

Energy efficiency and HVAC systems in existing and historical buildings

The topic of refurbishing historical buildings is one of the energy challenges all over Europe. In this scenario, AiCARR developed a proposal for a conscious approach in energy retrofitting.

Keywords: historical buildings, energy efficiency, HVAC systems.

The challenge of refurbishing existing and historical buildings

Refurbishment of existing and historical buildings is a priority in many European Countries. In 2014 AiCARR published guidelines intended for both design engineers and superintendencies. Due to the need of developing a harmonized approach focusing on historical buildings, AiCARR developed a specific guidebook entitled “*Energy efficiency in historic buildings*” [1] to support technicians in carrying out energy retrofit actions in historical buildings. The guidelines provide the design engineers with a tool for the energy audit of the historic building and offer a framework for the design of possible energy upgrades, which are conceptually similar to those provided for non-protected buildings, but appropriately tailored to the needs and peculiarities of the cultural heritage. On the other hand, the guidelines provide the institutions responsible for protecting the building, the possibility to objectively decide on the level of energy efficiency achieved as a result of the rehabilitation in accordance with the conservation criteria.

Whenever an intervention is required to a protected property or nevertheless to a property of cultural value, it should be considered that the work to be carried out falls within the scope of restoration and the priority objectives are *to preserve and bring these assets in line with the future* in the best possible condition [2].



LIVIO DE SANTOLI
Università degli Studi di
Roma “La Sapienza”,
President of AiCARR,
livio.desantoli@uniroma1.it



FRANCESCA R. D'AMBROSIO
ALFANO
Università degli Studi di Salerno,
AiCARR,
fdambrosio@unisa.it

Even the energy efficiency measures should pursue the above stated purposes, which means considering energy efficiency as a tool for protecting - rather than a process of upgrading that conflicts with the conservation requirements. It follows that the design choices should be made by consulting with the conservation experts. In this regard, the following criteria set out in the Venice Charter for Conservation and Restoration [3] are of invaluable help: compatibility, minimum intervention, reversibility, distinguishability, expressive authenticity, durability and respect of the original fabric.



Figure 1. Integrating historical buildings with new innovative solutions (from: 49th AiCARR International Conference, Historical and existing buildings: designing the retrofit. An overview from energy performances to indoor air quality. Rome 2014).

In historical buildings refurbishment is very important to respect the relationship between restoration and installations that today is still little explored from a theoretical point of view, and definitely less, for example, than the corresponding relationship between restoration and the need for full accessibility - or even between restoration and structural consolidation works.

Even in this case, as for the structural consolidation, it is necessary to radically rethink the concept, which is reflected in a new methodological approach, an example of which is suggested in these guidelines.

If we start from the same experience that some years ago brought about a debate on the problems related to the historical-critical process, and to the scientific-technical process for consolidation restoration projects, which recognized the need of a rigorous method of unity, this same method should be proposed for the energy efficiency of a cultural asset.

In the restoration-systems relation we still see a gap in the rules and regulations. Notwithstanding this gap, the need to include systems in the restoration concept and the three-point criteria (minimum intervention, reversibility and compatibility) is well established.

To this regard, AiCARR specifically proposes that the concept of “improvement” replaces the concept of “adaptation” in the current standards and requirements also with regard to safety and comfort, elaborated along the lines of “integrated conservation” [4].

Proposals to *improve* the energy compliance of a historic building (or, even, of a cultural landscape) can be made by taking appropriate measures that are well-balanced for a suitable architectural or landscape integration. This means that you will often have to settle for a partial architectural integration, rather than a total integration, as would be desirable for new buildings. The required level of integration must be such that the interventions proposed do not upset the asset itself, which is the case when “adapting” it to the current standards and requirements, as if it were a new building.

The proposed methodology should be based on an interdisciplinary approach, the main steps of which are clearly set out in the guidelines. These steps include: following the general principles and concepts; an analysis of the plant engineering systems; measuring the environmental quality and determining the risks to historical buildings (including identification of the proposed intervention as it relates to the building and the system).

AiCARR procedure to improve the energy efficiency of historic buildings

Figure 2 shows the flow chart of the proposal made by AiCARR regarding the best improvement procedure on how to improve energy efficiency.

The procedure involves some preliminary actions aimed at a correct energy audit, downstream of which the actual energy performance index must be calculated.

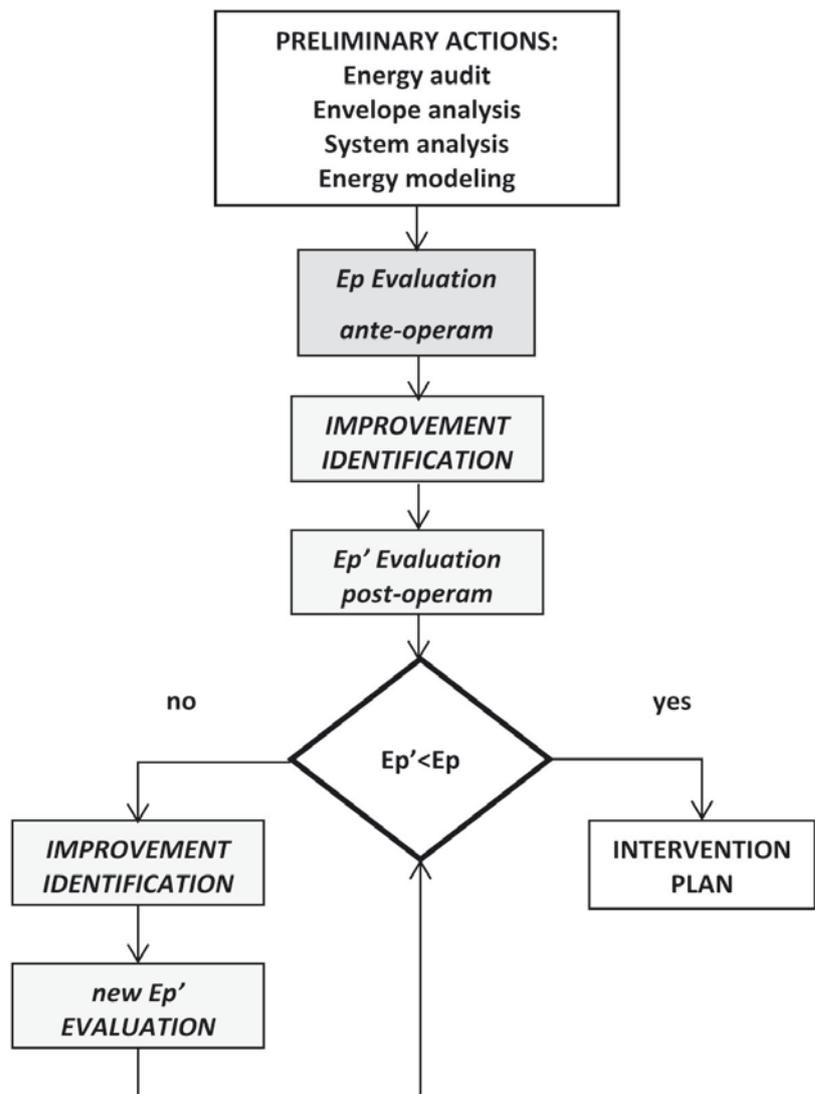


Figure 2. Flow diagram of the energy efficiency improvement procedure.

The energy audit should also be used to evaluate the possible improvement actions, which must be calculated on the basis of the post-construction energy performance index. Obviously, if the improvement has led to concrete results it is possible to proceed; otherwise the process should be repeated by analyzing the audit levels more thoroughly.

HVAC Systems in existing and historical buildings

From the HVAC systems engineering point of view, historic buildings that have not been affected by recent maintenance work, whether ordinary, extraordinary or preventive, are generally equipped with obsolete equipment. HVAC systems, in principle, could be replaced, but can actually be evidence of the past and as such have a historical interest; therefore they should be carefully recovered, valued and, if possible, made useable. Consider the little-known, but extremely interesting Italian San Leucio monumental complex (**Figure 3**), belonging to the World Heritage List, which includes the so-called “Bathroom of Queen Mary Caroline”, which can be traced to the ancient Roman baths.

It goes without saying that an assessment to possibly reutilize HVAC systems that have a historical value involves problems of protection and often enhancement. It is an interdisciplinary process that the designer has to manage in terms of thermal engineering and also requires the typical skills of Cultural Heritage experts. An analysis of historical works to assess the possibilities

for protection, enhancement and fruition is therefore an integrated process in which the designer plays a particularly important role.

It is clear that an improvement in the energy performance of a building as a whole must include work to the installation, unless particular historic, architectural or functional restrictions make it inadvisable or impossible to carry out.

Regarding the performance of a building envelope, measures are generally taken on the thermal insulation of opaque and transparent, horizontal and vertical components by applying materials and/or technologies that increase the thermal resistance and reduce the internal/external thermal exchange. Thermal insulation may not always be practicable in a historic building whose facades and/or interior elements are of a historical or architectural value, whereas such work can be done to an existing building, which in itself has no historical value but holds a cultural heritage; for example, a newly built museum.

A tool to assess landscape integration

To improve the energy efficiency of historic buildings can have, more often than not, an impact on the landscape due, for example, to interventions which might interfere with the characters of historicity and antiquity of the building or to plant engineering installations that may not be synergistic with the landscape, seen aside from the building.



Figure 3. San Leucio complex: an example of renovation (from ©Google Earth 2014).

In these cases, special attention has to be paid to landscape integration, which must be assessed at different scales of intervention for each typological element on the basis of the following criteria:

- Technology, intended as the degree of replacement of the building and system components;
- Landscape, morphological, form and colour perception.

As a first assessment of the overall degree of integration of the project, a sheet such as the one shown in **Table 1** can be used to be filled-in by the designer of the intervention on the basis of the documents produced, as illustrated below, and which is assessed by the Cultural Heritage national Offices. This sheet is a summary that will then be compared with the results of the energy

assessment and is also useful to for an initial screening on the acceptability of the project, in the sense that interventions, which are not characterized by at least a partial degree of integration, cannot be submitted.

HVAC system maintenance

The new Italian Cultural Heritage Code [5] for the first time includes the concept of maintenance in the Italian national legislation on the protection of architectural and landscape heritage. This topic is crucial for historical buildings. Maintenance to the installed systems must therefore be provided during the design phase, included in the general maintenance plan and must be consistent with the requirements specified for proper conservation of the entire building over time. Choosing suitable positions according to the conservative requirements is not sufficient: it is also necessary to provide for regular accessibility to the systems without causing any damage to the

Table 1. Preliminary assessment sheet for integration in the landscape.

Scale	Typological element		Integration level			
			Technological	Scenic		
				Formal	Morphological	Chromatic
Microscale Architecture Building- place- construction	Cover	Opaque surfaces				
		Transparent surfaces				
	Façade	Opaque surfaces				
		Transparent surfaces				
	HVAC systems					
Mesoscale Square-block- surrounding	Cover					
	Façade					
	Installations					
Macroscale territory	Cover					
	Façade					
	HVAC systems					

Integration level: ○ = partial; ● = total

existing building. Furthermore, care must be taken to control the physical and chemical characteristics as well as the behaviour of new materials over time to prevent the occurrence of events that are incompatible with the proper life of the historic building. The overall energy efficiency of a building also depends on the level of maintenance performed, obviously with special regard to the management and maintenance of technical installations.

In Italy HVAC systems must be designed, constructed and installed so that cleaning of all internal surfaces and components can be performed in accordance with the provisions of the UNI 12097:2007 standard and national guidelines. This is a prerequisite to ensure that these systems can be operated and maintained in such a way that hygiene requirements are complied with at all times. Regular technical inspections and maintenance servicing as well as frequent health checks must be carried out by specially appointed qualified personnel. Therefore, a register for the documents related to ordinary and extraordinary maintenance to water systems and air conditioning systems should be adopted.

Historic buildings and standard evolution related to energy efficiency: the AiCARR proposal

In the case of historic buildings, it will be necessary to interpret the possibility of unifying and simplifying all the Italian current laws and decrees related to energy performance of buildings in a more incisive manner. This topic is currently being discussed by the operators of the heating sector, who are often in difficulty with reference to the interpretation of the scope of the legislative body on energy efficiency in buildings.

AiCARR believes that it is necessary to clarify the subject of energy saving in the building industry in general, and with special reference to historic buildings, establishing a few rules that are clear and that cannot be interpreted at will. To this end, AiCARR believes that the following would be essential:

- introducing a performance index that takes into account only non-renewable primary energy;
- defining the energy performance of a building only through the primary energy requirements;
- providing a definition of energy from renewable sources;
- defining the nZEB (nearly Zero Energy Building) univocally, i.e. a building characterized by a low demand for non-renewable primary energy;
- defining the assessment method on exported energy, for example by referring to the territorial context.

According to AiCARR, these rules should only relate to matters regarding the energy performance of the building, during the design or upgrading phase, not to checks and inspections of use and maintenance. In particular, aspects related to the minimum performance of the building as a whole should be separated from those related to energy certification, so as to eliminate the misunderstanding that the design activity is aimed only at obtaining the energy performance certificate.

With regard to the minimum performance, AiCARR believes that it is necessary to identify the minimum requirements which can be easily verified by the municipality or concerned institutions, without necessarily having to perform a complete calculation of the energy performance. For instance, the following criteria could be taken into account:

- transmittance: indicate the value of the transmittance of the walls responsible for 60% of the total dispersion;
- subsystem efficiency: provide a minimum reference value;
- production efficiency: indicate a minimum value of the nominal efficiency and think of a way to limit oversizing.

Evidently, appropriate adjustments for historical buildings should be provided and regulated. ■

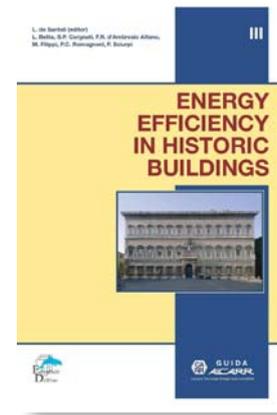


Figure 4. The guidebook developed by AiCARR.

References

- [1] L. de Santoli et al., 2014. *Energy efficiency in historic buildings*. AiCARR Guidebook. Milano: Editoriale Delfino;
- [2] Italian Ministry of Education, 1972. *Charter for conservation and restoration*;
- [3] ICOMOS, 1964. *International Charter for the Conservation and Restoration of Monuments and Sites* (Venice Charter);
- [4] Congress on the European Architectural Heritage, 1975. *The Declaration of Amsterdam*.
- [5] President of the Republic of Italy, 2004. *Italian Cultural Heritage Code*.