundström, S. *Hur ett Affärsmässigt Bostadsföretag Fungerar*; Rapport 2011:1; Institutionen för Fastigheter och Byggande, Kungliga Tekniska högskolan: Stockholm, Sweden, 2011.
26. Stenberg, J.; Thuvander, L.; Femenias, P. Linking social and environmental aspects: A multidimensional evaluation of refurbishment projects. *Local Environ.* **2009**, *14*, 539–554.
27. Della Torre, S. La conservazione programmata: Una strategia per il patrimonio storicoarchitettonico. In *La Conservazione Programmata del Patrimonio Storico Architettonico*; Della Torre, S., Ed.; IReR–Istituto Regionale di Ricerca della Lombardia, Regione Lombardia Direzione Generale Culture, Identità e Autonomie: Milan, Italy, 2003.
28. Jaggs, M.; Palmer, J. Energy performance indoor environmental quality retrofit—A European diagnosis and decision making method for building refurbishment. *Energy Build.* **2000**, *31*, 97–101.
29. Michaityte, A.; Zavadskas, E.K.; Kaklauskas, A.; Tupenaite, L. The concept model of sustainable buildings refurbishment. *Int. J. Strateg. Prop. Manag.* **2008**, *12*, 53–68.
30. Ebbert, T. Re-Face. Refurbishment Strategies for the Technical Improvement of Office Facades. Ph.D. Dissertation, TU Delft, Delft, The Netherlands, 2010.
31. Giebeler, G.; Fisch, R.; Krause, H. *Atlas Sanierung Instandhaltung, Umbau, Ergänzung*; Birkhäuser: Basel, Switzerland; Berlin/München, Germany, 2008.
32. Feilden, B.M. *Conservation of Historic Buildings*, 3rd ed.; Architectural Press: Oxford, UK, 1982.
33. Johnson, B.; Wilson, A.H. *Terminology of the Conservation Industry*; Division of Building Research, National Research Council of Canada: Ottawa, Canada, 1982.
34. Douglas, J. *Building Adaptation*, 2nd ed.; Elsevier Ltd., B-H: Amsterdam, The Netherlands, 2006.
35. Flourentzou, F.J.L.; Roulet, C.A. TOBUS software—An interactive decision aid tool for building retrofit studies. *Energy Build.* **2002**, *34*, 193–202.
36. SFS. Swedish Building and Planning Act. *Swedish Code of Statutes 2010:900*; 2010.
37. Boverket. *Regelsamling för Byggande, BBR 2012*; Boverket: Karlskrona, Sweden, 2011.
38. Jörgensen, E. *Att värma bostäder. Påverkansfaktorer och beslut* (Heating Homes: Influencing Factors and Decisions); Elforsk: Stockholm, Sweden, 2009.
39. Egmond, C.; Jonkers, R.; Kok, K. A strategy to encourage housing associations to invest in energy conservation. *Energ. Pol.* **2005**, *33*, 2374–2384.
40. Gruis, V.; Visscher, H.; Kleinhans, R. *Sustainable Neighbourhood Transformations*; Delft University Press: Amsterdam, The Netherlands; IOS Press: Delft, The Netherlands, 2006.

41. Borelius, U.; Wennerström, U.-B. A new gårdsten: A case study of a swedish municipal housing company. *Int. J. Hous. Plan.* **2009**, *9*, 223–239.
42. Mjörnell, K.; Kovacs, P. A Quality assurance system for improvement of indoor environment and energy use when retrofitting social housing. In *Proceedings of the 4th International Building Physics Conference*, Istanbul, Turkey, 15–18 June 2009.
43. Mjörnell, K. *Quality Assurance System for Energy Efficient Retrofitting of Multifamily Buildings*; Result Oriented Report; 2010. Available online: http://www.iee-square.eu (accessed on 23 January 2012).
44. Nordling, L.; Reppen, L. *Ombyggnad: Varsamhet vid Ändring. En Handbok i Anslutning Till Boverkets Allmänna råd om Ändring av Byggnad*; Svensk byggtjänst: Solna, Sweden, 2000.
45. Thuvander, L.; Femenías, P.; Meiling, P. Strategies for an integrated sustainable renovation process: Focus on the Swedish housing stock 'People's Home'. In *Proceedings of the International Sustainable Building Conference 2011*, Helsinki, Finland, 18–21 October 2011.
46. SuPerBuildings Homepage. Available online: http://cic.vtt.fi/superbuildings/ (accessed on 23 January 2012).
47. OpenHouse Homepage. Available online: http://www.openhouse-fp7.eu/ (accessed on 23 January 2012).
48. Miljöbyggnad Homepage. Available online: http://www.sgbc.se/index.php/certifieringssystem/miljoebyggnad (accessed on 6 July 2011).
49. Svanen Homepage. Available online: http://www.svanen.se/ (accessed on 23 January 2012).
50. Cole, R.J. Emerging trends in building environmental assessment methods. *Build. Res. Inf.* **1998**, *26*, 3–16.
51. Todd, J.A.; Crawley, D.; Geissler, S.; Lindsey, G. Comparative assessment of environmental performance tools and the role of the green building challenge. *Build. Res. Inf.* **2001**, *29*, 324–335.
52. Forsberg, A.; von Malmborg, F. Tools for environmental assessment of the built environment. *Build. Environ.* **2004**, *39*, 223–228.
53. Sidwell, T.; Clark, S.; Kumar, A.; Carlyle, B.; Holland, J.; Miller, G.; Setunge, S.; Hardie, M.; Nezmian, A.; Shah, A.; Mian, D. *Delivering a Re-Life Project: Preliminary Literature Review and Methodology*; CRC Construction Innovation, Queensland University of Technology: Brisbane, Australia, 2004.
54. Cole, R.J. Building environmental assessment methods: Redefining intentions and roles. *Build. Res. Inf.* **2005**, *33*, 455–467.
55. Ding, G.K.C. Sustainable construction-the role of environemntal assessment tools. *J. Environ. Manag.* **2008**, *86*, 451–464.
56. Haapio, A.; Viitaniemi, P. A critical review of building environmental assessment tools. *Environ. Impact Assess. Rev.* **2008**, *29*, 469–482.
57. SuPerBuildings. *D 2.1 Conclusions About the Needs for Development of Sustainability Indicators and Assessment Methods—Sustainability and Performance Assessment and Benchmarking of Buildings-SuPerBuildings*; EU Seventh Framework Programme, BBRI: Brussels, Belgium, 2010.

58. Essig, N.; Fischer, M.; Eberl, S. D 1.2.1 Assessment of Methodologies, Normative, Standards and Guidelines for Sustainability of Buildings at National, European and International Level. Draft (31/08/2010). In *OPEN HOUSE Benchmarking and Mainstreaming Building Sustainability in the EU Based on Transparency and Openness from Model to Implementation*; EU Seventh Framework Programme, Fraunhofer Institute for Building Physics: Stuttgart, Germany, 2010.
59. Malmqvist, T.; Glaumann, M.; Svenfelt, Å.; Carlson, P.-O.; Erlandsson, M.; Andersson, J.; Wintzell, H.; Finnveden, G.; Lindholm, T.; Malmström, T.-G. A Swedish environmental rating tool for buildings. *Energy* **2011**, *36*, 1893–1899.
60. Kajikawa, Y.; Inoue, T.; Goh, T.N. Analysis of building environment assessment frameworks and their implications for sustainability indicators. *Sustain. Sci.* **2011**, *6*, 233–246.
61. Blaviesciunaite, A.; Cole, R.J. The cultural values embedded in building environmental assessment methods: A comparison of LEED and CASBEE. In *Proceedings of the International Sustainable Building Conference*, Helsinki, Finland, 18–21 October 2011; Volume 2.
62. TC 59/SC 17. Sustainability in buildings and civil engineering works. Technical Committee. Available online: http://www.iso.org/iso/iso_technical_committee?commid=322621 (accessed on 23 January 2012).
63. CEN/TC 350. Sustainability of construction works. European Committee for Standardization. Available online: http://www.cen.eu/cen/Sectors/Sectors/Construction/SustainableConstruction/Pages/CEN_TC350.aspx (accessed on 23 January 2012).
64. Beck, T.; Eberl, S.; Essig, N.; Fischer, M.; Peyramale, V. D1.5 Baseline Model and Assessment Methodology. Draft (01/06/2011). In *OPEN HOUSE Benchmarking and Mainstreaming Building Sustainability in the EU Based on Transparency and Openness from Model to Implementation*; EU Seventh Framework Programme, Fraunhofer Institute for Building Physics: Stuttgart, Germany, 2011.
65. Zimmermann, M.; Bertschinger, H.; Christen, K.; Ott, W.; Kaufmann, Y.; Carl, S. Retrofit Advisor, Beta-version, November 2011. Available online: http://www.empa-ren.ch/A50/A50Retrofit%20Advisor.htm (accessed on23 January 2012)
66. Lorbek, M.; Stosch, G. *Architekturhistorisch Differenzierte, Energetische Sanierung*; 28/2003; Bundesministerium für Verkehr, Innovation und Technologie: Wien, Austria, 2003.
67. Skanska Miljonhemmet Homepage. Available online: http://www.skanska.se/Bygg-och-anlaggning/Miljonhemmet/ (accessed on 23 January 2012).
68. Wallhagen, M.; Glaumann, M. Design consequences of differences in building assessment tools: A case study. *Build. Res. Inf.* **2011**, *39*, 16–33.
69. *Energy and Buildings: Special issue EPIQR—Energy Performance Indoor Environmental Quality Retrofit*; Elsevier: Amsterdam, The Netherlands, 2000; Volume 31.
70. *Energy and Buildings: TOBUS—A European method and software for office building refurbishment*;Elsevier: Amsterdam, The Netherlands, 2002; Volume 34
71. Dascalaki, E.; Balaras, C. XENIOS—A methodology for assessing refurbishment scenarios and the potential of application of RES and RUE in hotels. *Energy Build.* **2004**, *36*, 1091–1105.
72. Flourentzos, F.; Droutsa, K.; Wittchen, K.B. EPIQR software. *Energy Build.* **2000**, *31*, 129–136.
73. Cole, R.J. Building environmental assessment methods: Clarifying intentions. *Build. Res. Inf.* **1999**, *27*, 230–246.

74. Lützkendorf, T.; Hajek, P.; Lupisek, A.; Immendörfer, A.; Nibel, S.; Häkkinen, T. Next generation of sustainability assessment-top down approach and stakeholders needs. In *Proceedings of the International Sustainable Building Conference*, Helsinki, Finland, 18–21 October 2011; Volume 2.
75. Kaatz, E.; Root, D.S.; Bowen, P.A.; Hill, RC. Advancing key outcomes of sustainability building assessment. *Build. Res. Inf.* **2006**, *34*, 308–320.
76. Häkkinen, T.; Belloni, K. Barriers and drivers for sustainable building. *Build. Res. Inf.* **2011**, *39*, 239–255.
77. Hájek, P.; Lupícek, A.; Pavlu, T. Literature and interview survey about stakeholders' needs and requirements for SB assessment and benchmarking methods. Part B. In *Sustainability and Performance Assessment and Benchmarking of Buildings-SuPerBuildings*; EU Seventh Framework: Prague, Czech Republic, 2010.
78. Boverket. *Nyttan med allmännyttan: Utvecklingen av de allmännyttiga bostadsföretagens roll och ansvar* (The Importance of Public Housing Companies: Their Role and Responsibility); Boverket: Karlskrona, Swenden, 2008.
79. Femenías, P.; Kadefors, A. Clients' strategies for driving innovation in low energy building. In *Proceedings of the International Sustainable Building Conference*, Helsinki, Finland, 18–21 October 2011.