

## **MANAGING THE INDOOR SECURITY AND SAFETY IN HISTORICAL BUILDINGS**

Sergio Olivero

*Istituto Superiore sui Sistemi Territoriali per l'Innovazione, Italy, [olivero@siti.polito.it](mailto:olivero@siti.polito.it)*

Pekka Huovila

*VTT Technical Research Centre, Finland, [pekka.huovila@vtt.fi](mailto:pekka.huovila@vtt.fi)*

Janne Porkka

*VTT Technical Research Centre, Finland, [janne.porkka@vtt.fi](mailto:janne.porkka@vtt.fi)*

Federico Stirano

*Istituto Superiore sui Sistemi Territoriali per l'Innovazione, Italy, [federico.stirano@siti.polito.it](mailto:federico.stirano@siti.polito.it)*

### **Summary**

In Italy there are a lot of historical buildings that are relevant in cultural, architectural and artistic terms. Such heritage needs a constant process of renovation to keep the buildings secure, safe and efficient and to make them fit to host offices, museums, events and art exhibitions. Unfortunately, most of these renovation activities consider only either the security issues or outward appearance or the indoor conditions or the installations; all actions are independently designed and implemented, and an integrated approach is missing. Italian Public Bodies strongly need support and guidelines to write optimal tenders for building refurbishments.

In this paper, we present a methodology for assessing the state of building and defining tender requirements. The methodology is based on the definition of performance indicators, related to security against human threats, thermal and hygrometric quality, living indoor conditions, air quality, lighting conditions, resilience and management of emergencies in case of natural disasters, accessibility, etc. A very important aspect that the methodology considers is compliancy to the regulations. Also some economical aspect will be considered.

The methodology is implemented in a decision-support software tool that put in relation to each other the different indicators, evaluating performance indexes. These indexes could be used to simulate different solutions helping to choose the best one. Particular attention is put on how the results are shown to end-users..

**Keywords:** indoor performance, security and safety, historical buildings, performance indicators

### **1 Introduction**

In Europe and in Italy in particular, there are a lot of historical buildings with a great importance from the artistic and architectural point of view in the culture of the people. Originally, these construction sites hosted the residence of monarchs and noble families, or the first industrial structures. They are complex buildings with a lot of rooms and spaces

that could host different activities with different performance requirements regarding the indoor performance.

However, historical buildings pose some challenges from the conservation point of view, as, in the past, most of them were abandoned, thus requiring a great renovation effort to make them adapt to host the desired activity. This paper describes a methodology for assessing the actual status of the building and to evaluate the conformity to regulations of historical buildings, define the proper tender requirements for renovation works in order to keep the building efficient and able to support demanding needs (climate, comfort, accessibility, ICT connectivity, etc.) and to identify proper management plans.

This paper describes an approach to manage the indoor performance of Villa Reale applying the methodology of the FP7 Perfection (Performance Indicators for Health, Comfort and Safety of the Indoor Environment) project.

## 2 Historical Buildings

Historical buildings are typically employed for cultural activities. For historical reasons, museums and art galleries are often hosted in these structures. Also conferences, fashion shows and presentations are organized in these buildings to provide a choreographic and suggestive location to the event and to emphasize the relevance of its cultural aspect.



**Fig. 1** Villa Reale di Monza

In addition, the ownership of a historical building can represent a good investment in the real estate market. The chance of an increment in the value in time offers to insurance

companies, banks and foundations the ideal stimulus to buy and renovate these buildings in order to make them their headquarters. Often, they are owned by the Government, thus making them suitable to host offices of Public Bodies. Other relevant commercial activities could be based on these buildings, such as restaurants, hotels, shops, stores, showrooms, libraries, bookshops, etc.

All these activities have different requirements in terms of indoor environment performances. Outward appearance, security issues, indoor conditions, ICT connectivity, equipment installation are only some examples of elements that must be considered for a proper conservation of the building. However, to maximize the results and the building overall performances an integrated approach is necessary in order to analyze the building structure as a whole and to not choose solutions that apparently solve one problem but create issues on other aspects. Such approach is also encouraged by National Bodies, as stated in the Italian “Codice dei Beni Culturali” [10] that aims at defining technical requirements for cultural heritage conservation (art. 29 and art. 114).

Thus, owners and managers need help for:

- assessment of current status of the building
- design of conservation works
- definition of proper management plans, including preventive conservation
- improvement for energy efficiency, health, safety and security of the building (compatible with laws on cultural heritage protection)
- guidelines for writing tenders.
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The use of historical buildings in different ways, compared with original needs and capabilities in construction, requires a check and a modernization of building characteristics (structure, electrical system, heating system, etc.). These needs must comply with national and international regulations aiming at preserving historical building aspects, such as the artistic and cultural value. So the potential modernization works have to be respectful of the building preservation and as less invasive possible.

### **3 Performance Assessment Methodology**

To provide a helpful hand to owners and managers of historical buildings, an assessment methodology has been defined. The methodology aims to assess the current overall performances of the whole building, analyzing the possible relevant aspects in an integrated approach. The analysis is performed through the analysis of different points, with the definition of a set of indicators able to measure the relevant parameters and provide an overall score of the building.

The main aspects considered can be summarized as:

- *Indoor Environment Quality*: analysing all the parameters that play an important role in guaranteeing that the building provide optimal conditions with regards to the appropriate use classifications;
- *Compliance with Regulations*: ensuring that all the refurbishment actions must comply with national and international law and regulations;
- *Cost Management*: assessing the costs of day-to-day operations to keep the building always in order.

### **3.1 Indoor environment quality**

The indoor environment quality can be evaluated through a set of parameters that could be divided into proper categories. The following subsections will describe the most relevant of them.

#### **3.1.1 Comfort**

The first aspect to consider is the study and the analysis of the parameters related to the comfort of people inside the building. These parameters include temperature and relative humidity in each room, but a relevant role is also played by the evaluation of the air quality, detecting the presence of gases, VOCs (volatile organic compounds), presence of tobacco smoke, etc. ([1], [2]). All these factors are really important in order to determine the well-being of people working or visiting the building.

However, as historical buildings often have artworks inside them, even if they don't host a museum, a particular attention must be put to ensure the proper conservation of these objects. The identification of the right devices to control such parameters

#### **3.1.2 Security**

Another important issue to analyze is the security of the building. The assessment of the risks against man-made malicious actions (thefts, vandalisms, etc.) could really help in the definition of the security measures to adopt in order to prevent damages to the building and/or the people and objects inside it ([3], [4]).

The definition of procedures and the identification of the proper device to install to improve the security level of the must be done accordingly with the constraints related to the artistic properties of the building.

It's necessary to define security procedures also for management of emergencies due to natural disasters ([5]). For example, in case of earthquakes it is important to quickly assess the status of the buildings and put in action adequate procedures to reduce the consequences of disasters on people and objects inside a building.

#### **3.1.3 Accessibility**

As said before, nowadays historical buildings host activities that are open to the population. Thus, accessibility is a very important aspect to take into consideration. With the term accessibility, we mean both the availability of structures that facilitates the access for normal people (presence of parking lots, public transport services, etc.) and the access of disabled people ([6]), taking into account the architectural barriers that could prevent them from using the buildings.

### **3.2 Compliancy with regulations**

Due to their great value in artistic and cultural value, historical buildings are subject to constraints coming from local authorities when dealing with refurbishment works.

Each country has promoted several laws and regulations that must be apply in constructions, with a special reference to the buildings open to public. The methodology presented in this paper aims to provide help for Public Bodies to assess the compliancy of historical building in their current status to such regulations. If some problems were detected, the framework could be the base for the development of tender requirements for planning proper refurbishment works.

### 3.3 Cost management

A relevant role in the management of historical buildings is played by the evaluation of the costs associated to a proper maintenance of the structure and the installations. Also the day-by-day costs have a great influence on the necessary budget to keep the building in order ([7]).

Our methodology could help in identifying how much the planned operations impact on the overall expenses. All the relevant aspects are taken into account, from the initial installation of the systems to their disposal at the end of their life-cycle. The analysis could be performed for the whole building complex, or considering only a room at a time (the second approach is very useful when rooms could have different scopes and different performance requirements).

## 4 Performance Indicators

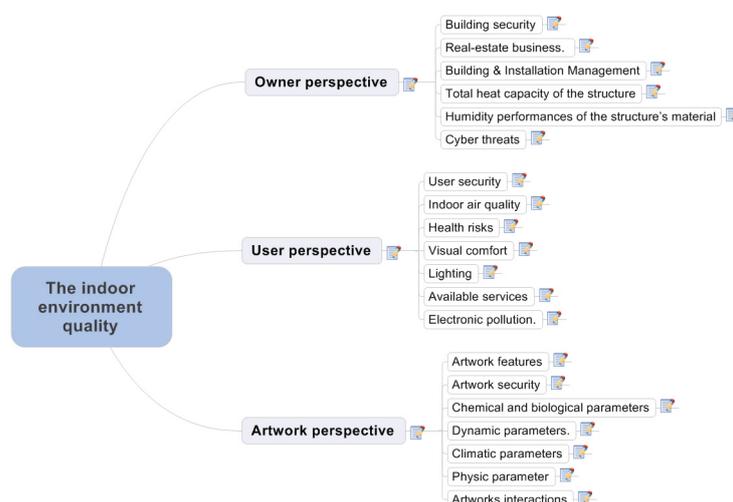


Fig. 2 Classification of Indoor environment quality indicators from different perspectives

### 4.1 Owner perspective

The main objective of the owner is to ensure the security and safety of people and object inside the building, keeping an eye on the economical issues. Therefore, in these categories we tried to include the evaluation of the information related to building structure. The indicators could be classified in the following sub-categories:

- *Building security*. Evaluation of the security measures that could prevent unauthorized accesses, burglaries and vandalisms against the building itself;
- *Real-estate business*. Economical evaluation of the building complex and of its use on the basis of the real-estate market properties;
- *Building & Installation Management*. Analysis of the costs related to the installation, management and maintenance of the building and the technological systems inside it;
- *Total heat capacity of the structure*. Study of the building performances in terms of thermal insulation in order to evaluate the performances of heating and air conditioning systems and identifying possible alternative solutions;

- *Humidity performances of the structure's material.* Analysis of the hygrometric performances in order to detect possible problems and damages to the building structure and, if necessary, plan proper restoration works;
- *Cyber threats.* Analysis of the vulnerabilities of the technological control systems adopted inside the building to control the indoor performances, in order to prevent malicious actions against or unexpected failures of such systems.

## 4.2 User perspective

In the user perspective, we include all the parameters relevant to the comfort of people inside the building (workers, visitors, etc.), mainly considering the environment and the services that could be found. The indicators could be classified in the following categories:

- *User security.* Evaluation of measures and actions taken to avoid criminal action by and against people inside the building;
- *Indoor air quality.* Analysis of the parameters that play a relevant role in ensuring an adequate comfort level to people working in or visiting the building. Examples of such parameters are: temperature, relative humidity, presence of gases, etc;
- *Health risks.* Detection of the presence of chemical or biological substances that could represent a hazard to human health;
- *Visual comfort.* Analysis of the layouts and objects to identify possible annoying situations for workers or people visiting the building;
- *Lighting.* Suitability of the lighting characteristics, with references to the activity carried out in the different rooms (type of work, exhibition, presence of sensitive objects, etc.);
- *Available services.* Evaluation of the presence of additional services to improve the usability level of the building;
- *Electronic pollution.* Detection of electromagnetic fields deriving from electronic devices that could represent a hazard to people's health.

## 4.3 Artwork perspective

In a historical building there are often a lot of artworks, with different properties and characteristics. So, it's necessary to take into account also the conservation and security requirements of such objects in addition to owner and user needs.

Artwork conservation is typically based on guidelines provided by Public Bodies and Institutions (for example, in Italy, artworks protection is defined by [8] and [9]), that contain the limits for the environmental parameters depending on each artwork property. This aspect has a great relevance in the design of installation for controlling the indoor environmental quality, but also on the definition of exhibitions layouts, as it provides specifications on artwork typologies that could share the same rooms. Furthermore, it is necessary to take into account the comfort of workers and visitors. In [11], this issue is very well described, providing a methodology to determine the compatibility between people and artwork comfort.

The defined indicators are grouped in the following categories:

- *Artwork features.* Identification of specific artwork characteristics in each room. This is the base for the definition of the parameter limits, measured by the other indicators, that has to be respected in order to ensure a proper conservation for artworks;

- *Artwork security*. Measures and actions to prevent damages and vandalisms against artworks inside the building;
- *Chemical and biological parameters*. Analysis of the presence of chemical and biological parameters representing a hazard for artworks;
- *Dynamic parameters*. Evaluation of vibrations and shocks that could provoke physical damages to artworks;
- *Climatic parameters*. Study of the thermo-hygrometric parameters that could affect the proper conservation of artworks;
- *Physic parameter*. Analysis of physical parameters that do not fall in the previous categories but that could trigger a degradation process for artworks;
- *Artworks interactions*. Analysis of the environmental compatibility to ensure the proper conservation of each type of artwork and the best comfort for people.

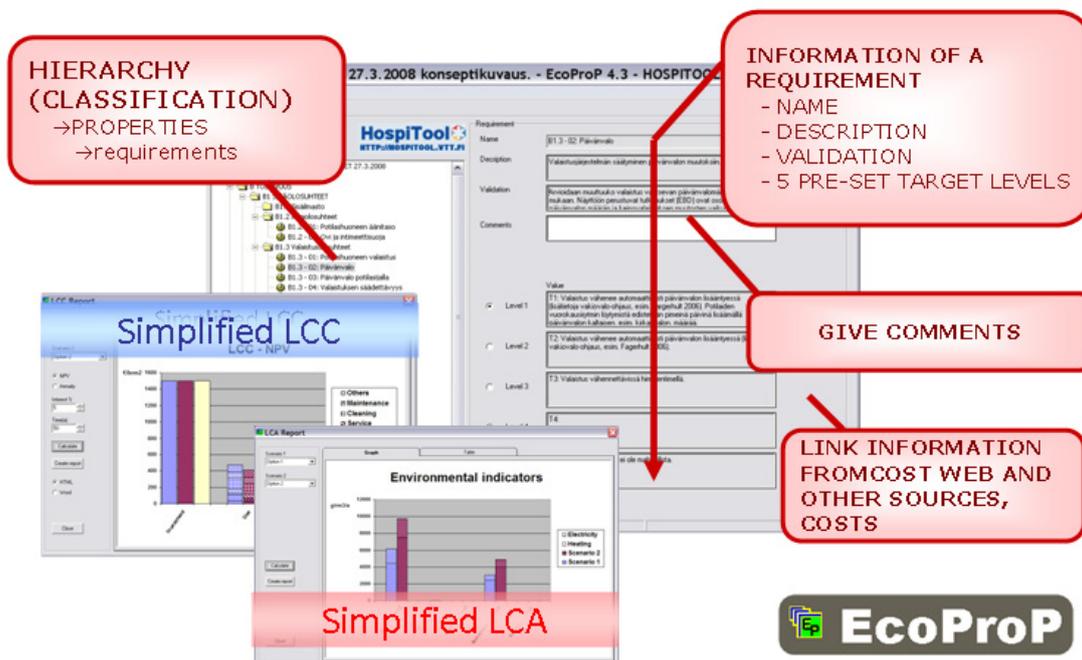
As normative requirements vary for the different kinds of artworks, it is necessary that the analysis on artwork perspective must be carried out room by room and not considering the whole building as a single environment.

## **5 Decision Support Tool**

This paper describes an assessment methodology for the indoor performance of historical buildings. The methodology is based on performance indicators which should be implemented to tools to encourage their use in projects [12]. Yet only a few decision support tools enable such functionalities. This chapter provides short overviews to two decision support tools. The first one, EcoProP [14] software, is a commercial product, while the other, Perfection portal [15], is currently under development and therefore a short introduction to its functionality is presented. Particular attention is put on how the results are shown to end-users.

### **5.1 EcoProP software**

EcoProP is an application that is based on performance approach, where emphasis is put to products performance instead of technical specifications, and requirements management that helps to know what the customer really wants [16]. Its third generation version draws from tens of international projects and contribution in Finland on indicator assessment [17]. EcoProPs strength is its systematic requirements management process; user needs are first collected, then defined to requirements, and finally verified from the end result. This systematic process is provided to user through hierarchical structure (see Fig. 3), requirements are described to database that enables users to build a new sets from earlier developed ones. The main functionality are custom reports that may be produced individually to project stakeholders. These reports may include export from one design alternative or two alternatives maybe compared. Additionally the application has also modules for life cycle cost (LCC) calculation and life cycle assessment (LCA). LCC module follows ISO15686 directive, and LCA connects it to environmental pressure during the operation phase of the building.



**Fig. 3** EcoProP software for systematic requirements management

During the last ten years, EcoProP has been used in schools, nurseries, residential housing, shopping centres and office buildings [14]. It encourages project team towards more open and transparent dialogue. In relation to earlier, the commitment on common goals also increases when team develop the solutions together. Simplified cost and environmental calculations help to understand trade-off between higher construction cost and lower life-cycle cost. Altogether, EcoProP has proven to be a valuable aid in implementing the performance approach to Finland [13]. More information on EcoProP is available at <http://cic.vtt.fi/ecopro>.

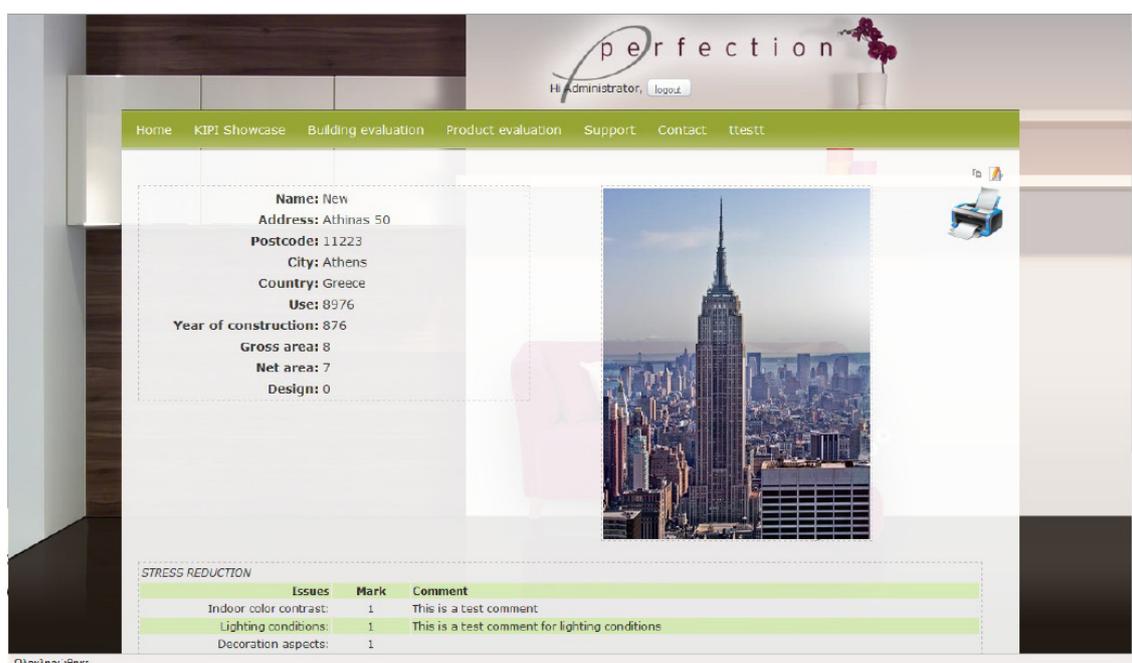
## 5.2 Perfection portal for indoor performance

The second decision support tool, Perfection portal, is focused to indoor performance. The development work for the portal is currently ongoing at <http://indoorperformance.net>. The baseline is that it is used to distribute knowledge on Key Indoor Performance Indicators (KIPIs) indicators described in Perfection project, an EC funded FP7 coordination action for performance indicators for health, comfort, and safety of indoor environment [17]. The strength of the tool is its innovative and user-friendly approach that holds a large potential to attract wide consumer interest.

The strategy in the Perfection portal is different than in EcoProP. Perfection portal has an ambitious goal to increase awareness of indoor performance. The portal is a web application that eases networking and it has been built with open source content management tools. Secondly, the portal has also stronger business focus. In addition to manage indicators it also takes has linkage to product perspective enabling builder practices and related provider offerings to be shown to users [15]. A new promotional strategy is used to engage material suppliers and manufacturers stronger to indicator

assessment. Perfection portal is used for indicator assessment, and results are visible to public in building showcase (see Fig 4).

Besides these direct indirect benefits, the portal also intends to promote social and economical value, and to stimulate research and environmental policy development. The portal development is planned to be verified in Perfection case studies. Users can also interact and have discussions in the Perfection forum connected to the portal.



**Fig. 4** Screenshot from Perfection portal for indoor performance indicators

## 6 Future Works

The indicator framework described in this paper has been developed accordingly to the needs of historical buildings and regulatory references, trying to identify which are the priorities of intervention and the most relevant aspects that have to be taken into account when planning refurbishment works.

However, the application of the performance indicators set to Villa Reale di Monza can help in validate the project choices. This site is a very suitable case as it is undergoing a huge renovation work that will involve the whole building complex with a very high number of rooms and spaces. To effectively design the activities and, eventually, a management plan, owners need help in define tender requirements and the presented methodology is fully suitable to this scope. At the end of the refurbishment process, the Villa will host services and training activities, thus both visitors and workers have to find proper indoor conditions.

Moreover, the experiences coming from Villa Reale di Monza could help in further develop the indoor performance indicator system in Perfection project, helping in identifying the most relevant optimization to the framework. Also the software tool could be further developed to better meet the requirements in terms of parameters to be monitored and user interface for presentation of the results. In such a way, the tool could be used for the systematic management of the indoor performance of historical buildings.

## 7 Conclusions

There's a huge potential to improve effective use of Europe's cultural heritage by managing the indoor performance of historical buildings. This paper presented an approach using indoor performance indicators in software tools to enable setting the objectives and assessing actual indoor performance.

The indicators were based on the framework defined in the EC funded Perfection project, with a customization due to the peculiar characteristics and needs of historical buildings. Such structures have intrinsic artistic values and typically have a lot of artworks inside them. Thus, when defining a management plan, the proper conservation of artistic artwork must be considered, in addition to ensure a comfortable environment for people.

To better address the various needs, the proposed framework divided the indicators into three main categories: owner perspective, with the evaluation of the information related to the building structure, user perspective, considering the parameters relevant to the comfort of people inside the building, and artwork perspective, with the identification of the mechanisms related to the safety and security of valuable objects. The framework has been implemented in proper software tools to obtain an overall score related to the indoor performance of a historical building.

This integrated approach allows owners and managers

- to evaluate the current status of the building, identifying critical points and priorities of intervention;
- to plan conservation activities in order to reach the performance levels identified in the analysis phase;
- to compile accurate call for tenders;
- to perform a final check to assess if the performance levels required have been met or not;

making the proposed tool a valuable help in the definition of systematic management plans for historical buildings.

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