Lifecycle oriented approach for sustainable preservation of historical built heritage
Valentina Cinieri¹; Emanuele Zamperini¹
¹ University of Pavia, Department of Civil Engineering and Architecture (DICA), Pavia, Italy

1. Introduction
Change is the only certainty of our existence thus preservation should be the research of regulation of transformation. Therefore the intervention on Cultural Heritage has evolved from an idea of a post factum restoration (after that decay occurred) [Urbani, 2000, 114] that puts an end to a process of continual becoming, to a preventive and constant maintenance, to be interpreted as a less destructive and cheaper action. Actually it is the recovery of a philosophy of approach to intervention on historical buildings that have been part of the discipline of restoration since long ago: it’s the “care of monuments” warmly supported by John Ruskin.
In addition to the preservation of physical consistency of historical buildings, care and maintenance must face the problem of sustainability, to be seen from the economic, environmental and social points of view. Historical buildings don’t meet perfectly current standards in terms of energetic management and they have many restrictions in terms of construction techniques and typological and functional features, however they have many sustainable features: the energy of realization (embodied energy) had already been spent; they provide for a saving of material resources because they don’t need neither new land consumption nor the extraction, production and processing of great amount of materials; furthermore they often have morphological and technological features appropriate to environment and climate.
The idea proposed in this paper is to consider the life cycle concept as possible method of sustainable preservation. The Life Cycle Assessment mantra “from cradle to grave” is usually applied to new products, taking into consideration all their components, from the extraction/production of the raw materials to the disposal of the constructive elements. Instead the main goal of historical buildings’ conservation strategy is to shift to infinity its “dismissal time”. Thus in contrast with the established LCA method, the study aims to lay the foundations for an innovative approach for sustainability assessment of existing buildings that should consider the resources savings and doesn’t set a time limit for the building’s life.

2. Sustainability and Built Heritage
2.1. The concept of sustainability applied to Cultural Heritage
Nowadays the term “sustainability” often recurs in all areas of human activity related to production and management of material goods: beside a building methodology, the sustainability represents a life style [Vitiello, 2012, p. 53]. The Brundtland Report, published in 1987, adopted a definition of sustainability as an equilibrium between the satisfaction of the present needs and the maintenance of possibility for future generations to meet their own needs, so proposing a sustainable development that should be able to guarantee good
living conditions in the long term. After that, in 1996 the conference of Kyoto enquired directly the building sector, because of its relatively heavy environmental impact; in the same year, at Istanbul (Habitat II conference) commitments for the application of sustainability in this sector were defined, and some aspects have already been taken for granted, as cultural responsibilities and training of building workers. Also in the field of the existent buildings, professionals are beginning to think to radically revise the discipline taking account of these issues. Indeed, in many part of the world the new buildings represent only a little part of the built heritage and the bursting of the real estate bubble (2007-8) has further reduced their “relative importance”; however the inclusion of sustainability issues in interventions on historical buildings is quite recent. The European directive 2002/91/CE highlighted the problem connected with the existing built heritage, but it stated that the application of performance requirements to historical-cultural buildings is at the discretion of Member States; performance standards were not defined and the field of its action on existing patrimony seems to be quite restricted.

In Italy, interventions on architectural heritage - buildings subject to protection according to Italian law (D.Lgs 42/2004) - are subject to authorization by the competent bodies and derogations are provided to European performance parameters. However this doesn’t regard most of the traditional preindustrial built heritage, that is not officially declared of cultural interest according to law; for this reason laws often seem to be in contrast with actual moral needs of safeguarding, which are progressively spreading to “new patrimonies” [Cini, Zamperini, 2013a]. Furthermore, Italian laws which implemented European directives often trivialized the concept of sustainability, they promoted a simplified analysis process, providing for guidelines based only on energetic assessment.

In recent years, it has been encouraged the development of research in the field of sustainability of historical built heritage. Nonetheless, also in this case studies were focused almost exclusively on the elaboration of intervention approaches and guidelines aimed to improve energy efficiency. In this field we can place some Italian researches - patronized by ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic development) - in which there is a study for the elaboration of a methodology aimed to the energy improving of historical building, considering as subject the first main floor of the royal palace of Monza, restored and used as an exhibition space [Morandotti, Besana, Riccardi, 2011]. In this case, the research was focused overall on the theme of building envelope performance improving with the suggestion of possible actions, compared between themselves and related to restrictions due to building typology and material preservation, and to needs connected with the new use.

Among the studies in this field, we can also mention the development of a certification method for historic buildings by Italian GBC (Green Building Council), suitable to meet the needs of buildings subjected to protective restrictions, and capable of measuring energy efficiency in relation to feasible restoration actions, with the aim of improving the quality of housing; however, the limit of
this methodology is the possibility to apply it only to buildings that are directly protected by law [Vitiello, 2012, p. 75]. Although the historical-cultural value of traditional preindustrial buildings is recognized [Cinieri, Zamperini, 2013a], they are included among the “EBOM” (Existing Buildings: Operation & Maintenance) procedure, that favours the existing buildings retrieval and the reuse in order to “rectify” the “environmental debts” in a quick way, nevertheless without considering their historical building features; thus unprotected built heritage could be heavily refurbished, being a supposed source of environmental unsustainability.

There are also in progress researches aimed to the creation of an assessment approach for the existing buildings quality, which are based on the LCA (Life Cycle Assessment) and on the SBTool (iiSBE, International Initiative for a Sustainable Built Environment) method for the built heritage [Mančík, 2010; 2012]. The historical-cultural value is included as a classification criterion, affirming that: «it is obvious that it is necessary to approach differently to a building with cultural-historical value and building with a minor cultural-historical significance» [Mančík, 2012, p. 34]; a view that engenders doubt about the demarcation line between major and minor importance and between what to define more historical then something else, a subject which has already been amply discussed and still debated and cannot be trivially resolved looking at the building age3.

If the sustainability issue - even if often only from an energetic point of view - is becoming an obligated presence in the design of new buildings, greater complexities restrained the application of sustainability principles to built heritage, although it represents, as better explained in the following paragraphs, one of the greatest potentialities of development. Indeed the building should be considered in its all life development as «part of an articulated system of ties that man has been able to forge between its artefacts and territory» [Vitiello, 2012, p.60-61]; moreover the historical buildings’ sustainability should be declined in the interdependence between knowledge, preservation, and property fruition, also considering the benefits that society can draw from conservation works.

2.2. Environmental sustainability of existing buildings

The present environmental situation and the awareness of the finiteness of resources make indispensable a careful assessment of environmental sustainability. In particular, in Europe the buildings employ 42% of the consumed energy [Lavagna, 2008, p. 70] and the building sector produce about 50% of the pollutant emissions and of the waste [Bazzana, 2008, p. 23]. If in the sphere of new buildings, the environmental sustainability issue has been already considered since the design stage, in the case of the existing buildings there are more complicated problems, even if they represent the majority of the built heritage, including the buildings with historical-cultural value.

It’s common to consider existing buildings, and in particular traditional historical buildings, as a source of energy consumption and pollution, looking at new buildings as the solution to environmental problems related to construction activity; a custom which often induce to give preference to demolition or heavy
refurbishment interventions, especially in the case of buildings that have no protection restrictions, even if they belong to the cultural heritage of a territory (spontaneous vernacular architecture or traditional preindustrial buildings, that are abandoned and not registered as heritage buildings, etc.). Nevertheless, as already written, the energetic aspect is not the only responsible of the environmental problems; the environmental sustainability purposes should comprehend, besides the energy saving, the saving of material resources, the reduction of waste and of pollution, the safeguarding of human health. Many professionals think that a building could be made environmentally sustainable just by providing it with several technical elements with positive environmental impact (solar collectors, photovoltaic panels, wind generators, etc.). However these actions are not sufficient: it is necessary to integrate environmental issue in all its aspects and revise all the process of design and use [Lavagna, 2008, p.73].

An existing building, which consumes a greater quantity of energy than a new building, could nevertheless be much more sustainable from the environmental point of view, because its huge quantity of embodied energy (energy consumed for raw materials, production, transportation, building) has already been spent.

Moreover the preservation in use of an existing building permit to have a minor environmental impact, because the realization of a new building needs demolition and reconstruction, with consequent energy consumption, pollution and creation of waste for disposal⁴.

Indeed, besides the energy already spent on the construction, the supply of raw materials, the transportation of large amounts of materials into and out of the construction site, the disposal of demolition debris in landfills, as well as the possible emission of harmful or toxic substances in during demolition (e.g. dust) and construction, as well as during life of the building by new products, have a strong impact on the environment, causing health and pollution problems⁵.

Going into details, the supplying of raw materials during the construction phase influences from the point of view of the material consumption and of the impacts caused by the materials extraction (quarries), a problem that cannot be resolved only by the construction of buildings which use renewable materials instead of non-renewable ones. The building process uses half of the extracted materials in the world and more than a quarter of all the waste is produced during construction and demolition of buildings, for a total of 450 million of tons [Lavagna, 2008, p. 70]. The waste produced during construction activity only amount to 10-20% of the total of construction/demolition debris [Lavagna, 2008, p. 232]. They are classified into “clean” and “dangerous”: the first are remainders of various materials, production scraps, defective products, packaging, earth of excavation, indeed the second one consist of remains of paints, waterproofing materials containing tar, containers of dangerous materials. currently there is still little awareness about recycling at the life ending [Lavagna, 2008, p. 180] and building materials are rarely biodegradable, e.g. the use of some products as fireproofing or antifungal/antixilophagous paints make difficult also the composting of wood, as well as its recycling [Lavagna,
It should also be highlighted that waste due to erroneous installation has a significant impact. In the past building materials were for the most part local and easy to source, with a minor impact on transportation, at present time we should make sure not only that products could be find locally, but also that the whole production chain is “local”; furthermore the distance between the extraction, production, or processing site and the construction site is not the only thing that influences on fuel consumption, but also the weight of the materials and the transportation dimensions [Lavagna, 2008, p. 228]. Together with transportation, a significant environmental impact is caused by the product packaging and by the occupation of land due to quarries and buildings. Moreover the soil handling and the connection with underground utilities alter the biophysical features of the ground. The construction site is also place of use of machineries, that need energy and resources (water, raw materials, fuel), generating pollution and noise. Ancient buildings were mainly constructed with natural materials or low toxicity products (whose emissions had normally been already exhausted) and with low pollution, on another hand the realization of new buildings sometimes originates severe damages to the health of workers and users which often are discovered after several years. The described situation explains that the demolition of an existing building and its replacement with a new generation construction don’t prove - at least with current technology - to be lacking of severe environmental problems, whose evaluation should carry weigh within the assessment of a new building presumed ecology. In addition an existing building could be upgraded through compatible actions that are aimed to reduce its energy consumption, with lower waste of resources and energy compared to its reconstruction. Moreover traditional buildings were usually built with features adequate to the climate of their specific territory; in consequence, they often have characteristics favourable to the reduction of heating and cooling energy consumption (e.g. thermal inertia). A further essential consideration is that architectural goods can be divided in categories related to the type of use: continuous or discontinuous. In the last ones there are included buildings that are not continuatively used during the year and are used everyday (second homes, public buildings with periods of prolonged closure, as seasonally used buildings, public buildings in rural territories, oratories, churches, etc.). Energy consumption calculation should not be carried out, as it usually happens, according to a hypothetical continuous use, but to the actual use, therefore also meeting more easily preservation issues. Actually on one hand the oversizing of upgrading interventions, resulting from this misconception, prompt to highly invasive refurbishment works or to reconstruction, on the other hand it supports the abandonment (non-intervention), because - requiring an “excessive” investment - disincentive to preserve/maintain the existing heritage.

2.3. Social issues of built heritage preservation

Historical built heritage embodies the character of the local tradition and the
identity of places, and it constitutes a reference point for the population. Therefore, through the maximization of permanence and the lengthening of the life time of cultural heritage, conservation of material cultural contains in itself issues of social sustainability.

In spite of this, an anthropological risk is connected with the perception of a sense of discomfort in historic construction, because of their difficulty in responding to new needs, dictated by social transformations and the resulting changing in lifestyle.

To these problems, those intrinsically connected to Italian monumental protection system must be added: indeed it considers only assets «of particularly important interest» [D.Lgs 42/2004, art. 10, clause 3] and not the widespread heritage that strongly connotes each territory. In addition, the strategies so far used demonstrated limited effectiveness, because they impose constrictions - limits often perceived by owners as a punishment - and provide for funding given only to individual important buildings, moreover this method is problematic due to the lack of adequate economic resources and leads to a situation in which only a few goods can enjoy the little funding» [Cinieri, Zamperini, 2013c, p. 847-848].

Although refurbishment often leads to changes that greatly alter the historical features of buildings, the risks of non- refurbishment may also be higher and cause a degradation that can rapidly lead to the total loss of the good [Cinieri, Zamperini, 2013a] with negative consequences from the point of view of territorial enhancement and, therefore, of social sustainability.

The preservation of historic neighborhoods and social housing should also be accompanied by the protection of the social fabric, in order to avoid a very negative social impact, as it happened in Italy, during the requalification works of historic city centers after World War II. At that time «most humble social classes that dwelled in these decayed neighborhoods - the first for which general refurbishment works were planned - were systematically expelled from city central areas and moved into newly built suburbs, with the declared intention of provide them with hygienically healthier housings» [Cinieri, Zamperini, 2013a].

As a further proof of the greater social sustainability of the maintenance of built heritage with respect to its rebuilding, we should also point out that building refurbishment is a productive activity with a high labour content; therefore - costs being equal - in addition to a lower consumption of materials, this involves a higher rate of employment. A proper intervention on existing buildings also requires the rediscovery and understanding of historic building techniques; this allows the preservation and perpetuation of the intangible culture heritage which produced the material evidences of historical buildings, promoting, therefore, also the cultural sustainability of refurbishment.

2.4. Economic issues of cultural heritage management

Existing historical buildings are usually considered a heavy burden from an economic point of view, because of the several activities of restoration and adaptations which they often need.

The solution of the problem should be an adequate planning of the main-
tenance activity”. In fact, even a newly constructed building needs constant maintenance, and not carrying it out leads to a shortening of the expected life of a building, and to a situation similar to that of an old building to be restored. Moreover, new technologies offer more efficient materials from the energetic point of view, but often with more accelerated obsolescence which requires an early replacement [Lavagna, 2008, p. 252].

On average the maintenance of a building throughout its lifetime requires more than 10 times the money spent for its construction [Lavagna, 2008, p. 250-251], but if a building has a long life cycle, and we are able to maintain stable its performance levels, the average annual management cost is reduced [Cecchi, Gasparoli, 2012, p. 65]; instead, if a building has a short useful life because its function decays or it is abandoned or because it has been built with poor quality materials, it has a rapid performance decay, the management costs are higher and the impact on the environment is high, requiring several cycles of production and construction to ensure its use in time.

In the field of “planned conservation” of cultural heritage many theoretical studies and researches have been done, starting with the “preventive restoration” theorized by Brandi [Brandi, 1956]. A few practical experiences have also been carried out in Europe since 1970s (Dutch and Belgian Monumenten-Watch, the BAUDID in Germany, Maintain our Heritage in England, etc.). The strategy of “planned conservation” is emerging as a management procedure for properties that combines the mitigation of large-scale risks with the precise organization of daily activities and it can be conceived as a passage from “restoration”, meant as an episodic and exceptional event, to “conservation”, meant as a continuous and long-term process [Della Torre, 2010, p. 47]. In the approach to cultural built heritage management we should endorse monitoring actions and maintenance work that must be carried out through interventions characterized by minimal building and economic impact: maintenance and repairs «have to be organised with systematic research, inspection, control, monitoring and testing. Possible decay has to be foreseen and reported on, and appropriate preventive measures have to be taken» [The charter of Krakow].

The meaning of “cultural heritage” has evolved from an idea of singular emerging monument, to an idea of an asset closely connected with territory, which is in turn valorized by the presence of its widespread heritage [Cinieri, Zamperini, 2013b, p. 199]; therefore the economic sustainability of the built heritage management is the basic prerequisite in order to preserve this widespread heritage, because it will never enjoy free grant funding. Confronting refurbishment with the realization of new buildings, in the analysis of economic sustainability we must include the costs borne by the community that aren’t directly paid by who build or manage the property, such as waste disposal, land decontamination, pollution-related health care costs, … The failure to consider these aspects often involves partial and misleading economic evaluations.

3. Conclusions: Life Cycle Thinking for Cultural Heritage
An evaluation system for buildings taking account of environmental, social and economic issues can be implemented through the use of life cycle criteria. Life cycle is defined as «The time interval from the beginning of design of the
entity and the ending with its disposal» [UNI EN 13306:2003]. Designing the life cycle means making decisions that affect not only construction, but also management, maintenance, disposal, imposing «a long-term vision […] taking responsibility over the entire life cycle of the building» [Lavagna, 2008, p. 77]. Furthermore - as Roberto Cecchi and Paolo Gasparoli state - «In the field of building maintenance the “life cycle” is essentially related to the still recognized capacity of buildings to provide performances and thus it is substantiated in assessments that are related to the possibilities and forms of use» [Cecchi, Gasparoli, 2012, p. 67].

LCA method was first applied to industrial products, studies on its application to buildings are still in progress. The life cycle thinking leads to identify strategies for operating in a sustainable manner all along the production chain; this method should lead to a rethinking of the productive and design process, of the type of products and their use [Lavagna, 2008, p. 303]. The LCA method leads us to predict the end of life and to estimate the impact of all that this involve (demolition, waste of energy, waste, possibility of recycling, etc.). This make it hard to apply the method to buildings designed for the long period8; however, the deletion of the last phase of the process leads to eliminate some of the toughest environmental impacts (see par. 2.2), and it has also a positive impact on social and economic aspects, on the basis of what is written above in more detail.

The primary objective of the intervention on historical heritage is its transmission to future and the maximisation of building life; the life cycle approach leads us to consider the asset management in the long term from many points of view. Therefore application of LCA criterion to built heritage leads us to rethink the approach to intervention on historic buildings, considering all aspects of sustainability and putting in place a balance between positive and negative contributions in the long term.

Notes
1 «[…] about two million of firms, with 11 million of collaborators, organize the habitat of 380 million of Europeans with the realization and the usage of buildings […]» [Vitiello, 2012, p.57].
2 «Member States may decide not to set or apply the requirements […] (of energetic performance) for the following categories of buildings:
- buildings and monuments officially protected as part of a designated environment or because of their special architectural or historic merit, where compliance with the requirements would unacceptably alter their character or appearance,
- buildings used as places of worship and for religious activities […]» [2002/91/CE, art. 4, clause 3].
3 The Italian legislation predicts a facilitated procedure for the apposition of the historical restriction in case of public buildings that are older than 70 years old (50 years till 2011) [D.lgs. 42/2004, art. 10 , comma 5].
4 In the world the construction industry uses 3 billion of raw materials and «[…] the buildings are responsible for consuming 40% of stone, gravel and sand, that are used globally each year, and consumption of 25% virgin wood» [Lavagna, 2008, p. 173].
5 A research established that the CO2 emissions in Japan are constituted by 19% of embodied CO2, 23,2% CO2 by the building operation and 60% of CO2 provoked by
production and transportation [Oka, Sawachi, 2013, p. 10].

6 «Earth excavation is one of the most consistent entry of “waste” of construction» [Lavagna, 2008, p. 225].

7 «According to the latest regulation, the Maintenance Plan on buildings in use is aimed at maintaining the efficiency of a building whose benefits are deemed to be sufficient to provide acceptable answers to the current requirements of users. [...] Maintenance thus means “realigning” the performance or state of conservation of the building (which has suffered decay over time or where there are deficiencies with respect to use), to a state as close as possible to that at time of commissioning.» [Cecchi, Gasparoli, 2012, p. 35].

8 The Ph.D. thesis by Manuela M. Bazzana (Ph.D. course: Building Engineering and Architecture, University of Pavia, XXIII cycle) considered and studied the application of the LCA method on the temporary architecture.

References


The charter of Krakow 2000, Principles for conservation and restoration of Built heritage.