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Analysis of existing buildings for energy-saving measures taking into account the conservation of historical value

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Introduction

The aim regarding the energy refurbishment of historic buildings should not be to save as much energy as technically thinkable but instead to implement as many measures as possible without destroying heritage values or, worse, damaging the building.

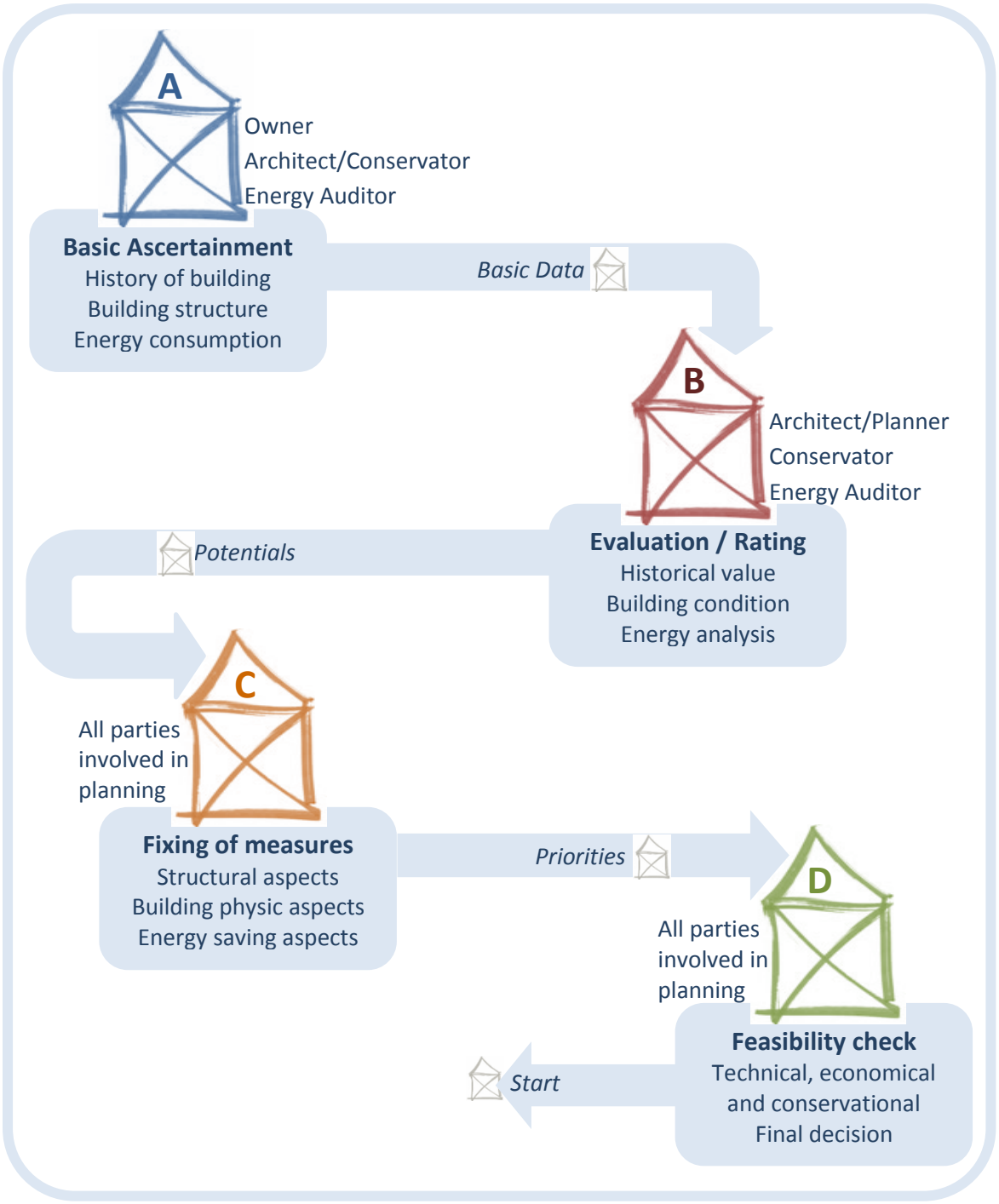
Every project starts with an initiation – mostly by the owner – and continues as an iterative process in general. Therefore it is necessary to clearly define the different responsibilities from the beginning on. In small projects, normally the architect manages the whole process; in bigger projects, often a special team has to control the project targets, especially regarding dates and costs.

This document on the analysis of existing buildings for energy-saving measures while taking into account the preservation of the historic substances of the building has been prepared as a guide with recommendations for action in terms of project management. It therefore includes the basic approach and explains the causal relationships from which the structure is derived. The step-by-step guide reflects both the basic steps of the project as well as the depth of the research and planning content. The sequence is therefore hierarchically structured so that the individual activity steps can be read in order of priority. The project structure which has been developed thus allows its use in both small construction projects and very complex, large construction projects.

But this document, because of the complexity of the individual subjects, reveals no detailed practical instructions for each individual test and planning step. This was not possible to do within the framework of the Co2olBricks project. Therefore, the very diverse requirements and recommendations for action which are laid out here should first be applied at EU and national level. At this point, from the perspective of the project partners, it would be desirable to merge ideas and implement some form of international standardisation in order to facilitate cooperation. Therefore this should be more deeply explored in the context of other projects and research projects within the EU.

Glossary

Stakeholder	All parties involved in planning (owner, architect, conservation officer, energy consultant, planner: building physicist, structural engineer, technical facility planner, building biologist)
Feedback analysis	An iterative and continuous process for finding the best solution/result
Conservation plan	This can be implemented for a single building as well as for an ensemble or a whole quarter, if the buildings are of the same type. In a conservation plan all possible measures should be described for refurbishing and preservation without destroying the historic substance
Historic building	Building of cultural value; may or may not be listed as cultural properties
Historic value	The whole building as well as parts of it or single elements, assessed/ accepted as valuable and designated for preservation
Room book / Building book	A registration and description (text and pictures) of every room and part of a building; very helpful for all planning and implementing processes



Source: Dr. Daniela Scherz

A – Basic Ascertainment

1. Collect together existing inventory documents (history of the building)
   » Register of immovable properties, plans, photographs, calculations, permits, etc.
   → 2 stages: 1. Owner; 2. e.g. Architect, art historian, conservator
2. Documentation of its current status
   » Photos, measurement, assessment of condition by visual inspection
   → 2 stages: 1. Owner; 2. e.g. Architect, art historian, conservator
3. Energy inventory
   » Complete building and when indicated individual elements
   → 2 stages: 1. Architect; 2. Energy Consultant

B – Evaluation of data and rating

1. Historical classification
   » Significance of the whole building and of individual elements (exterior and interior)
   → 2 stages: 1. Architect; 2. Conservator
2. Examination of the structural condition of the building/ensemble
   » Substance of the whole and of individual elements as well as potential weaknesses
   → 3 stages: 1. Architect; 2. Planner (building physicist, structural engineer, technical facility planner, building biologist, etc.); 3. Material analysis (sampling and laboratory testing)
3. Energy inventory analysis
   » Identify vulnerabilities (weak points) and potentials
   → 3 stages: 1. Architect; 2. Energy consultant; 3. Calculations/simulations
4. Target-setting
   » Identify priorities for renovation
   → all stakeholders

C – Definition and fixing of necessary and possible measures

→ all stakeholders

1. For static-structural reasons (repair and maintenance)
2. For building physics reasons (repair and maintenance)
3. For energy reasons (modernisation)
4. Further development of buildings (conversion, modernisation)

D – Feasibility check

→ all stakeholders

1. Evaluation of the technical, economical and conservational feasibility
2. Final decision of the measures to be implemented

Short explanation and examples of the different steps

Each building has individual building physics, each building has to be examined individually, and not all examinations are affordable or necessary for all buildings. Therefore the examinations have to be done in different steps – but each time it starts with a basic analysis.

A - Basic Ascertainment

It is of paramount importance that the historic value of the building is well understood. Therefore a basic assessment has to be done, starting with the owner. The owner should be responsible for collecting all existing construction documents, including land registry and historical photos, etc.

The inspection of, for example, construction documents in local government offices belongs to the second level and should, due to the complexity, usually be done by an architect or an art historian/conservation officer. The same is true for comprehensive construction documentation, which includes measurements, photographs as well as a structural condition assessment by visual inspection. For larger buildings/ensembles, a detailed building and/or room book should be created.

The third stage of this phase includes a basic evaluation in terms of energy (investigation of energy consumption). This is usually done through the collection and analysis of existing consumption data for total energy balance. If this data is not available a simplified calculation for a first rough estimate of the total energy consumption can also be done. Furthermore, at this point, an initial assessment of individual parts of the building may also be required. There are some useful existing guidelines for the examination of the energy consumption of buildings, for example ISO 50001 Energy Management, BS EN 16247-1 Energy audit, or DIN 4108-6, DIN V 18599, DIN 4101-10.

The goal is a building documentation that forms the basis for all further planning by providing all the necessary information on the one hand about the history of the building and on the other hand about the current state of the building.

B - Evaluation of data and rating

Consequently, before thinking about any rehabilitation work, irrespective of whether it is connected to energy efficiency improvements or not, the actual building physics as well as the special characteristics that define the historic value have to be known to all stakeholders involved. Normally historic buildings have undergone many changes due to their already long life. Besides that, often it was already built differently than planned, or changes were

not documented. Therefore it cannot be expected that the walls are built to any known standard, or even to what was originally planned when the building was erected.

1. Assessment of the historical value
In this first step, an architect or an art historian assumes an initial assessment of the historic structure and its historical context. In the second step, the preservation/monument value of the whole and of the individual parts will be assessed. This is usually done through the relevant heritage preservation department.

2. Assessment of the present structure of the building
For everything to be planned, the present structure of the building and the condition has to be assessed. That has to be done with as many non-destructive methods as possible. One of the most important things to do is the analysis of the structural fabric in order to know the exact condition of the building. This is important for the planning of the measures as well as for calculating the energy efficiency. Starting with an initial assessment by an architect, early on in more complex projects additional planners usually need to be involved in a second step. If the existing documents and data are not sufficient, then detailed assessments and sampling are to be carried out as the third stage. For example, to get detailed values of brick walls, the following examinations have to be done, mostly by specialised laboratories:

- Examination of the bricks: resistance to pressure, absorptive capacity of water, salinity
- Examination of the joints: binder, aggregates, salinity, resistance to pressure, mortar class, specialities

If a sufficient number of historic walls have been investigated, this data can be put into a data base so that in the case of similar buildings not every building has to be reassessed from the ground up. Also indoor climate measurements are very helpful, especially as a part of an energy audit of historic buildings. This indoor environment condition survey should include sufficient information on:

- Temperatures (air and surfaces),
- Humidity,
- Ventilation rates,
- Existence of moisture damages, mould, and other contaminants.

3. Assessment of energy loss, energy saving, and energy supply
Furthermore, the physical and technical properties of the parts of the building which are relevant for energy consumption have to be examined. This should be done in order to collect real data first (like measuring infrared thermography), so that calculations can be done afterwards. An initial assessment is also done by the planner, supplemented early on by the energy consultant, who then takes over the necessary calculations and simulations. One of these could be a dynamic hygrothermal simulation, for example with software tools recommended by funding organisations. They have sufficient complexity to model the energy consumption, because the static models are not complex and detailed enough to

simulate difficult situations. The examination should be done especially with a view toward weak points in the construction and their potentials, for example leakages, imperfections, thermal bridges or rain protection and moisture in general. The following examinations should be done in detail:

- Roof, cellar and walls, doors and windows
- Air tightness of the building envelope
- Heating-, cooling-, ventilation-, water-, and electricity system
- Control systems

4. Definition of the intention of the measures
The decision on the usefulness of the measures must be defined at this point by the ultimate goal. All involved in the project are jointly responsible for this. One of the important aspects when deciding is to make a clear analysis of the future use of the building. Is it going to be an office, a workshop, a living space, a storage area? They all have a different energy demand which influences the energy concept. And as already mentioned the aim concerning refurbishment for a building under heritage preservation is not to save as much energy as possible but to save as much without destroying heritage values.

The goal is to evaluate the collected data and through the analysis of the weaknesses and potentials to define all basic options for renovation (e.g. preservation versus change in the facade, installation of new, historic or historically citing elements, etc.).

C- Definition and fixing of necessary and possible measures

For the fixing of the requirements for the necessary or possible measures to be taken – as in the previous definition of objectives – all stakeholders involved in the planning must be included. The following order of precedence for the activities should be observed:

1. Static and structural reasons
These have top priority and are fundamental and mandatory requirements for the preservation of a building and can be necessary for both repair and maintenance.

2. Building physics reasons
Again here, the compliance with requirements for the maintenance or upgrading of the building is mandatory, whereas there are usually more opportunities available to exercise upgrading measures than in the structural physics.

3. Energy reasons
These generally fall under the area of modernisation and must therefore submit to both the structural design and structural physics requirements first. At this point there is already a correlation carried out with the physical construction parameters.

4. Development of buildings

In the hierarchy for the evaluation of possible and necessary action, the requirements for the conversion or modernisation of buildings play the least important role.

The goal is to define a priority of the measures necessary through the evaluation of the possibilities detected from different perspectives. On this basis, further planning can take place planned and feasibility can be decided on.

D – Feasibility check

As a final step, the previously mentioned measures must still show a certain range of possibilities which can be examined in terms of their technical feasibility and in terms of their economic feasibility and of course in terms of their conservational feasibility. Only then can the final determination be made. Again here, all stakeholders involved in the planning should be included in the process.

1. *Feedback analysis*
   In a first step, the basic technical measures identified must be checked for their economic feasibility and rechecked with the historical values of the building. The transitions between all three feasibilities are fluid, and therefore require continuous feedback until the final determinations are made.
2. *Final decision*
   In the second step, on the basis of all previously obtained data, final decisions will be made and further planning steps prepared.

The goal is the final determination of the action to be taken, based on which further planning steps and then the renovation will take place.

Further recommendations

Iterative process

From the aforementioned steps it is clear that working on historic buildings always demands interdisciplinary collaboration of the involved stakeholders, who have to work as one team. This is a big challenge and therefore in the selection process of the right experts, their social competencies are also important. Together they have to define benchmarks and key elements of that building or to create the building design tasks. The use of checklists can be very helpful to find the point to start a project and to define the main goal and the targets when going to the different steps.

Specific qualification of the participating experts

As laid down in the Co2oLBricks Joint Declaration and the Co2olBricks Policy Paper, only experts who can prove that they have the specific expertise for energy efficiency in historic buildings should be used. Historic buildings are much more complex than new or non-historic buildings and big damage can be easily caused if the wrong measures are applied. Especially the energy auditors have to be educated in heritage preservation and, vice-versa, the conservators have to be educated in building physics. Without this mutual understanding a fruitful collaboration is, in our opinion, not possible.

Funding programme examination

Besides the heritage and technical aspects of the rehabilitation of a historic building, the economic side is crucial as well. So when investigating the possibilities, the available funding schemes have to be examined as well. To ease the cost situation for the examinations, more research of typical construction types and materials used in historic buildings is necessary. For most of the expensive examinations, like for a conservation plan, external funding is also necessary.

Follow-up (measuring of real data) after implementation of the measures

A natural course of action has to be that follow-up measurements of real consumption data are done in order to validate or invalidate the effect of the energy efficiency measures. To check whether the calculated saving potentials have really been achieved (for example in case of the prebound/rebound effects) would help to know what the effect really is and also to assess how good or bad the overall energy efficiency increasing programme has worked so far. But only a large data base can give thorough statistical data.