Analysis of Built Heritage - energy and culture

O. Wedebrunn[1], C. Colla[2], T. Dahl[3], C. Franzen[4]

ABSTRACT

Built heritage is a balance of sources and assets of energy and culture, which have to be maintained and enhanced for a sustainable continuing fruition. This is emphasized and specified as insight of research throughout the 3ENCULT project in view of preserving the construction stock but coupled with measures for reducing inefficiencies and thus carbon emissions in Europe. Discussions of historic, architectural, functional aspects, measures, data, models, practical solutions have taken place to evaluate the sources of value and the expressions which identify the quality of preservation as balance of energy and culture.

Keywords

3ENCULT, heritage, documentation, energy efficiency, cultural value, NDT

1. Introduction

Neither energy nor culture are solely defined by natural or social sciences, it is the complexity, context and behavior that refer to environment and historic areas. Heritage is the physical definition of material, construction and building, it is the original and authentic presence and the dynamics of history and lifecycle. Thus, analysis of built heritage should be based on criteria of compatibility of energy and culture, through a methodology of environmental assessment, multidisciplinary expertise's and references. It is important to assess the heritage object and its historic area as a whole, as an asset and an energy source of the environment, where the impact assessment ensures the balance of energy and culture.

The analysis of Built Heritage is the topic of a work package in the EU, FP7, 3ENCULT research project on Energy Efficiency in Historic Constructions. It aims at identifying heritage, by building research, integration in urban concepts, investigations on site, measured drawings, archive research and relevant documentation to balance energy and culture case by case and by generic replicable factors. The results of the work package are reported in the following excerpts from deliverables of the work package.

2. Demand Analysis

To know how to improve the energy efficiency of a listed building, it is necessary to analyze its significant heritage value, although the result of this process is always valid only for a group of people with a distinct image of history and it is always tied to a particular time. So, for example, the message delivered by a monument was different fifty years ago and will be different for the following generations as each generation asks its own questions to history, monuments, and cultural heritage. From a viewpoint of facts to be considered in a single and immutable way, the only perspective for historic buildings would be to change nothing: the whole preservation of the as-found situation, including damage, decay, inefficiency, discomfort for inhabitants or users.

This is simply not correct and not feasible in view of maintaining the stock of existing and historic constructions alive: if action is not taken, historic buildings and monuments will fall into disrepair, not considered attractive anymore and be abandoned to ruin. Instead, if a sustainable preservation is attempted through well considered actions, then changes to the buildings, although of minimum is strictly necessary, and unavoidable. Preserving measures for each and all the existing or listed buildings in Europe are only viable and sustainable if the aim is to maintain the majority of them in use. In this way, they can provide a valuable asset with economic return, although sometimes indirect or postponed.

Though this may be already known, it is important to keep it in mind when discussing interventions and when interacting with different groups of historic monuments. To balance the respective interests of monument preservation, functional requirements and environment protection is always an iterative process. Here beneath, it follows an attempt to discuss in detail the concerns of curators of monuments and cultural heritage as, nowadays, heritage preservation includes improving the energy efficiency of buildings.

The climate change endangers heritage buildings all over the world not least because new living standards and comfort demands cause problems to buildings for example by putting a higher stress on the building envelope. The ability to plan for economical use, including reducing energy use and energy inefficiency, would ensures the continued existence of heritage. Nonetheless improving the energy efficiency of built heritage is only acceptable if it does not diminish preservation nor it destroys or disturbs the historic value.

In the following it will be shown what the specific preservation reasons mean to preservation praxis. Often several motives are given for preservation of a building, some more important than others. Such a classification can help to understand what must be taken care of when

1 The Royal Danish Academy of Fine Arts, Copenhagen, Denmark, ola.wedebrunn@kadk.dk
2 DICAM Dept., School of Engineering and Architecture, Bologna University, Italy, camilla.colla@unibo.it
3 The Royal Danish Academy of Fine Arts, Copenhagen, Denmark, torben.dahl@kadk.dk
4 IDK Institut für Diagnostik und Konservierung an Denkmalen in Sachsen und Sachsen-Anhalt, Germany, franzen@idk-info.de

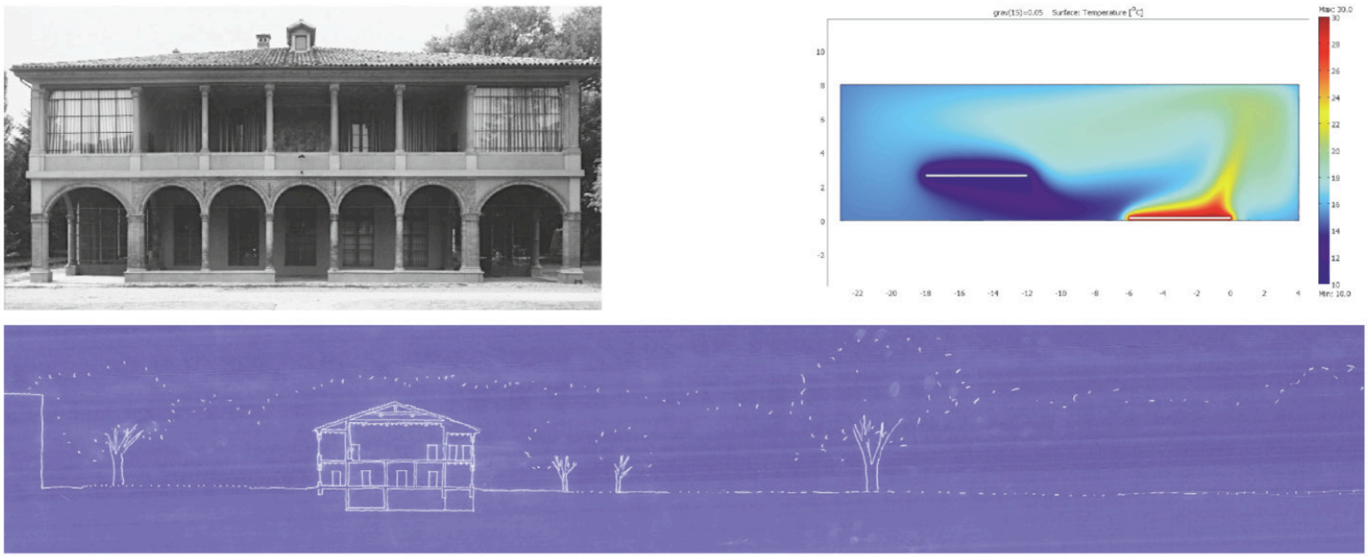

Figure 1, Historic ill. and 150 m section of Palazzina della Viola CS3 and context, CS3. The diagam of climate simulation could be applied to the interior space as well as to context (ill. artificial Gulf stream, Venezia, 2008, Philippe Rahm architects)

modernizing historic monuments although it is impossible to grade technical solutions as results of preservation motives. [1]

Listed buildings and all older buildings can be sorted in a way that corresponds to technical solutions for refurbishment and modernization. On this ground it should be possible to work out a catalogue to be used as guide and support for architects and preservation officers for decision making, to consider consequences, and to find possible solutions to match demands for increasing energy efficiency.

Every historic monument has its individual conservation and refurbishment requirements. Energy efficiency is closely linked with the type of use, thus it is necessary to analyze the demands of every building before planning refurbishment steps. Classification of heritage buildings is difficult and there is no way forward in attempting to divide monuments in groups and then finding suitable solutions for every group. Each single building needs individual analyses and an individual renovation. For planning measures of energy efficiency it is important to know which building parts, characteristics, materials, views of building are of high significance and cannot be changed. Classification by preservation motives can establish criteria for the demand analyses that could be useful as measures for a classification by construction types.

Measures to increase energy efficiency should preferably affect building parts of lower historical relevance or building parts that are worn out and no longer have a material value or no longer contributes to the value of building parts, which have to be replaced anyway.

The compatibility of measures to increase energy efficiency with the character of built heritage can be estimated by means of two primary criterions: how much historical building substance will be lost by fitting the new system and in which way the newly installed system will interfere with the perceived image.

A third point, introduced by the Venetian charter [2], is the question of reversibility. Especially if innovative technical solutions are introduced and practiced with no or little experience of possible effects and consequences, it might become necessary to remove these solutions or substitute them. Innovative techniques have also been used in heritage preservation in the past. Nonetheless, with innovation works sometimes one has to realize that new technology and new materials are not compatible with old ones and destroy the original substance or impair its appearance. Additional observations and experience allow writing that:

- adequate usage of a building can be a solution for energy efficiency, achievable by users behavior: destination use of a building and change of destination have to be carefully weighted “Not every barn can become a sauna”
- knowledge about original historic building climate systems can be a source of inspiration with high heritage compatibility value;
- solutions mechanically operated (minimal intervention) and use of renewable energy sources are more compatible with the character of heritage;
- reaching a total energy balance, despite all difficulties, has to be a central aim for energy and culture. Only a detailed energy saving can establish measures with positive impact;
- every single monument is an individual case and has to be analyzed and valued with these aims by the experts needed. Nonetheless, it is hoped and possible to develop a catalogue with solutions as suggestions for
- groups of buildings and constructions.

3. Energy efficiency measures and compatibility with Conservation

There are several possible energy efficiency measures to be applied for retrofitting a building. The decision on which of those measures to implement to a building is based on the estimation of their suitability. In the case of monumental buildings also their compatibility is an important, probably

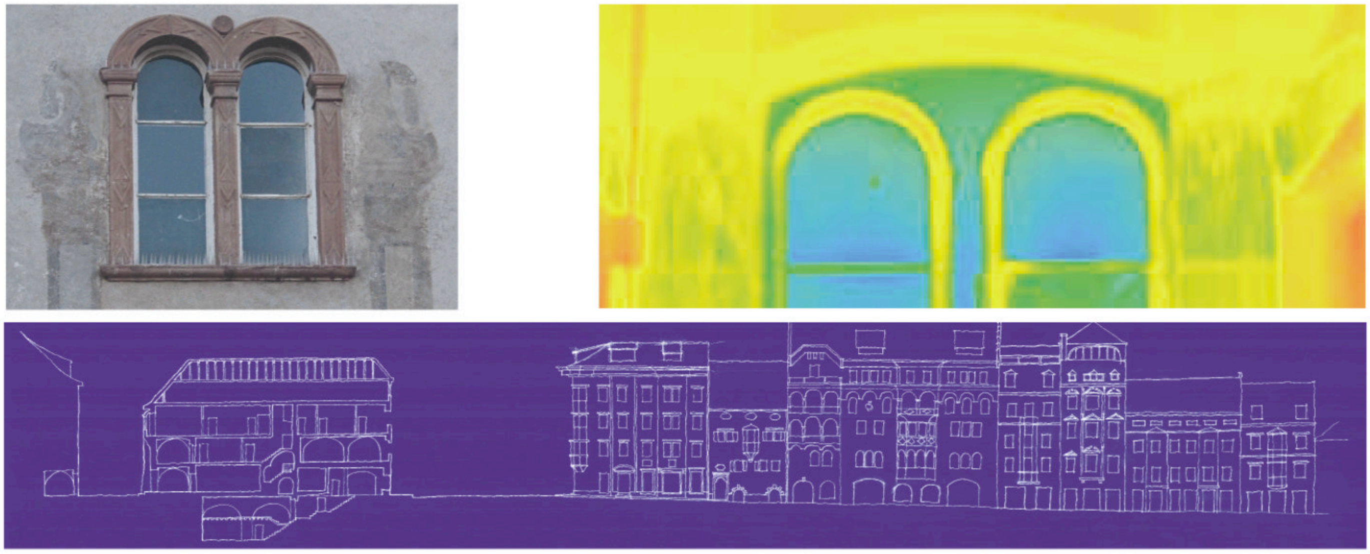

Figure 2, The historic façade with decorated windows of Waaghaus building in Bolzano, North Italy, CS1, and thermal view from the inside. Bellow 150 meter section of CS1, Waagehaus, Kornplatz and urban environment.

the most important, criteria. To date, several documents from different European Countries are available to pre-asses the compatibility of some energy efficiency measures for historic buildings. The final assessment and decision is up to the responsible monument conservation administration. Within this process, the basic hypothesis is always to respect multiple aspects in parallel. Thus, for consideration of the single cases, if possible, the work of a multidisciplinary team is needed.

Due to the many different aspects of energy efficiency and demands of historic and monumental buildings, proper criteria of qualitative and quantitative assessment would need to be set (Figure 1-4) in order to implement a comprehensive evaluation of the building under consideration. With the aim to develop a suitable approach towards the conservation compatibility assessment of several energy efficiency measures, firstly proposed by the 3ENCULT project and finally for a European Guideline, some successful procedures were evaluated. It was shown that several levels of decision are possible to come to best practice solutions, but the work to do so has to be managed. To introduce and integrate all experience of the whole project team a workshop took place in the frame of a project meeting.

Within the European policy specifically targeted towards energy requirements of buildings whether new or existing, residential or non-residential, the heritage stock takes a special position to reduce energy use and carbon dioxide emissions [3]. At present, most of the energy performance standards do not reflect enough towards "grey energy" inhabited in heritage stock and existing buildings. Upgrading the thermal efficiency of the existing building stock is a challenge, particularly where the building was built using traditional materials and construction methods and it is of architectural or historical interest. Evaluating the recherché in available material, it was most auspicious to combine the outcome of several different approaches:

- Irish guidelines (Ireland 2010) [4],
- Austrian guideline (Austria 2011) [5],
- Saxonian pilot study (Saxony 2011) [6],
- English Guidelines (English Heritage 2011) [7],
- Copenhagen approach (Denmark 2011) [17],

Among these, the Copenhagen approach was one of those chosen for closer examination.

3.1 An iterative approach: the Copenhagen example

With the energy retrofit of the listed Material Court in Copenhagen (Figure 3) the owner aimed not only at giving its contribution to CO^2 emission reduction, but also at showing on the basis of a study case, how this can be achieved for listed buildings in Denmark in general. Realea A/S, a foundation owning a large number of historic buildings, to this aim worked closely together with the Danish Heritage Authority and experts from the different fields. The final solution was developed in an iterative process, starting from a high number of potential solutions from which in several rounds of increasingly detailed analysis suboptimal solutions were deleted scratch and promising brought forward – the typical approach of what is known as Integrated Design Process IDP.

3.2 Overall approach

The Material Court is to be renovated and used for office purposes. The renovation objectives are to:

- Reduce CO^2 emissions and guarantee high indoor comfort with office use, in compliance with conservation and architecture.
- Provide a guideline for the more than 1000 protected buildings in Denmark used for office purposes

A schematic of the approach within the multidisciplinary work group was:

- Building analysis and description
- Broad gross list of possible interventions
- Dynamic simulation of single interventions and evaluation of CO^2 emissions and indoor climate
- Stepwise reduction of options and selection of the solution to be implemented

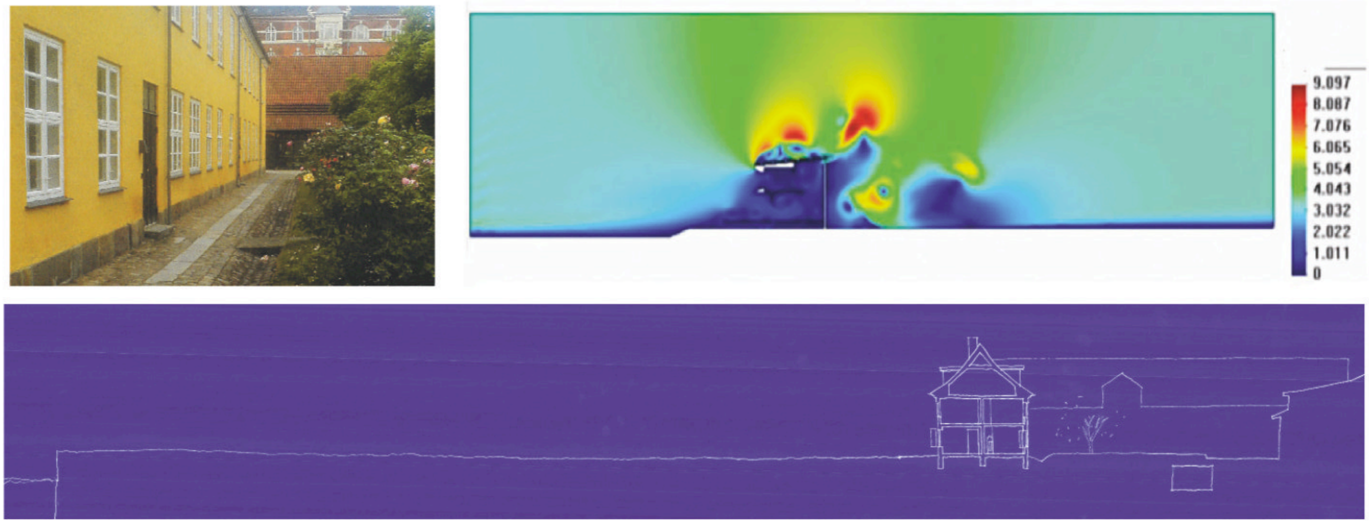

Figure 3, A 150 m section of CS4, Material Court, Copenhagen. Ill. of climate (wind) impact on construction by Elian Hirsch.

3.3 Multidisciplinary work group

Within the multidisciplinary work group, professionals with great experience in building renovation were contributing to the single tasks from their specific viewpoint:

- Building owner impact on rental opportunities, operating and maintenance conditions
- Heritage authority conservation viewpoint (also general evaluation of building typology)
- Architects, architectural shape, appearance, functionality, interior design conditions
- Structural engineer impact on existing construction, risk assessment (moisture [8])
- Services engineer assessment of energy and indoor climate.

The result of the multidisciplinary work will balance of energy and culture as an option to retain quality, develop building tradition and identify means and methods to be applied to the existing building stock. It makes it possible to develop a broad knowledge and generic replicable methods that can cover vast number of constructions with improvements by renovation worksas well as it will balances quality and quantity to maintain and renew building tradition. An inventory based on needed references and an efficient and balanced guide to renovation work will make it possible to plan and estimate the costs, gains and necessity it will take to retain and renew the quality of heritage.

3.4 Proposal on generic replicable factors

Heritage value must be understood and shared by different interest holders: stakeholders, public interest, owner, users, etc.

The state of classification for legislative protection must be documented, together with its Universal value, National value, Regional value, Funds interest, Private interest/ integrity.

Energy is closely connected to the behavior of the users. The documentation of building history should include historic use and energy sources, lifecycle analysis of behavior, performance of construction, production and social context of human activities. Thus when energy is identified as part of the context of the heritage object, its dynamic conditions, quantities and qualities should be identified.

Energy efficiency and its compatibility must be included in studies of user comfort and conservation, integrated as feature of architecture and heritage. It is important that the energy efficiency and cultural heritage is balanced in an argumentation where energy value and concept meets with legislative protection and value of heritage.

To maintain and enhance the balance of energy and culture, it is important to implement and gain from a continuous discussion. This involves society in a broad sense and many interests, not least the work of public service and administration.

These are some of the factors and aspects delivered in D2.3 as Generic Replicable Factors. In the analysis of built heritage, energy, culture and climate reflect many different possibilities for European culture, economy and innovation.

It is important to make the argumentations for energy and culture central in this process with building analysis and planning included in environment assessment. A procedure that emphasizes this as coherent quality is a necessary and great help when it comes to pay attention to the possibilities of creative and responsible future for heritage. [15]

4. EIA method on Energy Retrofit

When decisions are taken for energy saving interventions in built heritage, the 3ENCULT project has among other objectives the aim to develop a methodology to ensure a process which incorporates cultural and architectural considerations with argumentations of technical, social, economical and functional parameters.

4.1 Environmental Impact Assessment EIA

The deliverable D. 2.4 of 3ENCULT [15] takes its point of departure from Environmental Impact Assessment methods and aims at implementing principles from EIA on historical buildings' retrofit. To meet this request the 3ENCULT method, is developed as a practical guideline to assess and balance energy and culture for heritage retrofit.

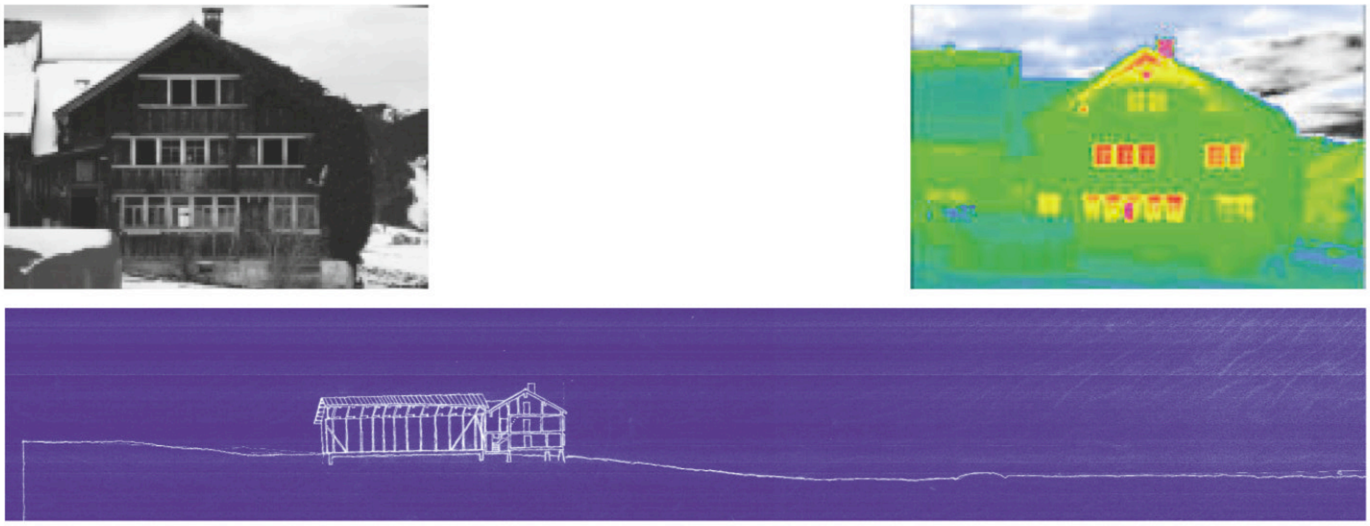

Figure 4, Alpine architecture: CS8, Appenzell, Switzerland; envelope energy distribution from exterior and 150 meter section.

The 3ENCULT method is developed to be operative and comparable; it is based on inquiries experiences and existing methodologies. It refers to standards and norms as well as to directives and conventions, and it relates to and utilizes existing methods and processes. It is a practical scheme to support and guide the assessment process.

The 3ENCULT method is developed to support a process to survey and assess the basic requirements for conservation of built heritage. It is rather a practical tool more than the comprehensive process of environmental impact assessment. Its target is to support and coordinate the argumentation for the process, and to establish comparable references and a shared language when it comes to argue for the balance of energy and culture.

The aim is to minimize the negative impacts on cultural values at the time of intervention but, at the same time, to maximize the value of the historic building in a long-term perspective. In particular the EIA (Environmental Impact Assessment) Directive [16] requires an environmental assessment to be carried out by the competent national authority for certain projects which are likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location, before development consent is given. These projects may be proposed by a public or private entity.

The SEA Strategic Environmental Assessment Directive (2001/42/EC) provides a high level of protection for the environment and contributes to the integration of environmental considerations into the preparation and adoption of plans and programs with a view to promoting sustainable development, by ensuring that, in accordance with this Directive, an environmental assessment is carried out of certain plans and programs. (Figure 5);

The SUIT project (Sustainable development of Urban historical areas through an active Integration within Town, EU 5th FP) has promoted the use of EIA and SEA procedures as a way to foster a long-term active conservation of urban fragments. As stated in the 'SUIT Vademecum', conservation of urban heritage requires a different approach to the one used for monumental built heritage. Conservation and changes in urban historical areas have to take into consideration the living city, the flow and life of its population, its infrastructure and its socioeconomic development, which means involving third parties such as members of the wider public and special interest groups.

For what was described above, the SEA, EIA and SUIT can all be seen as frameworks and guidelines for plans, programs and projects on a considerable higher planning level and more comprehensive than the energy retrofit of a single listed building and its surroundings. Furthermore, despite the environmental focus in these assessment methods, there is no special focus on energy efficiency as supply, consumption and climate, which is the main focus area of the 3ENCULT project.

On the other hand, it is obvious that principles and procedures from i.e. EIA and SUIT can be successfully transferred or modified to enrich the development of a methodology to improve the energy efficiency of historic buildings. This is particularly evident in the description of the different stages of an EA as found in the final report of the SUIT project.

This procedure involves the following actions and stages during an EA: Firstly, a proposal for a project is prepared or a proposal for a plan or program is prepared. During the Screening stage, which is a quick stage, the Competent Authority determines the need for submitting the proposal to a complete EA. The Scoping stage is aimed at establishing the program for the environmental assessment. The Environmental Report is prepared by the designated environmental experts. Consultations are then usually organized with designated authorities and the public, on the basis of the Environmental Report. During the Decision-taking stage, the Competent Authority takes the final decision about the proposed plan, program or project. The final decision is announced by the Competent Authority. The Monitoring and post-evaluation stage is a long-term stage during which the actual effects of the plan, program or project are monitored.

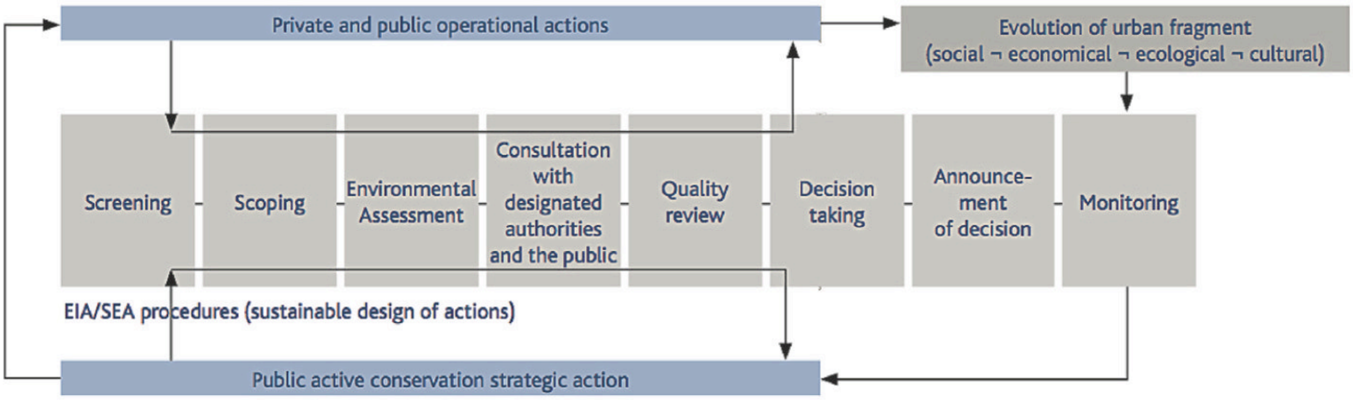

Figure 5, Diagram illustrating EIA and SEA procedures, illustration SUIT, a EU FP5 project.

This process has been subjected to an inquiry among the 3ENCULT case study responsible teams, and as mentioned earlier, there are procedures and stages in this process worthy of being transferred to a specific process for energy retrofit in historic buildings.

4.2 The 3ENCULT Methodology - heritage and urban context

Through the EU research project 3ENCULT a methodology based on EIA, environmental impact assessment, presently is developed. The methodology can be tested on the eight case studies of 3ENCULT, buildings wich in a broad sense represent qualities of European built heritage. The case studies are situated in urban areas and in the countryside, in cold and warm climates, in humid lowlands and in dry mountain areas. The aim of the methodology is to provide an approach and a process that makes it possible to identify and integrate values of culture and energy in conservation works of built heritage. It addresses the social and political environment of decision-making.

Thus the methodology becomes an instrument that identifies interests of stakeholders, involves public participation, and supports the process of decision-making.

Throughout the survey and the assessment process of decision-making the 3ENCULT methodology is a guiding process that identifies and balances culture and energy values, referring to cultural charters and conventions as well as to energy standards and directives. Through the 3ENCULT methodology, the survey and the assessment is processed to match local and even universal values of the environment. The identified values are integrated in scenarios and setups to support the democratic process, public hearings and decision-making. Scenarios will include passive and active energy retrofit solutions and evaluated in a multidisciplinary decision forum. [12]

The 3ENCULT methodology of EIA is implemented on the eight case studies [17], to survey energy and culture, to assess and balance effect of impact on the environment. Thus the implementation of the 3ENCULT methodology is tested as a generic tool for a process that includes energy and culture in environmental impact assessment in urban context thus following the line of the SAVE and SUIT method (Figure 6).

In a broader sense of environment survey, the Danish registration and evaluation system called SAVE (Survey of Architectural Values in the Environment) method is a tool and a basis for designation of landmark buildings and urban environments in Denmark. SAVE is basically addressing a complete survey of the built environment in a municipality for the purpose of producing a preservation atlas for the municipality. It could as well be applied for registration and survey of a group of buildings as for a single building and its surroundings. [18][9][10].

4.3 Developing the 3ENCULT Methodology

The aim of the 3ENCULT methodology is a transparent and operational approach to bridge the gap of historic buildings and efficient energy when it comes to program, interventions and projects,. It will ensure a sensitive and creative dialogue as well as it will put attention to potential resources and value inherent in the balance of energy and culture. Practically speaking, by presenting the methodology step by step as existing tools, system of inventories, possible interventions, [11] and decision-making processes it is a checklist as well as a frame. Thus, it is a guide to secure that projects meet what could be considered claims requested by European Directives.

The 3ENCULT methodology will be able to answer arguments and requests for the single project as well as it will be able to indicate balance of energy and culture as overall values and potentials for policy making and strategies. Following the draft of the 3ENCULT methodology, it is possible to define numeric values of initial energy performance, an elaborated argumentation for the balance of energy and culture, and the numeric value of the energy performance as result of the retrofit project.

It covers definitions of heritage analysis, the distinction and display of values as well as the methodology and process of assessment. The methodology is exemplified and illustrated by case studies of the 3ENCULT project.

For the major part of our built heritage, energy retrofit is indispensable for a sustainable development. The action of how and what to do when it comes to assess and preserve cultural heritage has to be derived from a thorough documentation and a balanced analysis of energy and heritage [13]. As heritage, energy in general and as consumption have to be taken into account with reference to

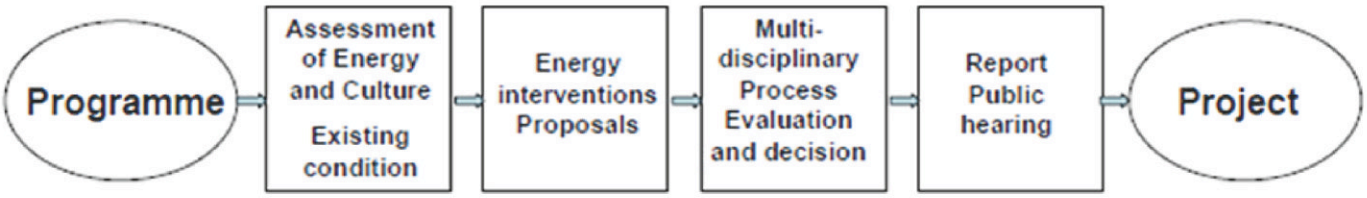

Figure 6, Draft 3ENCULT methodology. Putting attention to balance energy and culture, aswell as being an active source to assess impact of effect on the environment, the metholody supports decision making and direct attention to qualities of energy and culture.

tradition. It is obvious that the use of fireplaces for cooking and heating (Figure 7 and 8), as well as re-ejected heat from cooking places by leading chimney pipe through the house ensure optimal energy recovery for every room. Moreover the evolvement of building typologies are consequences of regional climate as well as the position of the house within the landscape or the urban quarter, as an acceptance of consolidated experience and to ensure the most effective use of the energy situation. Cooling, heating and lighting are aspects all builders and architects have respected when realizing optimal living comfort in buildings. Still through time and after several conversions and reconstructions the original balance of energy and culture of the building is sometime super-structured and difficult to understand.

To regain and understand the original use and structure is a major task when it comes to perform building analysis investigation. Thus, understanding of tradition is a key to find innovative solutions to energy saving actions of cultural heritage and historic buildings. Historic investigation that include the management of energy concept are indispensable sources when it comes to understand historical buildings, conservation policies, assessment of authenticity, sustainable development, and when it comes to argue for the responsible reception as intervention and energy retrofit of cultural heritage and architecture.

The character of energy sources, its use, the processes it involves as well as the infrastructure it takes to maintain it has to be investigated and described. The approach of this investigation will find its terms of references in the multidisciplinary and open combinations of different expertise such as producers, scientists and architects. This will make it possible to find innovative possibilities, principles, potentials of scientific tools, NDT and technologies such as simulation models, to be integrated, followed up and monitored as within a methodology that integrates energy and heritage in conservation strategies for historical buildings.

5. Conclusions

The various deliverables on analysis of built heritage and the correspondences between them are important contributions that ensure the sources and methodology that targets the values an scientific means that are indispensable for the balanced conservation policies developed within the 3ENCULT project. With reference to the interdiciplinary aims of 3ENCULT, they are sources and arguments for the strategy and diagnose guidelines to support active intervention on historic buildings. With this paper, we present results on analysis of built heritage and a draft for an enhanched methodology for conservation and energy policy.

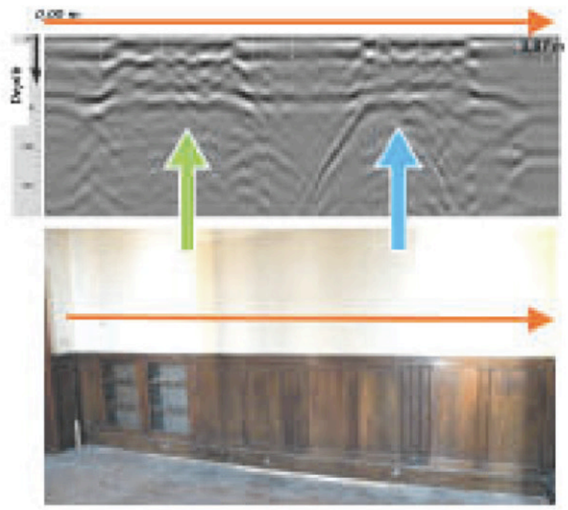

Figure 7, CS3 Palazzina della Viola, radargram collected along an horizontal line (in orange) on a masonry wall, showing the position of two chimneys below the plaster.

Figure 8, Original fireplace in Palazzina Viola. The comfort and the sensation of the original heating, maybe substituted by silver screen! It may be a dilema to have historic frescoes and living fire in the same space.

6. Acknowledgements

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