A tool for multidisciplinary development of energy efficiency solutions for historic buildings: the Raumbuch concept extended to energy aspects

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A TOOL FOR MULTIDISCIPLINARY DEVELOPMENT OF ENERGY EFFICIENCY SOLUTIONS FOR HISTORIC BUILDINGS: THE RAUMBUCH CONCEPT EXTENDED TO ENERGY ASPECTS.

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ABSTRACT

Through implementation of high quality energy efficiency solutions a remarkable reduction in the energy demand of historic buildings is achievable. Those solutions have to be very specifically targeted and adapted to the particular building case. Important basis for this approach is an experienced multidisciplinary team which guarantees a failure free implementation. This is the base postulate in FP7 project 3ENCULT. The paper outlines actual experiences with multidisciplinarity in the planning process both in heritage objects and low energy buildings and illustrates how the – in conservation well established – "Raumbuch" (room book) can be integrated with energy issues to support the constructive discussion across disciplines. It describes, which specific issues the conservation and energy experts look at in the survey and documentation phase and how the joint an structured documentation, not only on an aggregated level, but down till the single room supports also the development of solutions, comparison of different options and finally selection of the best one for the specific building. The potentiality of the tool does however not end with the support during a single energy retrofit as: Well documented study cases, where the reasons for decision can be reproduced, allow applying solutions in „smaller" projects where the application of the whole process would not be feasible. And finally the comprehensive documentation of as-it-is-state and all interventions together with supporting justification, given over to future generations – of restorers and users of the specific buildings – are the basis for the sustainable maintenance and long-term preservation of this piece of built heritage.

Keywords

Built heritage, historic buildings, survey, diagnosis, energy efficiency, retrofit solutions, multidisciplinary

1. Introduction

A reliable assessment of planned measures on a historic building is only possible if all foreseeable interventions in the building structure itself and the impact on the appearance of and around the cultural object are clearly defined and evaluated beforehand. Beside the changes on the building fabric also the indoor climate, the lighting and ventilation affect the appearance and substance. Only a profound knowledge on the building, its material, its structure and its history but also the significance of its parts allow a planning of energy efficient solution according to the specific claims of the specific building.

The indispensable multidisciplinary approach requires not only a common language, where terms like the original or appearance and image are commonly defined, but also common tools to work with. Ideally such tools enable the dialogue of the different disciplines and support an effective and thereby a cost-saving, planning process. On national and international level recently are discussed different concepts to support the planning process of energetic retrofit of historic buildings (e.g. in EU-project SECHURBA [1]).

Within the 3ENCULT we started with a particular concept for documentation, which is quite common in conservation praxis, the so called "Raumbuch" (roombook) [2]. It facilitates the survey and assessment in preparation of a refurbishment of projects in all sizes. For complex projects the concept is realized in databases.

Extending the "Raumbuch" tool to energetic aspects of a building acquisition, it can support the collaboration between the different stakeholders. The aim with this instrument is to have a systematic documentation of the building survey and a comprehensive assessment from different perspectives in a common tool.

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2. How multidisciplinary is the planning process?

2.1 Common practice

To date listed historic buildings can be exempted from applying the European Directive on Energy Performance of Buildings [3] and they also have an own status in the different EU national policies. Thus quite some of the necessary refurbishment measures are done with no or insufficient regard on energy efficiency. However, the demands for energy efficient measures in the historic building stock cannot be ignored. Nevertheless the planning of energy efficiency measures on historic buildings can only base on the precise knowledge of the heritage values. . In the past, in some cases the planning processes of renovations have suffered from the clear separation in the work of architect and building engineer. Since there are only few professionals perfectly trained in all areas, the cooperation of the various disciplines working with the cultural heritage has to be improved.

A good example of this cooperation is to be found within the integrated design process in Copenhagen (see below). Depending on the arrangement of the approval process for construction 0 projects in the various jurisdictions, the involvement of the preservation authorities in the planning process is not always possible. To address this problem in recent years several guidelines for different types of buildings or certain measures were developed to prepare the decision-making as best as possible [4][5].

2.2 Experience at 3ENCULT case study "Fortification Depot" in Copenhagen

The energy retrofit measure as carried out in case of the "Fortification Depot", a listed building in Copenhagen (DK), is one of the case studies within the project 3ENCULT. Here the stakeholders aspired a holistic approach from an early planning stage [6]:

With the retrofitting of this building the owner aimed not only at giving its contribution to CO_2 emission reduction, but also at showing on the basis of a case study, how this planning process could be achieved as concept for listed buildings in general. The final solutions were developed in an iterative process, among a multidisciplinary working group, consisting of building owner, heritage authority, architects, structural and service engineers. At the beginning of the design process the as-is state was detected regarding building and construction history, existing conditions and historic and architectural values. Starting from a broad gross list of possible solutions, the team decided in regularly meetings which ones they wanted to follow and which ones they had to remove. All decisions in each step were well documented, simulations of the single solutions helped to illustrate their possible effects and to evaluate.

The methodology to start with a multidisciplinary team from a high number of potential solutions from which in several rounds, with increasingly detailed analysis, suboptimal solutions are deleted and promising brought forward is typically known as the Integrated Design Process "IDP".

With this approach the working team elaborated an exemplary method to reach an adequate energy efficient retrofit by assuring the conservation demands. During the working process a tool for documentation of diagnosis might have been helpful or rather this kind of approach could be implemented in a tool.

2.3 Experiences from "outside" the Monument Conservation

While dialogue and collaboration cross disciplines might be particularly important when dealing with buildings of historic value, also in "normal building planning" a paradigm shift can be observed: Especially when it comes to developing buildings which should have "zero energy balance" over the year, the appropriate approach is that on every single solution and on every design step a decision is taken among all stakeholders (building owner, architects and engineers), who meet in regular workshops. Within these meetings results are presented and exchanged among the experts as a discussion basis for the decision-making. Simulations and calculations of several measures, regarding energy efficiency and energy production help to evaluate different measures.

In 2006 the United States federal government decided to employ the "Integrated Design Process" in the "Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings" [7] and the International Energy Agency Task 23 has illustrated "that the Integrated Design process has been shown in many case studies to result in high levels of performance, a superior indoor environment and greatly reduced operating costs, at little extra capital cost. In order to achieve an integrated building in terms of performance and cost, a traditional design process is in many cases ineffective. Although there will always be individual designers who are able to design brilliant buildings in an individualistic way, the IDP approach will be of significant benefit to most designers and clients who are attempting to achieve excellence in building design." [8]

3. Documentation and Diagnosis

The comprehensive investigation and documentation of monuments before and during an intervention is noted in European agreements on the protection of cultural heritage [9][10]. In the Venice Charter [11], article 16 it is written: "In all works of preservation, restoration or excavation, there should always be precise documentation in terms of analytical and critical reports, illustrated with drawings and photographs. Every stage of work of clearing, consolidation, rearrangement and integration, as well as technical and formal features, identified during the course of the work, should be included. This record should be placed in the archives of a public institution and made available to research workers. It is recommended that the report should be published."

Within the EU-CHIC project guidelines were developed and tested "that are required for the efficient compilation and storage of data pertinent to each asset under observation." It will be necessary to take into account these guidelines for the development of the database [12]. But the documents provide no information concerning the exact appearance of the documentations.

The need of a common multidisciplinary approach, where the single experts exchange information and knowledge from an early planning phase and where they collaborate in a multidisciplinary working group was also what experts emphasized during a multidisciplinary workshop, held among the project partners of 3ENCULT [13]. They asked for a tool which helps to follow this multidisciplinary working process and which supports the dialog among the experts by documenting every step from the beginning of analysis of the as-is-state of the historic building till the implementation of energy efficient refurbishment.

3.1 What a conservation expert looks at

In the 1980th the "Raumbuch", documentation and planning tool of the real estate management and new construction praxis, was transferred to the conservation praxis [14]. The aim was to propose a unified structure for documentations of built heritage. The basic principle is the room-related acquisition of the stock, which means the building is not systematized related to construction trades or building elements, but the description, documentation and condition assessment are structured according to rooms or room units. This practice is appropriate, because the room is usually the smallest design unit of the building. The data comprehend the whole life cycle of the building.

There is an absolute necessity of an accurate localization of findings and information to establish a communication among the different stakeholders and to respond to the individual requirements at the monument. All parts of the building, rooms, surfaces, and components are identified by a system of numbers. Another special feature of the room book is the connection of graphical and non-graphical information. The documented room surfaces can and should be shown in photos and drawings, which are accompanied by written information. Thus, a room with a floor plan and elevation drawings, detail drawings, photos and descriptions of the condition is documented. A chronological examination displays the changes to the building and enables a detailed reconstruction of past conditions.

The design of the investigation is flexible and should fit to the building and purpose. Information usually included, is listed in Table 1.

Table 1 Aspects of interest for the documentation of the conservation related as-is-state

General information Name/Company of surveyor, Location, name of building, Legal investigation (ownership, local legislation and development plans), Present function, original function, Date of completion, Architect/Artists/other persons, Construction methods, Short description (location, measurements, stories, axis, structure, roof, bays, balconies and so on), Heritage administration in charge of the object
Urban context. Location, accessibility, orientation, historical context
Building. shape/dimensions, levels/axes, short description of facades (surfaces) and roof, internal access/floor plan, building history/historical background
Rooms. Comprehensive description of the design including structure and arrangement, material properties and in association with the appearance such as color and texture, all features that indicate an existing or previously existing system of construction, design or function, all characteristics that indicate the disorder of these previous systems, description of the space-delineating elements like flooring, walls and ceilings regarding the construction, the surface, the immovable elements (windows, doors), the movable elements, installations etc.
The documentation is supplemented by the description of facades and roof with its appearance and structure.
The investigation of the visible facts is completed by comments on interpretations, valuations, conditions and damage and cross-references.

3.2 What an energy consultant looks at

To develop retrofit measures for an existing building, an energy consultant has to collect all information before starting to plan. The aspects regarding the documentation of the as-is-state are described in Table 2:

Table 2 Aspects of interest for the documentation of the energy performance related as-is-state

Local climate data / environmental conditions
Buildings consistency regarding static problems, fire protection, seismic safety, consistency and type of building services; particular architectural solutions related to original use of the building
Urban context. Position of building in city context, origin and location of overshadowing from trees or other buildings
Building energy consumption. Evaluation of the actual energy performance of the building by collecting energy bills and documentation from previous energy audits
Analysis of building elements. Analysis of construction of the external walls, windows, internal partitions and basement with the identification of materials, type and dimensions. Technical data of materials: density, conductivity, specific heat capacity, water vapor diffusion resistance index, long term water absorption; conservation state of building elements regarding humidity or any other visible stain/deterioration. Identification of passive use of solar energy (direct solar gains through transparent areas, use of solar energy for solar technologies as solar thermal or photovoltaic regarding possible surfaces and orientations). Possibilities for using daylight.
Analysis of technical systems/buildings services.

Analysis of the surrounding context in terms of: availability of sources for energy production, availability of district heating etc.; characteristic of the existing generation system, ventilation system, heating and cooling system, hot water production and water supply, state of drainage system, availability of renewable energies, state of electrical installations and lighting
Presence of constraints and limitations regarding preservation of building
Determination of design values for internal conditions (e.g. temperature, RH set point values), occupancy density, type of utilization and occupancy times.
Availability of space for plant room, space for e. g. building services like cooling towers, chillers etc., availability of suspended ceilings or void floors for technical installations and distribution systems as well as availability of existing openings and holes or not used chimney for distribution systems

3.3 Dialogue cross disciplines

Since in building preservation, restoration and conservation diagnosis and documentation are most important, and such is the practical data uptake of the building status prior to any energy retrofit planning, a common data collection and result is a logic consequence – even more, if considering that conservation and energy issues might even be overlapping, as e.g. the look at humid and salt contaminated walls.

This requires a method which is able to collect and visualize all data in a structured way: any information needed for the diagnosis like descriptions, plans, photographs, drawings of details, results of none or minor destructive testing, monitoring data as well as calculation results and models. Architect, conservator and engineer should be able to "move" through the building on different levels of detail, having the relevant information for constructive discussion at their hands.

The usefulness of this kind of method or tool should however not end with the diagnosis: Also the development of solutions, the comparison of different options and the selection of the best one for the specific building should profit from the structured presentation and simultaneous look at both conservation and energy aspects not only on an aggregated level, but down till the single room. Finally the integration of intervention documentation and monitoring of performance should complete this holistic approach.

4. Development& description of the tool

4.1 Technical needs and implementation

The 3ENCULT consortium agreed that a tool for such integrated documentation of conservation and energy issues based on the "Raumbuch" concept has to be developed und used within the project. It should be a digital database with remote access possibly via the web open for all project participants (including local case study teams). If necessary with differentiated access rights, which integrates documentation of diagnosis and monitoring as well as information gathered on energy issues with an on-site inspection following the guideline elaborated within the project, which supports also the design and implementation phase at the case studies and allows a continuous documentation of the progress.

Working with a database gives the opportunity to bring together all available information in a way that nothing gets lost and everything is taken into account on the way to project planning. It makes communication and handling easier because standard forms with standard terms are used and information has to be inserted only once – data can be made visible in several related places within the database, but also imported from and exported to external software tools. A database gives finally a clear "plus" of information by connecting documents and pictures as well as catalogues to different building layers.

Within the 3ENCULT project it was the aim, to base on an existing database. For the selection the following criteria were important: (i) the focus on the needs of conservation and restoration practice, (ii) the web-based system as well as (iii) a modular design that allowed the addition of the aspects of energy.

The decision was made in favor of the Monument Information System (DIS) developed by ProDenkmal, a web-based and modular database which is targeted at conservation and planning in the context of preservation [15]. ProDenkmal uses the tool for internal projects and provides it also to external users, adapting it to the specific use. Recent projects include the "Neues Museum Berlin", Eremitage St. Petersburg, and New Residence Bamberg. Similarly to 3ENCULT, the buildings, their structure and furnishing as well as their preservation and future were at focus.

4.2 Description of the DIS

In the following a tool concept and its needs is described looking at the example of database that is being developed within 3Encult:

As illustrated in Figure 1 the user interface is divided into different aspects like navigation, associated documents, main information deposited directly in the database in the central part, picture view and preview documents, which makes it possible to show different information related to one aspect at a glance.

4.2.1 Navigation (upper left)

On the upper left side the core of navigation is located: the tree is based on the structure of the building, thus one can navigate from layer to layer deeper and deeper into the building: starting from the whole building, over building part and building zone to the small level with the single floors, the rooms and its components (e. g. wall) and elements (e. g. windows).

When the user enters different information or when he attaches documents he can assign them to the different levels where they are of interest. Or the other way round:

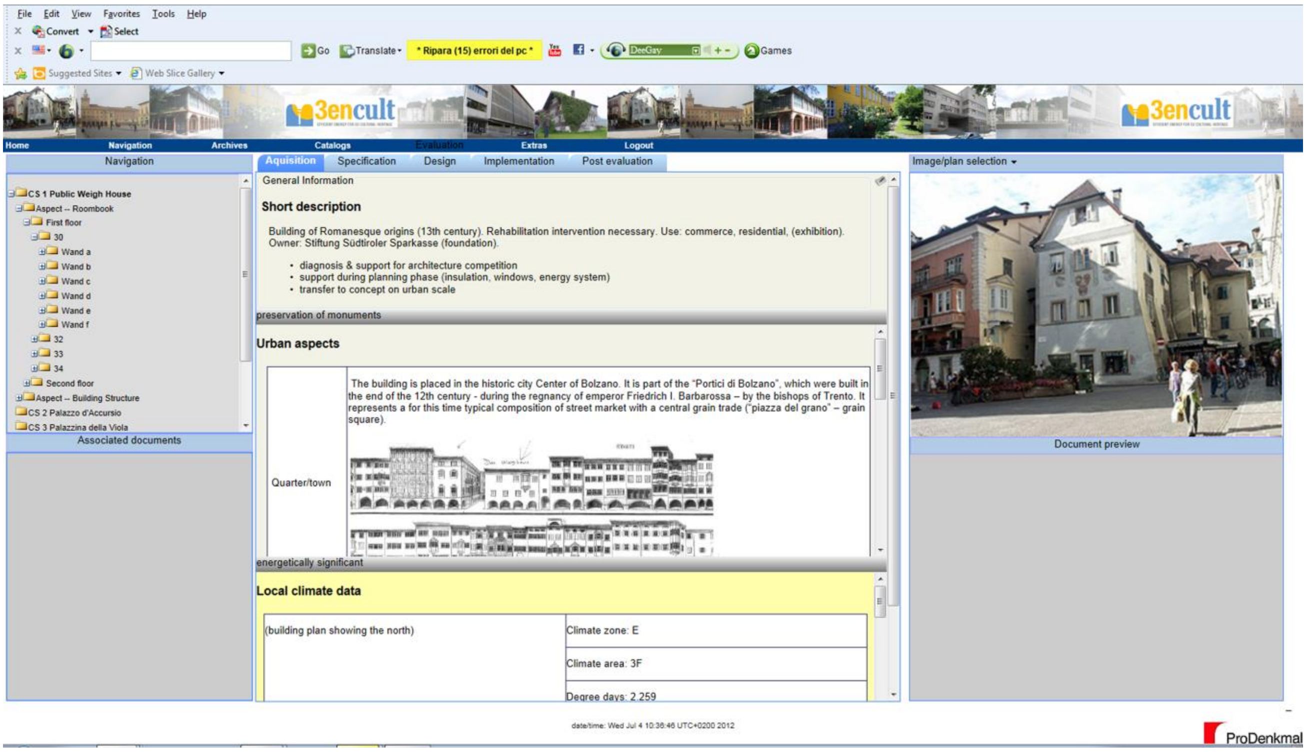

Figure 1 User interface database

When a user searches for information regarding e. g. a particular door, he navigates through the building to the respective element. At the same time this structure works like a filter: with every level deeper into the building the information gets more detailed.

Parallel to the layer "Raumbuch", which moves through the building and looks mainly at visible aspects, another chapter regarding the building structure respectively the "thermal envelope" was inserted which gathers information related to elements like the roof and top floor ceiling, walls and facades, ground floor and basement ceiling, windows and doors, chimneys and ducts as well as ceilings and internal partitions, which are important for energy related diagnosis and intervention development.

4.2.2 Main information deposited directly in the database (middle)

The central part of the user interface is the main section where data can be deposited directly in the database. It is subdivided horizontally into different stages or time steps of project planning like "Acquisition/Survey", "Specification", "Design (options)", "Implementation" and "Post-Evaluation". Vertically information is structured in "general information", "preservation of monuments" and "energetically significant" issues.

Also here the inserted information is linked to the building layers (navigation upper left). On the layer of the entire "Building" e.g. and under the stage of project planning "Acquisition/Survey" users give information with regards the name of the building, a short description regarding different construction phases and architecture, present and planed use (under "general information"). Under "preservation of monuments" on the "building" level users insert information with regards the preserving/architectural value of the entire building, while under "energetically significant" urban aspects like the position of the building in the city context or the potential of transferability of solutions are described, information on the position and local climate data of the building is given, the state of the entire building as well as the construction method and the architecture respectively the energetic potential always regarding the entire building is described.

Guiding the user from level to level with specific questions (defined previously based on the conservators' experience and the guideline for energy audit in historic buildings elaborated within 3ENCULT), the database works also like an analysis tool.

4.2.3 Picture view (upper right)

The upper right part of the user interface serves for orientation while the user is navigating through the building: when clicking on the "room" level e.g a picture of the ground plan of the related storey, indicating this room with its room number, is shown. Thus on every level the user understands immediately which position in the building the information shown in the middle and the linked documents refer to.

4.2.4 Associated Documents (lower left)

The database gives the opportunity to insert documents and to interrelate them with the layer of interest: Under associated documents on the lower left side of the interface the user can see the list of documents linked to the present navigation layer.

On the level of the “building” or “building part” e.g. certificates or reports which refer to this layer could be documentation of former refurbishments, interventions or energy audits; reports, analysis about state of the building regarding conservation, static or energy bills. Typical related plans would be the drawings of the whole building regarding the as-is state, and related calculations would regard the whole building like energy demand for heating of the as-is-state. Typical relevant measurements or diagnosis on the “building” level could be furthermore blower door test, IR thermography or monitoring data which concerns the whole building like the measurement of the total thermal energy consumption.

On the level of the “room” typical related documents would e.g. be photos from wall prospects, drawing sections of rooms, material sample analysis. Typical measurements could be the monitoring of the indoor climate of this room, while typical calculations are for example thermal bridges regarding this room.

The associated documents are categorized in sources, reports and findings, calculation and simulations, monitoring, planning documents and finally measures documentation.

4.2.5 Preview documents (lower right)

The lower right side works like a preview. Relevant pictures and documents can made visible in parallel with the relevant information shown in the middle part, if e.g there a thermal bridge is described at the same time the picture of the detail section with the indication of heat-transfer can be shown.

4.2.6 Documents and pictures (main menu)

All documents and pictures of the database visible under “associated documents” (lower left) can be managed under “archives” (horizontal main menu). Here the files can be uploaded to the database and directly linked to the relevant layers where they should then appear. The user here has also the possibility to insert information regarding the file like file name, document type, location or author etc. and to use a search function for finding documents.

4.2.7 Catalogues (main menu)

A very important function of the database is the catalogues: For every construction element of the historic building a section can be created within the “building elements catalogue”. The building elements of the catalogue can be linked to the referring building elements of the navigation (upper left). Similarly in the “material catalogue” a construction material can be documented. The material catalogue is connected with the building elements catalogue. Users insert the material into the material catalogue, while in the building elements catalogue he chooses the material from the material database and assigns it to the respective layer of the building element. For the windows an extra catalogue is under construction, based on an existing catalogue of ProDenkmal. The single windows can be linked with the “room” layer or with the “façade” under “thermal envelope” (see navigation upper left).

Export and import functions to two software tools used within the project (PHPP for static energy demand calculation and Delphin for analysis of hygrothermal details) are integrated. Interfaces to other tools are of course possible to be implemented.

Table 3 Three catalogues and their main information

Building elements catalogue
Name and the related area, the total thickness and the U-value can be inserted. Additionally a detail drawing as well as attributed photos can be linked to the element. In a separate table the stratigraphy of the element is documented by inserting each material, its thickness and its thermal conductivity (material can be from to the material catalogue)
Material Catalogue
Material name, thermal conductivity, density, thermal heat capacity, porosity and dynamic viscosity as well as information on air, vapour and water tightness (possibility to import material data directly from the Delphin material library)
Window catalogue
Number of windows, width and height, type and name of glazing and its solar energy transmittance (g-value) and thermal transmittance (U_g-value), thermal transmittance (U_f-value) and the dimensions of frame, typology, number of sashes and number of sash bars etc.

4.3 Levels of documentation – from large to small: interrelation of conservation and energy aspects

From an energetic point of view the entire building or building zones with similar interior room climate conditions are of interest as well as the structure/construction of the building, while the conservator looks besides the entire building primarily to the single rooms. The proposed database takes this into account by providing the under 4.2.1 above described navigation structure and focusing on the two levels “building (part)” and “room”. The levels of these two structures correspond with one another, thus e. g. the information on conservation and energy issues related to the room “meet” on the same level.

Relevant information with regard to preservation issues are the description of construction and utilization phases, equipment according to construction and utilization phases and general description of preservation/architecture value of the room and its equipment from the conservator point of view, regarding also installations like heaters and lighting. Relevant information with regard to the energy issues are the description of construction and material aspects (to link building elements from the building elements catalogue to the single rooms), wooden beam construction, thermal bridges, description of building services/equipment in this room like installations, heaters, lighting etc.

Another example illustrating the correlation of the different approaches is the urban context. Even if the structure of the database starts with the entire building and its focus will always remain on the documentation of individual buildings, the integration of the building into the urbanistic context is essential: on one hand side from preservation point of view in terms of evaluation of the impact of interventions on the surrounding buildings and on the other hand side from energetic point of view in terms of analysis of surroundings with regards the possible use of energy sources on the building of from nearby or the application of "smart grids" and overshadowing caused by surrounding trees or buildings.

4.4 "Mapping" of the different project phases

The utility of the tool does not stop with the documentation of diagnosis and analysis of the as-is-state of the building: the tool accompanies the single phases of the design process and the development of solutions up to their implementation and finally to the documentation of the state after refurbishment (post-evaluation).

In every progress stage the user of the tool profits from the formatted information and data and the simultaneous look at conservation and energy issues, associated to the respective building layer. Within the database the sequences of the different project phases are organized in the central part of the user interface – the user can move from tab to tab from "acquisition" over "specification" and "design" to "post-evaluation".

4.4.1 Acquisition/Survey

Information brought together in this early planning stage helps to detect and to consider the individual demands of the historic building. It includes e.g. detailed description of the as-is-state regarding energy aspects with focus on structural analysis, analysis of architectural elements and technical system and detailed description regarding conservation aspects and is accompanied by photos, first simulations of the building with regards energy performance, indoor climate and hygrothermal behavior as well as first monitoring results.

4.4.2 Specification

In the second phase of project planning, the "specification", information from the acquisition phase are completed and specified towards the design phase. The future use of the building has to be established in terms of a space allocation plan, which means that for every room a utilization/function is assigned. Targets for energy efficiency are formulated as well as restoration and preservation objectives.

Important part of this section is the description of the heritage value in terms of the (i) architectural value (significance in architectural history, proportions, harmony of composition, outstanding work of a certain architect), (ii) cultural-historical value (evidence of social functions or historical way of life, evidence of evolution in craftsmanship or technology), (iii) artistic value, environmental value (degree of harmony with the environment, architectural relationship with buildings in the neighbourhood), (iv) originality (degree of original exterior preserved, possibility of rehabilitation) and (v) authenticity (degree of legibility of historical information).

Specification includes determination of intervention needs, presence of constraints and limitations, guideline for intervention and first feasibility studies.

Regulations or extracts of laws from the local preservation office and from building authorities, regulations and guidelines regarding energy efficiency in existing buildings, certificates and reports on building safety and on materials complete the documentation in this phase.

4.4.3 Design (options)

The design phase is the core phase of the project progress. Here the user has the opportunity to document several interventions/refurbishment solutions and to assess their impact on the building from conservation and energetic, but also from financial point of view. In this way single interventions can be compared directly and be a basis for discussion among the experts team for decision-taking.

Here documentation includes description of single interventions and intervention packages with regards the building envelope and the technical system. The documentation is accompanied by simulations on energy performance and hygrothermal behavior as well as on costs. The single solutions are documented by means of description, drawings and evaluation table.

Besides the different solutions also the "way of decision-taking" is documented here. This means that the user can reproduce and understand how it had come to this decision.

4.4.4 Implementation

After determination of the execution project and implementation of solutions the final state of the building is documented in terms of implementation plans, energy certificates and technical report. The detailed documentation serves already for being the starting point for upcoming interventions on the building in the future – it is the detailed documentation of the as-is-state after energy refurbishment for future projects.

4.4.5 Post-Evaluation

Finally the project closes with the post-evaluation phase. Here the state of the historic building after the implementation of energy refurbishment is evaluated.

The building is analyzed with regards the effectiveness of measures, if targets from the design phase were reached also in reality, the impact of interventions on the building itself, on indoor comfort and on energy consumption. It has to be proven, if measures were executed in the right way and in case if the impact has been evaluated positively, it has to be proven if they are transferable to other similar buildings and could become a model character.

The documentation contains a report on the status post-intervention considering results of hygrothermal monitoring, structural and environmental monitoring.

5. Who are the users of the tool?

The potentiality of the tool goes far beyond the application in 3ENCULT, where it has besides the facilitation of communication and information exchange within the consortium also the very practical task to create the documentation deliverable.

5.1 Utilization in the planning process of projects of a certain size

The tool could be used directly (or be at least a good example) for the planning process of every refurbishment project. It helps to realize the integrated design process by accompanying the refurbishment planners in every phase of the project. In this way it guides the IDP, makes exchange of knowledge and information as well as communication among the different experts easier and helps to find the best solution for the individual building by considering both conservation and energy demands.

Possible users of the tool in this case are all stakeholders of the planning process, so building owner, architect, engineers (for technical system, static, electric, daylighting), conservators and other experts.

5.2 Utilization as guideline for intervention in smaller projects

Even if comprehensive diagnosis and multidisciplinary approach would be beneficial, in "smaller" projects funding might be difficult. Therefore well documented study cases, where the "way of decisions" can be reproduced and understood, can be a valuable resource for who has to find solutions in a "similar" case. To give an example, the comprehensive investigation and intensive research for the best solution in energy retrofit according to preservation issues of an Appenzell "Strickbau" study case within the 3ENCULT-project can be a best practice example for other, more or less similar buildings in the Appenzell valley.

It is important to emphasize, that only if it is known why a measure was chosen or not, it is possible to decide if it can be transferred to another object (different conservation issues, different pre-existing damage, and different building physics).

5.3 Documentation of the intervention history and their motivation

The comprehensive documentation of the as-it-is-state and the acquisition of all measures in a database ensure the maintenance of this information for the future. With the clear structure and precise spatial location of all collected information it enables to use these data for later interventions on the building. If there is a further refurbishment or stage of construction it can be established on existing research, which preserves the substance and is cost effective. For example, to avoid material incompatibilities with the following measures, the knowledge about already used materials is important. If there are unexpected damages to the building the cause can carried out efficiently with the help of a good documentation of previous interventions.

6. Conclusions

A paradigm shift in building design – away from the consecutive contribution of single specialists to the planning process towards an integrated design process gathering all stakeholders around one round table – can be observed as has been shown above.

Starting from the in conservation practice well-established room book concept, within 3ENCULT a tool to guide and support this multidisciplinary approach is being developed. Gathering and visualizing information in a structured way it allows architects, conservators and engineers to "move" through the building on different levels of detail with always the related information for constructive discussion at their hands. As illustrated in the paper the usefulness goes far beyond diagnosis, as the development of solutions, comparison of different options and finally selection of the best one for the specific building will profit from the structured presentation and simultaneous look at both conservation and energy aspects, not only on an aggregated level, but down till the single room.

The potentiality of the tool does however not end with the support during a single energy retrofit as illustrated above: Well documented study cases, where the reasons for decision can be reproduced, allow to apply solutions in „smaller" projects where the application of the whole process would not be feasible. And finally the comprehensive documentation of as-it-is-state and all interventions together with supporting justification, given over to future generations – of restorers and users of the specific buildings – are the basis for the sustainable maintenance and long-term preservation of this piece of built heritage.

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