3encult

EFFICIENT ENERGY FOR EU CULTURAL HERITAGE

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0 Introduction

***Imbued with a message from the past**, the historic monuments of generations of people remain to the present day as living witnesses of their age-old traditions. People are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage. The common responsibility to safeguard them for future generations is recognized. It is our duty to hand them on in the full richness of their authenticity*[1]. These are the words of the introduction of the Venice Charter, the still valid and contemporary International Charter for the Conservation and Restoration of Monuments and Sites. As many following chartes the Operational Guidelines of World Heritage elaborates on terms of the Venice Chartres *Authenticity does not limit consideration to original form and structure but includes all subsequent modifications and additions, over the course of time, which in themselves possess artistic or historical values*[2].

Thus not all parts and images of monuments and historic buildings are imbued in the same way as "message from the past", and with the concern for that authenticity necessarily not is equal to original. Following this argument it is necessary to analyse the original material and which parts of a listed building are crucial value as historic and artistic authenticity; and which parts can easier be altered when it comes to make measures to improve the building's energy efficiency.

The conservation issue usually applies to a group of people with a distinct image of history and is usually bound to a particular period, it is temporary. The message of a monument was different fifty years ago and will be different for following generations. Every generation raises their own questions to the history and monuments. If the facts are considered from that perspective the only solution for historic monuments would be to leave them unaltered, the whole and unchanged preservation. This is simply impossible. If nothing is done, historic monuments will fall into disrepair; and with preservation

First aim is the unaltered preserving of current substance and image so far as possible.

measures monuments will be altered. However, preserving all listed buildings in Europe is only feasible if the majority in use.

The improvement of energy efficiency of historic buildings is becoming increasingly important for monument preservation. The climatic change endangers heritage buildings all over the world. Additionally, modern living standards may cause climatically problems for buildings. Only the ability of economical use ensures the heritage's continued existence.

Measures improving energy efficiency are only acceptable for heritage preservation if they do not destroy the historic value or disturb its lasting. We will show, what the specific reasons for preservation mean for the preservation praxis. However, often more than one preservation criteria is given for a building, whereas some building parts prove to be more important than others. Such a classification can help to understand what must be considered when modernizing historic monuments. Still, it is impossible to grade technical solutions as results of preservation motives.

An example will state how protected and other historic buildings can be sorted in a way that corresponds to technical solutions for refurbishment and modernization. Based on these theories we propose to develop a catalogue for architects and conservation officers to be used as guidance and support in decision making, considering consequences and finding adequate solutions to match the demands for an increase of energy efficiency.

[1] Venice Charter 1964
[2] UNESCO 2008, par. 9

1 Demand analysis

Every historic monument has its individual requirements for conservation and refurbishment and energy efficiency is closely linked to the type of use. To pursue any defined energy saving goal without knowledge of the building will definitely result in disturbing the authentic historic character of the

Knowledge about original climate system of the historic building can be the motive for solutions with high value to heritage compatibility.

monument. It is necessary to analyse the demands of every building before planning refurbishment steps. There must be reached a compromise between heritage, environment and building climate aspects that preserves the monument in the most sustainable way. The objective of this chapter is to introduce a wide range of requirements.

1.1 Comfortable Building Climate and Preservation of Construction

Bekanntermaßen müssen viele der bislang verfügbaren energetischen Ertüchtigungsmaßnahmen für den historischen Baubestand als problematisch eingestuft werden, vor allem in ästhetischer, aber auch in baukonstruktiver Hinsicht (*As is known many of the present available measures increasing*

To use the building is of particular importance for preservation. New demands for comfort and environmental protection, however, often require the upgrading of energy efficiency in historical buildings.

energy efficiency of historic buildings has to classify as problematical, above all in aesthetic but also in constructive respect.)[3] This was written in a study for the Saxon Government in 2010. The constructive problems affect the heritage building in there substance.

In most cases, it is regional materials and their usage which characterize historic buildings. Energy demands and needs were resolved within these regional conditions. Nevertheless long-time experiences have helped to produce buildings with a functional building climate, meaning building physics which does not endanger the construction and creates a comfortable environment both for living and general use.

The roman house built around an open court or atrium is an example of long-time climate adaption. Water in a shallow pool cooled the court by evaporating; all wall-openings were protected against sunbeams by roofs, supported by columns. The rooms were prevented from being heated by the sun, and fresh air was circulated from the atrium.

Another example is the so-called *Umgebindehaus*, which has a *Bohlenstube*, a living room built from full- or half-split beams, like a block house. The wood is an insulating material and has also buffering hygroscopic characteristics. The windows had wooden shutters on the inside, so called *Ritschel*, which give additional insulation particularly at night. Stove heating in combination with permeable windows had the positive

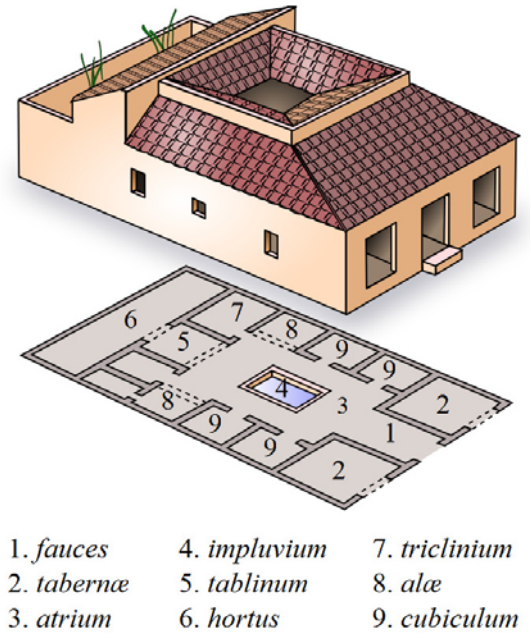

Fig.1 Scheme of the Roman atrium House. Wikipedia, Tobias Langhammer.

[3] Grunewald, Will 2010, p. 9

effect of bringing fresh air into and moisture out of the rooms.

Fig.2 Umgebindehaus in Obercunnersdorf, Saxony (Germany)

The above-mentioned and other building types have existed since hundreds of years which would not have been so if they had proved insufficient for functional or living purposes. To maintain historic function and to repair it should be the first step for energy efficiency. Even the original climate system of the building is part of the authentic monument and to improve it is therefore more acceptable than install a new one.

To make a house comfortable for modern living requirements the room temperature will mostly need to be increased in all rooms of the building. Baths and showers bring additional moisture into the houses. Central heating and airtight windows without other measures cause moisture problems which consequently may lead to severe damage. The historic building may become uninhabitable when its construction is damaged by corrosion or fungal attack. However, this is a worst-case scenario. Still, such negative effects are mainly the result of ill-planned modernisations, only an analysis of the building and a complex planning can prevent such processes.

The consequence of complex planning is often also a complex solution. Every solution for a problem may cause new difficulties. Buildings will be insulated to prevent mould. It has good effects for a plain wall. But around windows, or where construction elements are intersecting the wall such as balconies, smaller windows with insulated jambs and new balconies firstly appear to be the ultimate solution to problems caused by thermal bridges. Thus the heritage building is altered step by step, with the consequence of severe loss of original substance but also authenticity. Its historic value declines. This primarily occurs buildings of the 19th century. But other constructions, other periods and other building types have other difficulties. The very best for heritage are simple solutions adapted to historic materials and forms that have been standing the test of time.

Only long-time experiences can guarantee that a solution provides the required sustainability.

The consequence of such cases for the built heritage ought to be getting the existing building climate system into a good trim. This means that it is necessary to analyse the building to find simple solutions for a comfortable climate and to use well-established solutions for energy efficiency. This would also be in accordance with the Venice Charter, which says: *the consolidation of a monument can be achieved by the use of any modern technique for conservation and construction, the efficacy of which has been shown by scientific data and proved by experience*.[4] That goes especially for measures not necessary to consolidate the monument. Every measure causes alterations and loss on the heritage's side. They might not be majorly significant; nevertheless they can only be justified if the measures taken will give real benefits in a long-term perspective. The validation of such benefits must also take into account the possible loss of material quality in a short time perspective or the causing of other environment problems. Furthermore, it is to be taken to concern that the craftsmanship might not be exactly as calculated and the function and behaviour caused by the use of the building will be destructive. This may not even be result of a pure coincidence thus the quality of solution can only be assured through long-time experiences. Thus, new solutions for heritage buildings should be based on thoroughly tested materials and techniques. A modular energy saving system for heritage preservation could be an issue, with solutions for different constructions, walls, windows, heating and air-conditioning systems, etc. Particular measures for a special monument could be chosen to give a satisfying solution for the entire building.

[4] Venice Charter 1964, paragraph 10

1.2 Economic aspects

Fig.3 These residential buildings have been uninhabited for years.

Heritage buildings, this is also a well-known experience, can only be preserved, if they are in use. Therefore they have to be competitive in property market. The European countries have different ways to support costs for refurbishment and preservation, but also running costs, as running energy are of significance. Even if new or renewed building services and a better insulation of the building envelope is the aim of economy as to protection of climate, this does not correspond to all cases. For example, earth-source heat pumps reduce the carbon dioxide emissions but the energy costs remain unchanged[5] as electrical energy for the heat pump is more expensive than oil or gas compared to heat. This means, that even if clients choose economical solutions which are rather good for the environment they may be a bad choice for the historic building.

One example is to be observed at housing companies in eastern part of Germany where many vacant flats are there. They have been supported by the government for energetic modernisation and are in competition with other housing companies for low rents and low running costs. Housing estates are modernised with regard to high energetic efficiency, though not necessarily carried out aesthetically. Heritage preservation is frequently ignored, not even considered and worse not even recognized. Still, the real energy consumption often remains unknown. The consumption of historic buildings calculated

Energy efficiency is also achieved by user's behaviour.

by rules can be up to hundred percent higher or lower, than actually measured result of the modernisation.[6] In most cases, there are no records about the real consumption before refurbishment,[7] thus it is not clear how much energy is actually saved.

Moreover, there is a lack in calculation of energy saving, i.e. the energy for producing and disposing insulation material, for transport, shortly speaking: a total energy balance lacks. Consequently, it could happen that historic values were given up even if the energy saving measures did not cause the expected results, and sometimes measured results did not cause the intended economic effects.

Despite all difficulties, providing total energy balances has to be central aim for energy and culture. Only detailed energy saving can establish measures, with positive impact on the value of monuments and positive effects for an environmental solution.

It is still not acceptable, that authenticity and historical value of monuments were given up only regarding economical aspects without benefit for environment. CO_2 is only one of the environmental problems. Measures to improve energy efficiency must not cause other environmental threat. Historic materials and technologies make this sure in most cases.

1.3 Conclusion

When it comes to improve energy efficiency heritage conservation not always pursues same goals as owners, investors and as environment protectors. These actors focus often only on heating energy

[5] Grunewald, Will 2010, p. 104
[6] Weller et al. 2008, p. 12
[7] Grunewald, Will 2010, p. 45

and building insulation. Still especially building insulation is in many cases not compatible with the demand of monuments. Solutions more suitable for heritage buildings can found in a wider range. Improving heat and light technology, influence user behaviour and involve urban possibilities are starting points when it comes to develop innovative solutions that doesn't harm monuments.

2 Preservation criteria

The discussion of classification in the context of energy efficiency measures is followed by the idea that such classification could even help to choose suitable solutions for every listed building. Classification in heritage conservation praxis is a rarely discussed subject[8]. In some European preservation laws a distinction is made between monuments of high national historical value and others of lower regional value. In practise, this distinction is often used to determine resources which are to be applied when it comes to restore a historical building and whether local, regional or national administration is mandatory when it comes to decide on building applications. But this kind of classification gives no criteria for the refurbishment praxis. Historical value of monuments could be the design of the façade or the fine mouldings of the interior, special materials, outstanding images, historical craftsmanship, historical utilisation and much more. Thus every historic monument has individual requirements for conservation and refurbishment.

The adequate use of building is a precondition for energy efficiency. Not every barn can become a sauna.

Energy efficiency is closely linked to the type of use. It is necessary to analyse the demands of every building before planning refurbishment steps. For planning measures of energy efficiency it is important to know which building parts, characteristics, materials, views of building are of high significance and therefore not to be altered. Distinction by preservation motives can establish criteria for such a required analysis. When it comes to decide if a building is to be listed such a decision is made from preservation motives enacted in national heritage preservation laws of the European countries. The World Heritage Convention and other international documents concerning heritage and preservation of historic monuments also include lists of preservation criteria. They differ from document to document and between countries but overlap in a group of motives that are discussed in the following.

2.1 Shape and Design – the Art History Value

Shape and design determine the artistic value of buildings. This art-historical value is the most common preservation motive, often only translated as beauty. But not all artistic masterpieces are beautiful and not all beautiful things are heritage. The notion of beauty seems to be a platitude but in practice there are frequent examples of beautiful refurbishments but seldom authentic refurbishments. Artistic value means a successfully realised design. This goes also for simple houses or rural buildings like farmhouses. There is no architect and no artist, but a design and an idea greater than the pragmatic need to have a roof over one's head.

The art history value can be a result of the artistic design of the whole building, of the façade and of ornamentation as the significance of a certain artistic period, as one of the last remains of an artistic period, or from the significance to the complete works of an artist.

Fig.4 Art deco buildings are often of high artistic value. Example from Bad Nauheim, Hesse (Germany).

[8] A German Example is the Symposiums "Nachdenken über Denkmalpflege" in 2005: "Nur die Prachtstücke? - Kategorisierung in der Denkmalpflege". Papers were published under: kunsttexte.de, 2005, Nr. 2

Therefore the design to preserve can include the whole building or parts of it. The artistic value of architecture is described by art or architectural historians as a scientific question and not a question of taste. This means that art historians are needed in multidisciplinary analysis of heritage buildings.

Art and therewith also architecture are always connected to the original substance. Usually only original historic material is able to testify the validity of authentic idea and image. But if parts and materials of monuments no longer can be preserved, they should at least be replaced with authentic materials corresponding to the original material. Still, sometimes modern materials or building parts may or have to be used. They will be a substitute for to the original material, and always means a alteration of the idea, sometimes more, sometimes less. If possible, the new material has to be chosen in a way which does not harm the original idea or the aesthetic image. In every case the impact of the alteration ought to be discussed, if the need for replacement is a disadvantage or if advantages are inspired by the new material.

Often doors, windows and plaster have been replaced not only for energy efficiency but also for security reasons; firstly, because historical materials are unavailable and too expensive, or secondly, because the unawareness of original quality. PVC windows with broad frames holding the heavy insulated glazing are only one issue when it comes to consider this problem. The appearance of glass and frames of windows is a significant factor in shaping the overall character of the building.

Fig.5 The new windows disfigure the façade of this residential buildings of a housing company in Duisburg, North Rhine-Westphalia (Germany).

Measures to increase energy efficiency are only possible, where there is no impact on authenticity or on the quality of artistic design. This can be insulation on the inner side of the wall or the installation of a more efficient heating system. Sometimes insulation on the backside of the building gives some possibilities for energy efficiency. For buildings which are internally and externally of artistic value, with ornamentation on the façade and stucco on the inside, finding solutions will be challenging.

2.2 Use, Function, Tradition – the historical Value

If a historic building is realised as a witness to use, function or tradition of the past, this functional characteristic needs to be kept recognizable. The best would be to keep the original function of the building, but in many cases this option is not feasible. Especially buildings of production like mills, barns or industry which are no longer in their purposed use need to get a new function. The historic use is closely linked to the plan, order and disposition of the rooms, and to the equipment of a special building type. If buildings keep their characteristics, it is possible to understand traditional ways of life - what people did do when, how was life and work was organized, what was of great value, what was of less? Historic value means remembrances of the past, and not only the great events of history.

Fig.6 This engine shed is no longer used by the railway company. The past function can be realised by preserved gates and rails. Marburg, Hesse (Germany).

Sometimes it proves to be a rather easy task, like the windmill in figure 7, which was converted to a guesthouse. The blades have been added in the historical technique and thus it got the authentic image of a windmill. It is more of a museum then an actually used building. There is no question of energy efficiency as it is closed during winter periods. This kind of use is not possible for the factory buildings of the 19th century. If they were converted into lofts the result is at least that new heating requirements have been added. Internally, the buildings were altered entirely while the image of the

factory building is preserved outside. This is often the only way to keep remembrance of an industrial area. The image of factory buildings, among others, is based on the material's character of brickwork and steel window frames. A very clean façade and wooden window frames do change the image. A better way is suggested by keeping the façade as well as installing second glazing on the inside. Also insulation is possible internally.

Fig.7 Windmill near Dresden, Saxony (Germany).

To give another example with a complete other history the Goethe-House in Frankfurt should be mentioned. It was entirely reconstructed after World War II. Such reconstructions are strongly discussed between conservators and architects. The attempt was to recreate a historic image but mostly, the result ended up as an image of our time. The Goethe-House is authentic because of the historic furnishings. The building gives the impression of how it could have been as Goethe lived here.[9]

2.3 Techniques – Heritage as Scientific Source

A scientific source is not an image that illustrates a written history but a source, where historians and other scientists can find answers to newly raised questions, not only of historic events but also about material characteristics, historic techniques and knowledge, which was necessary as source of the

The identification of nature of energy and energy supply in history is an important source for efficient energy and conservation strategies.

building and of what happened with the building after it was completed.

Heinrich Tessenow invented a special wall for the reasons of material saving and good building climate. However, this wall is not flawless and we can try to improve it. So it is possible to learn from the past, which is one reason to preserve heritage. If the wall was replaced by a modern insulation material the energy efficiency of the building could be very well increased, but with this innovative system it would be impossible to make further research in the future.

It is demanding to keep buildings as sources for the sciences, and only realistic for few historic buildings.[10] Biologists find special biotopes; geologists investigate natural stone weathering and so on. As we do not know the questions of tomorrow, it is important to keep the heritage substance as it is the only way to keep the open and potential access to original sources. The image for these buildings might be of lower value but it is necessary to identify them as sources for potential research objects.

2.4 Location and Setting – Urbanistic Value

To understand structures, historical areas, and whole towns as heritage and urban values, it is necessary to apply the same methods and values as when it comes to survey, identify and assess values of single buildings. There are artistic urban designs and historical areas as well as urban spaces of historic functional value. A single building can draw the image or identity of a town (or even both) as well as relicts of bygone urban structures and groups of buildings that formed urban space of a special artistic, historic or scientific value. In Germany, such groups are called *Ensembles*. The

[9] Wendland, 2010

[10] Scientific importance as reason to list buildings is mentioned for example in Cultural Heritage Act of Croatia 1999, in Dutch Monument Act of 1984 [Kono 2010, p. 161] and in some German heritage preservation acts. On the other hand [Breuer 1980] suggests the problem to describe the scientific value since every thing can become object of scientific research.

whole structure means more than the sum of single buildings. These can be places, streets, housing estates and so on. For urban heritage, the urbanistic impression is important. The urban heritage is more than shape and size; it is determined by materials, constructions, decoration, windows, and surfaces as well. Finally the historic image is determined and testified as historical substance, original and authentic materials.

Fig.8 Minner housing estate. All buildings create a significant historic urban space. Lusatia. Saxony (Germany).

2.5 Authenticity

One of the most important requirements of monuments is the demand for authenticity. It is not alone a request of the Venice Charter but also side by side with integrity a high important requirement to be listed as UNESCO World Heritage.[11] Authenticity characterizes the ability of a monument to testify truthfully a historical idea or event. This ability is inherent in different qualities of monuments depending on cultural preference. As described above, an western civilisations the most important qualities of a historic monument is the preservation of its substance and image dating from the period which it is bearing witness to. At the *Nara Conference on Authenticity in Relation to the World Heritage Convention* in 1994 the participants tried to define the concept valid for all cultures of the world. Further information sources of heritage were added which can testify the validity of a monument for contemporaries. *Aspects of these sources may include form and design, materials and substance, use and function, traditions and techniques, location and setting, and spirit and feeling, and other internal and external factors.*"[12]
For measures taken on monuments this means that in addition to preserving image and substance also function, use and traditions associated with the monument and surroundings have to be preserve. In some cases such preservation can be more important than substance and image if it maintains a living heritage, where traditions and ways of life of ancestors are passed on from generation to generation and accumulated with today's experiences, and thus keeping up their spirit and emotions for future generations.

2.6 Conclusion

Historic building classification by preservation categories can be summed up as follows: the requirements of a good heritage preservation strategy are not easy to formulate, whether it is a single building or class of buildings, made by categories. Preservation reasons overlap themselves; medieval churches, for example, have urbanistic values, artistic designs and historic values. In the same way the dwelling house of Heinrich Tessenow in the garden city of Dresden-Hellerau is not only preserved because of the Tessenow wall. It has urbanistic as well as artistic value. Furthermore, it is worth mentioning that diversity is a particular character of society; thus value of monuments differs between several groups. A deep historical and multidisciplinary analysis is necessary to bring out, which parts have to be conserved and where alterations or modifications may be possible.

Due to the complexity of monuments only a complex multidisciplinary planning process can guarantee a compatible sustainable solution.

The compatibility of measures to increase energy efficiency with the character of a monument can be estimated by means of two criteria: how much of historical building substance will be lost and in which way it will interfere with the image. No rebuilt window, door or building part can have the same value as source and witness of the past as the original. The image of a building is always determined by its substance. But if the parts are rebuilt closely to the original, they can contribute to the historic image of the monument and in this way to the authenticity.

[11] UNESCO 2008, par. 79-84
[12] Nara Document 1994, art. 13

A third point, corresponding with Venice Charter, is the question of reversibility. Especially, if innovative solutions are introduced and practiced with no or little experience, it might even become necessary to remove them. Innovative techniques have also been used in heritage preservation of the past. Occasionally, it is realised that innovative technologies and materials rather destroy the original substance or affect its appearance.

	Substance	Image	Reversibility
Artistic Value	+ +	+ +	+ +
Historical Value	+	+ +	+
Heritage as Source	+ +	+	+ +
Urbanistic Value	+	+ +	+

Fig.9 Simple scheme to illustrate the value of Substance and Image depending on preservation criteria.

3 Task-oriented classification systems for sustainable conservation

3.1 Building classification

A guideline to improve energy efficiency of monument buildings will try to assign approaches to such building classes to which they can be successfully applied to while preserving the historic value. For heritage buildings they must be orientated to the methods of restoration and refurbishment. Such classes include buildings with similar construction types. Some studies which elaborated during last years created such building classes for all ancient buildings and especially for monuments. Regularly, the first criterion was the age of structure concerning the technical history. It is mostly combined with the building typology and aims to identify construction systems that were used repeatedly. In addition it is reasonable to differ between detached or terraced houses. For energy efficiency this is not

Every single monument is an individual case and has to be analysed and valued by. Nevertheless, a catalogue with solutions as suggestion for some classes of buildings and construction systems is respectively possible.

negligible as well as the climate zone, where the building is situated of which the energy efficiency should be improved.

Temporary the TABULA-Project[13] works out typologies of buildings in European countries. Residential buildings are the focal point. The typologies are elaborated regarding energy efficiency measures for existing buildings but without including heritage preservation aspects. Nevertheless, they can help finding means to characterize classes of heritage buildings.

It is no coincidence that the TABULA-Project and other studies focus on residential buildings. Classes of buildings for refurbishment can only help finding solutions if a significant number of buildings with similar characteristics do exist. Particularly monuments are mostly listed because they have special individual characteristics. Some of the case study objects of 3encult project have also a very special building history and cannot be assigned to a typological class. Every single building needs an individual analysis and individual renovation. Building classes and solution catalogues can only be of help when choosing the most compatible measures. Buildings can be compared with each other while research of how different energy efficiency technologies are applicable in different cases has to be ventured.

3.2 German example of building classification

A German example can illustrate how such classification system looks like. The Refurbishment Atlas edited by Georg Giebeler[14] distinguishes buildings from the view of supporting structure. Other classifications found in German studies of energy efficiency and historic monuments[15] use similar categories. The authors of these studies categorise the buildings by the age of their structures. However, buildings from before the industrial epoch are not included, because they are regarded as too individual and are also distinguished locally. Their number is limited since they were constructed. Some building types built over a long period of time, like half timbered houses and the so called *Wohnstallhaus* a type of dwelling house with adjoining shed, has an own category anyway.

The industrial era began in Germany in 1870 with a real boom; it includes the so called *Gründerzeit*. Buildings with similar constructions were built until the end of World War I. The buildings from 1920 to 1940 constitute a further category, where many estates with smaller free standing apartment houses

[13] Typology Approach for Building Stock Energy Assessment, a resarch project funding by Intelligent Energy Europe (IEE) and Foschungsinitiative Zukunft Bau, www.building-typology.eu
[14] Giebeler et al. 2008, p. 118ff.
[15] Grunewald, Will, 2010; dena 2010

were built on support by municipal finance, while questions of energy efficiency became less significant. The next category is the post war period from 1950 to 1965. But Giebeler declares that as it is not such a clearly defined period, so the definition of the period is an open question. The period after 1965 is titled by Giebeler as a period with buildings of prosperity. Materials and execution were of high quality, and different construction systems were used. Especially the time between 1870 and World War II seems suitable for categories sorted by the age of structures.

3.3 Planning Process

To put a really suitable compromise for cultural heritage in effect a multidisciplinary planning process is necessary. Before any measures are commenced it is crucial that a building survey geared to the requirements of the conservators is taken into account. State and value of all parts must be noticed. Art historians and conservators ought to be involved in such a research in the same way as architects, engineers and town planners[16]. A checklist for such a survey is given in Deliverable 2.5 *Report on Methodology and Checklist*. Only an analysis is able to deliver clear facts to decide what measure of improving energy efficiency suits the building in question best. They should preferably affect building parts of low historical relevance or building parts that are worn out and no longer have any material value or which no longer contribute to the value of building parts, which have to be replaced anyway.

The base for an adequate refurbishment must be a precise knowledge about the building elaborated in a research of building history, of structure and building climate documented in a common building survey.

Decision-making must still be an interdisciplinary process basing on certain knowledge of details of the historical building. Often historic research becomes able only when refurbishment process works or new information was found. This is the reason, why art historians and conservators should be involved in the whole process. Not in all cases public authorities are able to take over the required work entirely by themselves, freelanced offices should be included equally.

During the refurbishment process any alterations to the building must be recorded. Such a document provides the basis for future repairs or conversions whilst enabling the determination of historical and modern building elements and surfaces.

3.4 Modular System

For monuments it is only possible to choose measures suitable for construction and image if some information about materials and techniques, about practice and effects are available in advance. The following question catalogue asks for the most important features.

A catalogue of measures with all this information combined with a building classification could become an important and helpful tool for conservators, architects and all planners on monuments to find fast and easily feasible and individual solutions for any individual building. Still one thing must be clear and ought not to be forgotten: there are monuments so rich in there artificial appearance, so rare in material characteristics, so seldom in their building typology that it is more important to preserve them rather than improving their energy efficiency.

- **For which category/type of building is the measure applicable/not applicable?**
  (residential buildings; exhibition buildings; detached farmhouse; terraced buildings of the 19th century; ...)
- **For what type of construction is the measure applicable/not applicable?**
  (insulation for natural stone masonry; internal insulation for timber framed walls; coated panes for single glazing windows; ...)

[16] Charter of Krakow, article 5

- **Which parts of the surface will be affected? How can the new surface adapt to the historical one?**
  (Design of ventilation openings on the façade; demounting and replacement of the floor due to under floor heating; ...; What aggregate can be added to a thermal insulation plaster; how can solar panels be adapted to the existing roof; free choice of the floor material above an insulation; ...)
- **Will the historical energy system be altered?**
  (a warm roof is changed to a cold roof; air tightness of the windows; warming source on the outside instead on an inner wall....)
- **Which alternative measures will have similar effects?**
  (Sealing and repair of historic windows instead of installing new windows; interior instead of exterior insulation; ...)
- **To what extent will be the historic substance destroyed or affected?**
  (The historic windows will be destroyed when installing new insolating windows; The attachment of an insulation can lead to dehydration of the masonry; removal of the plaster; drilling holes, preparation of openings; ...)
- **Is the measure reversible and consequently, are damages to be expected?**
  (Is it possible to remove subsequently added films of windows without any residue?; Penetrate adhesive and chemicals into the surface?; ...)
- **What are typical problems of implementation, how serious are they and how often do they occur? How error-prone is the workmanship?**
  (On thermal insulation composite systems it may lead to attack by rodents and insects and therefore damage to the external shell, which in turn lead to penetration of moisture and cause rot; Have typical structural-physical and structural problems of the historical construction influence to the measure, e.g. has the movement of timber framing effect on the thermal insulation plaster?; Noise pollution by heating or ventilation system; If interior insulation is not complete face-to-face, it may create condensation in the resulting hollow spaces; ...)
- **Are there existing constructions/materials, which the measures are not compatible with?**
  (the historical setting mortar could chemically interact with new layers of plaster; ...)
- **How durable is the measure and what influences could affect the effectiveness?**
  (insulated windows lose their efficiency by incorrect ventilation behaviour of users; Collapse of plastic material by UV radiation; Cleaning and filter change in ventilation systems; ...)
- **What experiences do exist? What long-term experiences do exist?**
  (results from special monitoring projects; historical examples for the modern measure; ...)
- **What are the expected costs?**
- **What economical effects can be estimated?**
- **What is the whole amount of the expected energy retrofit and CO_2 reduction?**
  (possibility of calculation; experienced data, total energy balance; total CO2 balance)
- **What problems do exist with the sourcing and disposal of the used material?**
  (extruded polystyrene foam is not biodegradable; ...)
- **Which accompanying measures and pre-examinations may be essential?**
  (in the case of external insulation of the basement may need to accomplish archaeological excavations.; for the attachment of an insulation, the construction of the wall in all its layers has to be clarified.; ...)
- **What other measures are not compatible? / What other measures are recommended in combination?**

4 Theses

Finally some theses to open up the minds for really innovative solutions, not trying to make everything we already know a little bit better:

1. First aim is the unaltered preserving of current substance and image so far as possible.
2. The identification of nature of energy and energy supply in history is an important source for efficient energy and conservation strategies.
3. The adequate use of building is a precondition for energy efficiency. Not every barn can become a sauna.
4. Energy efficiency is also achieved by user's behaviour.
5. Solutions with services and technical equipment as well as use of renewable energy sources are by experience most compatible with the heritage character of buildings.[17]
6. Knowledge about original climate system of the historic building can be the motive for solutions with high value to heritage compatibility.
7. The base for an adequate refurbishment must be a precise knowledge about the building elaborated in a research of building history, of structure and building climate documented in a common building survey.
8. Despite all difficulties, providing total energy balances has to be central aim for energy and culture. Only detailed energy saving can establish measures, with positive impact on the value of monuments and positive effects for an environmental solution.
9. Due to the complexity of monuments only a complex multidisciplinary planning process can guarantee a compatible sustainable solution.
10. Every single monument is an individual case and has to be analysed and valued by. Nevertheless, a catalogue with solutions as suggestion for some classes of buildings and construction systems is respectively possible.
11. Only long-time experiences can guarantee that a solution provides the required sustainability.
12. To use the building is of particular importance for preservation. New demands for comfort and environmental protection, however, often require the upgrading of energy efficiency in historical buildings.

[17] Weller et al. 2008, p. 13

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