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SUSTAINABILITY EVALUATION OF RETROFITTING AND RENOVATION OF BUILDINGS IN EARLY STAGES

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Abstract. *Research on the barriers for building renovation in Denmark has revealed that an important obstacle is a lack of simple and holistic tools that can assist stakeholders in decision-making during the early stages of projects (pre-project phases). The purpose of this paper is to present preliminary research results and ideas for the development of a tool, which can be used as decision support for renovation projects in early stages. The research is part of the Eracobuild project ACES – "A concept for promotion of sustainable retrofitting and renovation in early stages" with participants from Denmark, Sweden and Cyprus. This paper is mainly based on a work package concerning benefits of restoration. The approach has been - after a literature review - to start by conducting a needs and stakeholder analysis with 10 interviews. Based on this initial analysis a requirement specification for the decision support tool has been formulated and an outline of a preliminary evaluation tool has been developed. The results of the needs and stakeholder analysis, the requirements specification and the outline of the evaluation tool have been presented and discussed with a group of main stakeholders at a workshop. The target group for the tool is the professional sector. Some of the main requirements are that the tool shall be a basis for dialogue among building professionals and building users and support formulation of objectives for renovation projects. It should also be usable for comparing alternative project proposals and to follow-up on a project and assess the results. The tool will cover the four main parameters: Environment, users (satisfaction), organisation (including competences), and economy (in a wide sense). Evaluations will be subjective, but based on facts and arguments. The different stakeholder's different evaluations will be presented as part of the results.*

KEYWORDS: Sustainability, Evaluation, Renovation, Buildings, Energy, Early stages

1 INTRODUCTION

Retrofitting and renovation of buildings is currently achieving increased attention in many European countries. A fundamental reason for this is an aging building stock following the huge increase in new building activities in the years following the WW2. Other important reasons are higher energy prices and the increased focus on sustainability and not least the need to reduce consumption of fossil energy resources and CO_2-emissions. Still higher

demands on energy performance of new buildings in EU-regulations and national buildings codes mean that the discrepancy in energy performance between existing buildings and new buildings becomes greater and greater. Even though the need for retrofitting and renovation of existing buildings is increasing, there are still fairly limited actual renovation activities going on in most countries. There are many different reasons for this, which has been shown in a number of research studies on barriers and incentives.

This paper is based on the joint research project: "A concept for promotion of sustainable retrofitting and renovation in early stage" (ACES), in which the Technical University of Denmark, the Royal Institute of Technology, Sweden, and Frederick University, Cyprus are involved. It is based on the fact that approximately more than 40% of the total energy in Europe is spent within the buildings sector, which significantly contributes to greenhouse effects and air pollution. Moreover, it is estimated that approximately 85% of the 160 million buildings within the European Union are thermally inefficient (Swedish ScienceNet, 2010). Hence, it is crucial for the existing building stock to become refurbished. The ACES project is part of the European Eracobuild programme with a particular focus on Value Dreive Processes.

The project is divided in a number of work packages and this paper concerns WP2 on evaluation of the economic and environmental benefits of sustainable retrofitting and renovation of buildings. It is based on the view that the value of renovation is evaluated differently by different stakeholders, so it is important to highlight the main stakeholder's subjective viewpoints. The research has included an initial literature review focusing on the measures, barriers, incentives and tools for renovation. This was followed by a needs and stakeholder analysis based on an interview survey with the aim to identify the areas where further work could make a difference and add value to the stakeholders involved in renovation projects. Based on that, the aim of WP2 is to develop a simple, qualitative assessment tool aimed at guiding the setting of objectives and supporting dialogue among user representatives and professional stakeholders in the pre-project stage of renovation project.

The purpose of this paper is to present the main results of the literature review and the needs and stakeholder analysis as a background and reasoning for the development of the proposed tool, which is also outlined. The paper is structured so that the literature review is presented in section 2 with a focus on barriers and incentives as well as on existing assessment tools. The methodology of the empirical study is explained in section 3. The results of the needs and stakeholders analysis is presented in section 4 and an outline of the proposed tool called RENO-EVALUE is presented in section 5. The paper is finished with conclusion in section 6.

2 LITERATURE REVIEW

2.1 Barriers and incentives

Several international research studies have analysed the barriers for initiating renovation projects. The World Business Council for Sustainable Development (WBCSD) has produced a number of reports about energy efficiency in buildings with a global outlook. In WBCSD

(2009) they state that several barriers stand in the way of rapid progress ranging from market and policy failures, through professionals' inadequate knowledge and understanding, to the behaviour of building users. Their modelling work indicates that measures with a substantial impact are unlikely to meet normal financial investment requirements and are therefore unlikely to be implemented. Furthermore they identify several structural obstacles that significantly inhibit the likely take-up rate even of financially attractive investments.

A European ERABUILD project on building renovation and modernisation in Europe conclude in their final report (Itard et al., 2008) that the barriers in general are the lack of knowledge and information and the lack of cost effectiveness and funding. For owner-occupiers and private landlords the lack of knowledge and information, and funding are seen as the main problems. An additional barrier for private investors is that they do not profit themselves from the investment made in rented out buildings – often called the landlord/tenant dilemma (IEA, 2007). In relation to opportunities Itard et al. (2008) regard that they are going to be generated by governmental actions and market processes. Demands of owners and occupants (e.g. with regard to comfort) have been changing and are going to change in the near future, which will have a positive effect on sustainable renovation.

In the UK the Better Buildings Partnership has produced reports about low carbon retrofitting. Better Buildings Partnership (2010) identifies barriers in the following five areas:

1. Commercial, including failure to provide a compelling and viable business case for investment in retrofit and the inherent split incentive between owners and occupiers.
2. Roles and Processes, including no defined process to designate individuals within an organisation with the responsibility and authority to identify, plan and deliver energy saving and carbon reduction interventions.
3. Financial, including access to and availability of capital funds – whether they are provided by the owner, occupier or third party.
4. Technology, including a lack of knowledge of the options available to upgrade buildings and issues associated with the implementation of specific retrofit activities.
5. Policy, including a lack of regulation or government intervention to stimulate the uptake of retrofit activity.

The Danish Building Research Institute has identified a number of barriers for energy renovation divided in internal barriers, which cover the inertia among building owners, and external barriers covering lack of knowledge, resources and solutions (Jensen, 2009). One of the main incentives is supposed to be the Energy Labelling system (EMO). The regulation varies for different buildings types. However, a recent report about the Energy Labelling in Europe from The Danish Building Research Institute concludes that the label is not being utilized by Danish building owners (Gram-Hanssen & Haunstrup Christensen, 2011).

In Denmark there has recently been published a White Book on building renovation (BiD and GI, 2011). A stakeholder analysis has been made as part of this work, and this summarizes the main barriers as follows (Advice A/S, 2011):

1. Too little political consciousness about the value creation by renovation
2. Weak economical incentive structures – including the paradox problem
3. Lack of life cycle cost perspective
4. Lack of standard solutions/concepts

5. Clear 'hen and egg' problem – lack of demand causing lack of development causing lack of demand
6. Overview and common direction is lacking among the actors
7. No overview of potential and priority
8. Renovation has an image problem compared to new building activities

The stakeholder analysis identifies a large number of different stakeholders with different interests in energy renovation of buildings, but except for the paradox problem the stakeholders do not have contradictory interests.

2.2 Assessment tools

Haapio and Viitaniemi (2008) make a critical review of 16 different building environmental assessment tools. Half of the tools can be used for existing buildings, but only 5 of those are suitable for assessment of refurbishments of a building. These include the internationally used environmental certification systems BREEAM developed by the British Research Establishment and LEED from the US Green Building Council as well as ATHENA[TM] Environmental Impact Estimator from the ATHENA Sustainable Material Institute in Canada, BEAT 2000 from the Danish Building Research Institute in Denmark and EcoEffect from the Royal Institute of Technology (KTH), Sweden. BREEAM, EcoEffect and LEED are in the paper classified as whole building assessment frameworks or systems, while ATHENA[TM] and BEAT 2000 are classified as whole building design or decision support tools.

Gohardani and Bjørk (2012), who are part of the ACES-project team from KTH, investigate selected tools and methods for refurbishment. They point to EPIQR as a decision support tool to upgrade current comfort standard, fulfil ecological demands and achieve optimal energy performance, which combines technical, financial, energy and comfort analysis for refurbishment. The flow of information from cost and energy performance characteristics enables the EPIQR-user to make informed decisions regarding building refurbishment. An interesting aspect of the EPIQR methodology is the involvement of tenants of the apartment buildings in form of questionnaires. This survey method gathers data on indoor environmental quality issues prior to any suggestions for suitable refurbishment and retrofitting actions. There are many multivariate designs and multiple criteria tools available for retrofit of buildings and ECBCS Retrofit Advisor represents one of these instruments that allow a simple evaluation of retrofit options for apartment buildings. TOBUS is a decision-making tool for selecting office building upgrade solutions. With aims of elaborating consistent refurbishment scenarios and estimation of reasonable investment budget in the early stages of a refurbishment project, this method complements EPIQR. Different indoor environmental quality aspects of office buildings can also be investigated through TOBUS. XENIOS represents a proposed methodology for performance of a preliminary hotel audit and an initial assessment of cost-effective energy efficient renovation practices, technologies and systems.

A state of the art report on building renovation of buildings in Denmark (Jensen, 2011) has been produced as part of the ACES Project and it includes an overview of tools and methods and some of these will briefly be mentioned in the following.

A report from the civil engineering department at the Technical University of Denmark includes a chapter about economical assessments (DTU-BYG, 2008). It distinguishes between private and societal economical assessments. The latter are based on a guideline from the Danish Energy Agency. For private economical assessments the report recommends the method Cost of Conserved Energy (CCE) or Cost of Saved Energy (CSE), which is a measure of the price of saving one kWh. The report from 2008 presents this method in a quite advanced form based on net present value calculations. In a more recent report from the same department with an idea catalogue for building renovation the method is used in a more simple form without including net present value calculations, finance cost, inflation and other future economical conditions (DTU-BYG, 2010).

The Danish State Building Agency (earlier the Property and Palaces Agency) has on their homepage a tool for calculating the profitability of energy investments. It is included in an Excel spreadsheet and the calculations are based on net present value with a formula used by the Agency of Economy. The discount rate is 5% p.a. determined by the Danish Ministry of Finance and the annual increase in energy prices exclusive of inflation is 0.92% based on prognoses from the Danish Energy Agency. The calculation requires the following input data: Service life expectancy, annual savings from the investment in DKK and the initial investment. The tool also includes some typical examples of service life expectancies.

Besides these methods for economical assessments of energy renovations there are a number of other tools on websites for refurbishment and energy renovation, see Jensen (2011).

3 METHODOLOGY

In an early phase of WP2 (January – March 2012), a needs and stakeholder analysis has been conducted following an initial literature review (Jensen, 2011). The analysis was carried out through 10 interviews with different stakeholders in order to determine their point of view and needs in relation to sustainable retrofitting of buildings in Denmark. The interviews were conducted with the representatives from the Danish Association of Construction Clients, the Danish Ecological Council, 3 building clients (housing association, real estate administration and municipality), 3 consulting engineering companies and 2 contractors.

The interviews had a qualitative form and were of a semi-structured nature. A general list of themes and questions was prepared in advance and some questions were omitted while others were included during the course of the interviews. Interview minutes were sent to the interviewees for acceptance. The interviews were compared and analysed in search for common issues and topics that stakeholders find important in relation to sustainable retrofitting of buildings. Based on the literature review and the analysis, a proposal for a tool for evaluation of renovation projects (RENO-EVALUE) was developed. The results were presented and discussed at a workshop with 18 participants in March 2012. The work on WP2 continues with a number of case studies and further developing of the tool.

4. FINDINGS FROM THE NEEDS AND STAKEHOLDER STUDY

4.1 Needs and stakeholder analysis

In the beginning of the analysis it was important to determine key motivators for renovation of buildings in Denmark. It was however not a simple task since earlier research has documented many barriers for initiating building renovation projects. The barriers can generally be divided into two categories: economic and informational barriers. Lack of the financial incentives and life cycle perspectives are the most significant economic barriers while too little political consciousness; lack of common direction amongst the main stakeholders and lack of overview where to prioritize are the most important informational barriers. In addition, new constructions are considered more attractive and get more attention than existing buildings. In general, the problem is not a lack of technical solutions but more of a problem to get the building owners to implement the existing solutions.

4.2 Motivators for retrofitting

Almost all stakeholders mentioned deterioration of buildings as a key motivator for energy renovation. In some cases problems with indoor climate in newer buildings are motivators for renovation involving energy optimization. In public institutions, housing associations and private companies, energy renovations are often used for branding or as a part of organization's strategy in relation to Corporate Social Responsibility (CSR). It is seen that especially global companies located in Denmark are requiring energy efficient buildings from their landlords.

In Denmark, energy labelling of buildings was implemented in 2007 with the intention of becoming a driving force for energy renovation projects, but it is not very popular. It is rarely used as a motivator for energy renovations and some say it is because of energy labelling is primarily based on theoretical calculations which do not reflect reality quite well. Especially for social housing a revised system of energy labelling is now been introduced to meet the criticism.

The state of the market is an important factor when talking about energy performance and renovation of building. In case of slump like today, tenants may have a slight advantage over landlords and can make demands that they probably could not in case of a financial boom. That is why the owners of the energy efficient buildings have better opportunity to rent their buildings out today than the owners of the energy inefficient buildings, anticipated that other criteria such as correct rent price, location etc. also are satisfied.

4.3 Building users and their interests

Through the analysis it was confirmed that building users often have different interests, but this varies depending on type of buildings. Public schools and listed buildings are usually part of a political agenda since they get a lot of attention from the inhabitants every day. Energy renovations in social housing in Denmark are highly dependent on residential democracy. It means that the majority of the residential voters have to support the idea; otherwise it will not be realized.

Landlord/tenant dilemma is present in the private building sector in Denmark and considered to be one of the biggest barriers for energy renovation projects (Ástmarsson, 2012). The landlord provides the tenant with housing, appliances and installations, and the tenant pays the energy bill. The landlord is therefore not interested in investing too much money in energy efficiency while the tenant wants to lower the energy costs, and this is where the dilemma occurs. The legislation in this field is very complex and the maximum rent is regulated by the law which in many cases is an obstacle for energy renovations because the maximum possible rent in most cases is insufficient for financing investments.

4.4 Decision processes

In the analysis none of the interviewees could present pure energy renovation projects. It is because energy renovations in Denmark are mostly combined with general refurbishment, moving/redesigning, or as a last minute solutions when service life of building components already has expired.

There are a couple of parameters that have an impact on a decision process. In many cases payback time is the most important parameter when considering energy renovations. Decision makers are mostly interested in short payback times which do not require huge investments. Typical examples could be replacing light bulbs and IT equipment, optimizing ventilation or heating unit, and installing photovoltaic panels. Comprehensive renovations such as re-insulation of the external walls, replacing windows, or roof replacement are more complex and thereby more expensive initiatives with a long payback time. They require long term planning and usually involve several parties such as architects, engineers, consultants, entrepreneurs, developers, building users etc.

Because of the complexity of comprehensive renovations, many calculations and simulations are performed beforehand, but according to the research, credibility of these results is questionable. Almost all interviewees mentioned that in many projects which they have been involved in, there was a remarkable difference between calculations and true energy performance. This difference was mostly estimated to be 10 – 30 %. Some blame the calculation tools for this inaccuracy, others think that the baseline is usually not set correct, and many also believe that it is user behaviour which in the end makes the difference. There are also some interviewees who think that the inaccuracy is the result of poor workmanship during the construction process.

The lack of confidence in achieving expected energy performance is an important reason for an increasing interest in Denmark for ESCO (Energy Service Companies) or EPC (Energy Performance Contracts), where a company promise guaranteed energy savings to the building owner. Particularly many municipalities have initiated ESCO projects in recent years (Jensen et al., 2011), but an increasing interest among other types of building owners is also becoming evident. ESCO is seen as a possible way to overcome the landlord/tenant problem - not least in private rented housing.

Energy renovations in Denmark are usually included in two types of projects: comprehensive refurbishment and energy optimization. In comprehensive refurbishment, energy renovation is a part of large project in which architectural and social parameters are

also included. Such energy renovations often comprise both building envelope and technical installations and also increasingly renewable energy solutions like photovoltaic panels. Energy optimization projects are mainly focusing on technical installations such as HVAC, their performance, maintenance and correct usage. In relation to correct usage, it is very important to work with user involvement and user behaviour, since they are consumers of the final product. There are many ways to affect user behaviour. Some stakeholders mentioned visualization of energy consumption, internal competitions on energy consumption, education of technical staff, as well as passionate local ambassadors as effective methods for achieving better energy performance. By automating technical installations, some uncertainties regarding user behaviour can be removed. In this case, it is important to explain caretakers and technical staff how equipment should be operated and maintained.

4.5 Non-energy benefits

Non-energy benefits (NEBs) are the benefits that follow with energy renovation projects as a side effect and are difficult to express in numbers (Amann, 2006). Typical non-energy benefits are indoor climate improvements in terms of better comfort, more daylight, less draught etc. According to the research, better indoor climate is directly linked to more productivity and less sickness absence which makes NEBs very relevant for office companies. On the other side, NEBs are not usually a decisive factor in the private sector but can be used as a good argument in the initial phase of renovation project. Since NEBs are difficult to express in numbers, they are not taken into consideration when calculating profitability, but several interviewees think that it should be changed, so that NEBs can become a valid parameter in energy calculations. However, there are also some interviewees who claim that it is difficult to talk about non-energy benefits in advance and say that they are first discovered when energy renovation is completed.

5 OUTLINE OF THE PROPOSED TOOL

5.1 Purpose of RENO-EVALUE

As previously described, there are many challenges and obstacles in energy renovations. Many possibilities are missed in the early stages of energy renovations because of the lack of knowledge and missing economical incentives, and there is also need for a better communication between different stakeholders involved in energy renovations. In order to overcome some of these issues, new evaluation tool called RENO-EVALUE has been developed. RENO-EVALUE is a tool for holistic assessment of sustainability in energy renovation projects. The main purpose of RENO-EVALUE is to be used as a decision support tool in the early stages of energy renovation projects. It is a process-oriented tool that can be used by anyone with insight into the project. RENO-EVALUE is not only focusing on a final product, but covers project organization, economy and renovation process too. It can be used to formulate goals for renovation projects and to enable focus on essential aspects for the primary decision makers. It can also be used as a communication tool between different stakeholders and help in making evaluations on the basis of expectations. The tool has to be

able to monitor and evaluate the obtained results and also to provide the opportunity to compare different projects and evaluate alternative proposals. RENO-EVALUE is also planned to be used to illustrate cases in the form of inspirational projects.

5.2 Target group

RENO-EVALUE can be used by the decision-makers who not necessarily possess the adequate technical competences for evaluating the energy renovation projects. The tool can be used by all stakeholders involved in the early stages of energy renovation project, as long as they have some knowledge about the project.

The evaluation tool is intended for use on large scale projects in the professional sector, not single family houses etc. Primary users of RENO-EVALUE might be client organizations, housing associations, estate administrators, facilities managers etc. One of the advantages of RENO-EVALUE is that it can be used as a communication tool between developers/landlords and representatives of inhabitants, tenants, employees and building users. Architects, consultants and contractors might use RENO-EVALUE for illustrations and comparisons of different proposals.

5.3 Application method

Since the tool is addressing different stakeholder groups, it has to be easy to understand and simple to use. Data is collected through interviews with primary stakeholders and there are no new calculations in the tool. An interviewer collects facts about the project beforehand and checks them with the stakeholders during the interviews. Interview questions are standardized with minor deviations depending on stakeholders and building types.
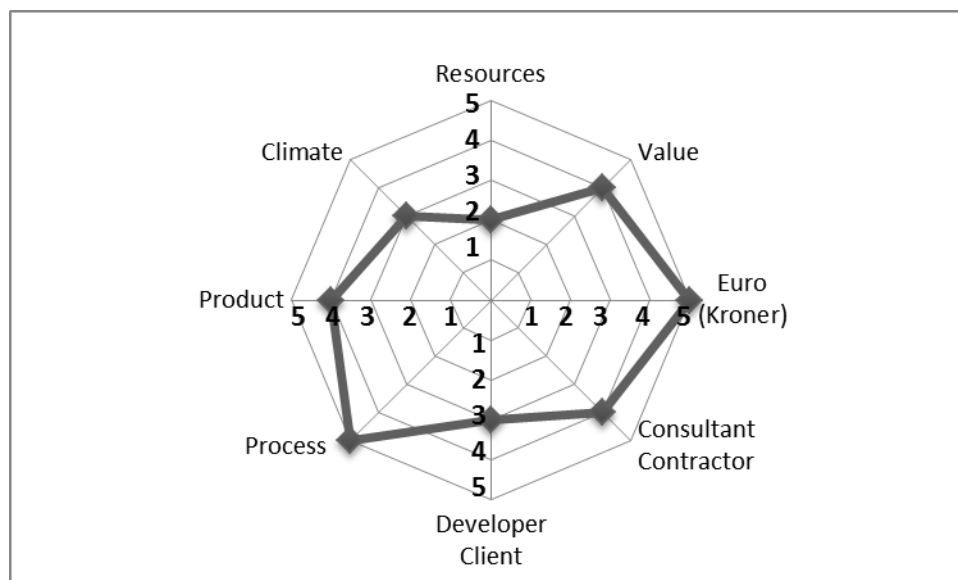

Figure 1: A preliminary illustration of RENO-EVALUE model

The evaluation of project is based on subjective assessments, but also supported by project facts. Furthermore, there is a written explanation for a certain rating and the information about valuator is available too.

The RENO-EVALUE model is in Figure 1 illustrated as a spider's web in which it is possible to rate parameters and their factors with grades 1-5 from low to high. It is possible to make the rating both before and after the energy renovation is completed, which in the end makes it possible to compare the expectations with the final results.The advantages of RENO-EVALUE are that it does not take long time to do the evaluation, the graphical illustration of results is easy to understand, and the model provides a quick overview of the current situation, seen from a certain stakeholder's perspective. It can for instance be useful in the early stages of the energy renovation projects, in order to improve the matching of expectations between different stakeholders and defining the success criteria for a project. After the project is completed, the evaluation results from the initial phase can be used to determine whether the success criteria are fulfilled or not, and there is also possibility to evaluate the project again. The evaluations can internally be used to compare "before and after" situation, and externally for experience exchange and comparison between different projects.

5.3 Parameters in the tool

The evaluation tool RENO-EVALUE is planned to cover the four main categories: Environment, Users, Organization and Economy. Each category is divided in two parameters with a sub-division in a number of factors. A preliminary list of factors is shown in Table 1.

Table 1: Preliminary categories, parameters and factors in RENO-EVALUE

Category	Parameter	Factors
Environment	Resources	Energy consumption Renewable energy production Water consumption Reuse of water Local discharge of water Amount of waste Reuse of waste
	Climate	CO_2-emissions Pollution
Users	Product	Architecture and aesthetics Function and user-friendliness Indoor climate and comfort Sustainability
	Process	Cooperation between participants Mutual information User involvement User consideration in implementation

Organization	Developer/client	Project management skills Ability for decisions Technical competence Cooperative skills Involvement of the operating organization
	Consultant/contractor	Project management skills Technical competences Problem solving abilities Cooperative skills Coherence in supply team
Economy	Euro/Kroner	Reasonable rent Reasonable running costs Reasonable costs in the long term
	Value	Attractive dwelling Well functioning settlement Attractive area

6 CONCLUSION

Earlier research has documented many barriers for initiation of sustainable refurbishment and energy renovations. Research on the barriers for building renovation in Denmark has revealed that an important obstacle is a lack of simple and holistic tools that can assist stakeholders in decision-making during the early stages of projects. The needs and stakeholder analysis conducted as part of the present study confirms the results of former studies, that the barriers can generally be divided into two categories: economic and informational barriers, but it also shows that the main motivators for energy renovation is deterioration of buildings and payback time. Therefore energy renovation can be divided in comprehensive refurbishments, where energy renovation is an integrated part of an overall building refurbishment, and energy optimization, where mostly profitable measures with a fairly short payback time are implemented.

The needs and stakeholder analysis has also shown that even though the need for energy renovation is huge in the private owned individual housing sector, the most promising area for developing decision support tools based on rational arguments and choices is the professional sector. There are a number of tools developed to support energy simulation and building design, but there is a lack of simple tools that can support the initial goal setting among the primary stakeholders in early pre-project stages and support the dialogue between non-professional user representatives and building professionals in housing associations, architect and engineering consultants companies and contractors. This is where the proposed tool RENO EVALUE is targeted and it is planned as a holistic and qualitative tool to define objectives and clarify expectations as part of an initial dialogue and decision making process and as possible tool to follow-up on decisions and evaluate results. It is based on the three general accepted pillars of sustainability: Environment, Social and Economy, but being a tool related to retrofitting and renovation of buildings it also includes evaluation of the organisation involved in implementing such projects to achieve a holistic evaluation.

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