Sustainable upgrade: water as a key point in environmentally keen housing refurbishment

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ABSTRACT: The paper discusses in which way and to what extent Italian national and local norms, international regulations and indicators of sustainability are applicable to the refurbishment of the suburban multi-family European building heritage completed in the 20th century after the 2nd World War. To achieve the goal, rules from international agencies have been selected and collected as appropriate strategies under common requirements. Defining common objectives for different actions will be used to test, referring to the aforesaid case study, the feasibility and the impact of any recommendations. Italian national and regional norms have been considered as they represent the minimum quality required. The level of upgrade of the refurbishment will result with the comparison between the minimum standard and the refurbishment based on new tools.

1 INTRODUCTION

The paper aims at contributing to enhance applicable requirements and possible strategies of action with regard to the preservation and valorization of water in the built environment. The case study is the refurbishment of the suburban multi-family European building heritage completed in the 20th century after the 2nd World War. The method adopted consists on comparing proper reports, rules and indicators in order to:

- define a system of needs
- identify appropriate, comprehensive and easy to understand requirements
- suggest strategies and possible action/technologies to fulfill the requirements
- verify the applicability of the strategies to the case study
- relate the suggested actions with current prescriptions and rules
- evaluate the upgrade level these actions allow in comparison with current prescriptions

The study considers refurbishment in the most widely accepted sense of bringing existent buildings up to standards or to make them suitable for a new use (Burden, 2004). Different situation should be evaluated. The applicability of each strategy to the refurbishment can’t always be reduced to a univocal response, that’s why it’s not inserted in the final table but discussed in the proper paragraph.

In the paper, Italian national laws and regional rules are considered. However, this has to be considered as a particular case. The work should be adapted to different prescriptions depending on where to apply the method.

Proposed actions and strategies don’t aim at being exhaustive, but at illustrating the corresponding strategy.

2 STATE OF THE ART

The increase of the demand and the decrease of the availability of fresh water in the next few years is a prospect over which scientists’ opinions are concordant. Supranational organizations debate about the topic and give important indications contributing to clarify needs and problems related to water. Building generates great impacts in the environment and uses widely natural resources. According to UNESCO’s World Water Assessment Programme, buildings are responsible for the consumption of the 11% of channeled fresh water in high-income countries and 8% in low and middle-income countries (WWAP, 2003). International research institutes look with great interest to the preservation of the hydric resource. The International Council for Research and Innovation in Building and Construction (CIB) inserted water among the topics discussed in its international conferences. Since Agenda 21 on Sustainable Constructions (CIB, 1999) it highlighted the problems of the lack of fresh water, of leakage from distribution systems, inefficient water use, urban waste pollution and urban runoff. In particular it focused on:

- with regard to construction: selection of products, materials and constructive processes needing less high quality water.
- with regard to users: optimization of the consumption and water conservation.
- with regard to design: use of sustainable resources.

National government agencies worldwide are giving their contribution to focus on the needs related to preservation and valorization of water with regard to the built environment. They contribute to insert water concern into a systemic frame by relating it to a more general context. For example United States EPA highlights that energy utilized to treat, collect and transport water has been estimated to account for the 3% of total US energy consumption, underlying that strategies to preserve water have important effects on other matters (NSTC, 2008). Similar data can contribute to offer a systemic vision of the problems, with opportunities for systemic responses. Moreover, government agencies are often in charge for advanced programs experimenting integrated solutions. Singapore's national water agency (PUB) developed a program to purify wastewater in order to provide 30% of Singapore's current water needs, and a program to collect stormwater on a large scale for its water supply. Water flows in huge reservoirs and the last one was completed in 2011 across the seawater Marina Channel. Besides creating the fresh water reservoir, the barrage acts as a tidal barrier that prevents seawater from flooding the inland.

In addition, government agencies promote and communicate appropriate policies to a wide public. This is strategic because building designers and stakeholders should meet the requirement of the final user, who should approve and require high performance levels. Communicating effective messages is especially important for topics where long term money saving is not guaranteed. Water preservation is not always repaid by economical benefits. That's why agencies increasing public awareness of the state of the environment and communicating to users right strategies have been taken into account. Considered government agencies are:

- Singapore's national water agency (PUB)
- United States Environmental Agency (EPA)
- US Federal Energy Management Program
- Water Supplies Department of the Hong Kong Special Administrative Region Government
- Israel Ministry of Environmental Protection
- Australia's Water Efficiency Labelling Scheme (WELS)
- England Environment agency

According to Andrews (2006), sustainability indicators of buildings aim at making understand user requirements and at creating design options that fulfill the required performance in terms of environmental, economic, and health and community benefits. As they are performance-based tools, they have been analyzed and compared in order to collect needs as requirements referred to final users. Sustainability indicators of buildings give great attention to water concerns and comparative studies put in evidence the emphasis given by some tools and possible gaps in others (Ilha, 2006). Considered tools are:

- LEED for New Construction and Major Renovations, 2009
- LEED for Existing Buildings Operations and Maintenance, 2009
- CASBEE for New Construction, 2010
- Protocollo Itaca Nazionale 2011 residenziale
- BREEAM Multi Residential 2008

According to ISO (2006), a prescriptive approach describes an acceptable solution while a performance approach describes the required performance of the building. That's why it could be useful to confront laws (prescriptive approach) and performance-based sustainability indicators. Italian laws and local rules represent the minimum quality required. The level of upgrade of the refurbishment will result with the comparison of the minimum standard and the refurbishment based on new tools.

The first Italian law concerning water saving (L. 36, 1994) states that Regions should emit norms in order to reduce water consumption and to avoid waste. In particular it solicits the realization of dual water supply systems and water submetering systems for each building. This article was improved (D.L. 152, 1999) by providing that Municipality should give building permission only if the previous rules are accomplished. This legislative position was then confirmed and improved with the introduction of the obligation to reuse meteoric water (L. 244, 2007). In 2011 it was proposed to the Italian Senate a new law providing, among other, the obligation of collecting from building roofs 100% of rainwater, of using dual flush toilets and air-water taps, and of using permeable pavements for at least the 50% of the total building outdoor area.

Italian Regions and Autonomous Provinces have full responsibility on city planning administrative functions and emit norms to regulate city planning and building construction. Due to the impossibility of providing detail about all regional norms within the limits of this paper, Umbria regulations has been selected as one the most advanced and the one dictating to municipalities the most detailed technical standards. Pertinent rules emitted by Umbria are Regional Law n. 17/2008: "Norms with regards to environmental sustainability of building and urban design", and the implementation Regulation, n. 3/2011. They states that in the case of refurbishment and restorations building should:

- be provided with more efficient equipment such as dual flush toilet, tap aerator, low flow showerhead and high efficiency home appliances.
- be provided with waste reduction equipment such as automatic water control systems and automatic shut off taps

In the case of new construction or major renovation, in addition to the previous prescriptions, building should:

- collect and reuse rainwater when rooftop is more than 100sm and the garden is more than 200sm.
- ease maintenance
- be provided with dual water systems in order to supply non-potable water for compatible use
- be provided with water tanks to catch rainwater. They should be 3000l minimum if the rooftop is less than 300sm and 9000l minimum if the rooftop is larger
- be provided with permeable paving for at list 60% of the outdoor area. Parking areas are required to collect rain water and treat it on-site.

In addition the Regulation prevents from improper use of high quality water by forbidding its usage for garden irrigation, swimming pools, car washing, non-recycling water fountains and street and sewer washing.

3 WATER ASSESSMENT

3.1 *Reduction of stormwater load on local infrastructures.*

Impervious surfaces of the built environment prevent stormwater to percolate through soil forcing it to direct faster to storm drains or to wastewater sanitary systems, thus reducing time of concentration. Excessive load to systems can produce undesirable effects including the rise of water to unnatural levels and the overload of treatment facilities. Both results can cause contaminants to be released in aquatic ecosystems and can contaminate water quality with substances affecting its quality. United States Environmental Protection Agency (EPA) calculates that stormwater runoff and overload from treatment systems are one of the major causes of impairment of rivers, lakes and estuaries thus increasing the cost of high quality drinkable water production. Methods to produce potable water are energy-intensive and generate CO_2 as well as other GHGs (NSTC, 2008).

Appropriate on-site strategies have the potential to reduce stormwater load on local infrastructure diminishing energy consumption of potable water production. *Stormwater infiltration* collects actions to help water to penetrate into the ground and includes the use of pervious or semipervious pavements, as well as the use of superficial and underground infiltration systems.

While permeable pavements are widely applicable to multi familiar suburban building refurbishment, the use of infiltration ditches and infiltration basins, as well as infiltration trenches and drainage wells should be carefully assessed. The most common obstacles could be the proximity with buildings having underground non-water proofed walls and the proximity with polluted areas or potable water protection areas. *Stormwater slowdown* strategy includes all technologies that contribute retarding water to flow into treatment facilities. Rooftop applications can be effective and easy to use in refurbishment. In particular, roof top storage, which essentially consists on a basin used to detain water on rooftops, can be a low-cost option. The main design consideration will be the ability of the roof to hold the weight of the captured water, even if in most cases, roofs calculated to bear snow weight will be strong enough to hold the weight of stormwater. Rainwater tanks will be an option especially if reuse of rainwater will be provided.

3.2 *Recovery of non potable water*

The requirement includes all management operations that divert wastewater from the waste stream and directed at optimising the substitution of non-drinking water for drinking water. Use of alternative water sources for non-potable uses is one of the most discussed topics in the area of Technology of Architecture. Considered water sources are rainwater, grey water, black water and seawater. Grey water is water from non-toilet plumbing fixtures such as showers, basins and taps. Blackwater is water that has been mixed with waste from the toilet.

Water treatment includes all the on-site technologies to improve wastewater quality. Not all kind of wastewater is suitable for all uses. Rainwater is good quality non-potable water except for the rain falling in the first 15 minutes (L. R. Lombardia, 1985), which collects pollutants from the atmosphere and from the soil and should be separated using first flush rainwater devices. Appropriately treated greywater can be employed for outdoor use as well as indoor applications such as toilet flushing and clothes washing. Blackwater requires biological or chemical treatment and disinfection before re-use. Treated black water is suitable for garden watering. Seawater could be considered as a promising alternative resource for building non-potable use. Since the late 50s Water Supplies Department of the Government of the Hong Kong Special Administrative Region has developed a program to supply seawater, primarily for flushing, in high-density settlements. Nowadays it supplies with seawater for toilet flushing about 80% of Hong Kong inhabitants and studies demonstrate that it is an effective solution (Tang, 2007). *Non-potable water collection and supply system* includes collection tanks, pumps and mains to convey it to a supply system. A dual supply system should be designed in order to separate pipelines from different sources, some conveying drinking water, the others conveying appropriately treated non-drinking water. The applicability to the referred case study is manageable for rainwater, while it seems to be less easy and cost-effective for grey and black waters, especially because multi familiar suburban buildings are supposed to be already connected to sewage collectors. Nowadays seawater dual systems are in use only for big urban areas.

3.3 *Avoid flooding harm*

Numerous scientific studies analyse the protection of urban environment from raising water, stimulated also by some crisis, such as for example New Orleans in 2005. COST (European Cooperation in Science and Technology) instituted a research program between 2005 and 2009 specifically dedicated to urban flood management: TUD COST Action C22.

The four proposed strategies proceed from a publication by the International Panel on Climate Change (IPCC, 1990), as revised by IIT (2006). *Retreatment* refers to the preventive selection of a site not potentially affected by alluvial events. *Accommodation* includes all actions and technologies implying that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes elevating buildings on piles or buoyant foundations allowing building to move vertically (English, 2007). *Assimilation* is a strategy characterized by embracing the rising water levels and taking advantage of the resulting opportunities. It includes floating buildings. These strategies are not applicable to the considered case study. These strategies are not considered in the final table with regard to Regional norms because other tools such as town and country planning and territory plan regulate them. *Protection* is a feasible strategy in refurbishment. Possible actions are the use of mobile devices to prevent water to enter the building, as well as waterproofing the parts of the building potentially affected by flooding.

3.4 *Water quality*

The requirement aims at preventing against circumstances potentially dangerous for user's health. *Separate potable/non potable water systems* include all action directed to avoid the risk of using non-potable water for potable use. Legionella is a pathogenic bacterium, which is transmitted via inhalation of mist droplets or dust. Potential environmental habitats within buildings include cooling towers, swimming pools, domestic hot-water systems and fountains. *Avoid the risk of Legionella Pneumophila* collects actions to eliminate the conditions in which the pathogen can live. Many of these actions can be applied to refurbishment.

3.5 *Water saving*

United Nation agency UNDP (2006) spread some facts about water consumption per person: in developed countries it varies widely from a country to another, depending not only on water availability and gross domestic product, but also on cultural issues. Virtuous behaviour toward water saving should be promoted together with *more efficient equipment* consuming significantly less water. Their application in new constructions and refurbishment should be encouraged, as well as w*aste reduction* systems. Garden irrigation can require a lot of water. Proper strategies are *smart landscaping* providing the use of plants that, at the given climate, require zero or less water, more *efficient irrigation* systems and *avoid improper use* of high quality water for outdoor non-potable uses. Strategies for outdoor water saving can be applied easily to the case study.

3.6 *Selection of materials, components and systems*

The *embodied water* of a material is the total volume of freshwater used to produce it. It includes the extraction and processing of raw materials, manufacture of building materials and products, and construction of the building. It is measured in water volume utilized or polluted. According to Crawford (2005) the water embodied in building construction has rarely been considered and the same methods used to assess the energy embodied in buildings can be applied to the issue of embodied water analysis. BREEAM do not directly indicate as a correct strategy to use materials with minimum embodied water, but refers to the Green Guide Calculator rating, which is a measure of overall environmental impacts for materials and components covering many issues including water extraction.

3.7 *Adaptability, functionability and maintenability*

The three main types of benefits associated with sustainable construction are environmental, economic, and health and community benefits. Economic benefits include reduced operating costs, reduced maintenance costs, and increased revenue (Andrews, 2006). The requirement emphasizes the use of easy to access and to maintain systems in order to delay the decline of the performances and augment of costs. *Warning* includes all actions and technologies to detect leakages and malfunctioning. *Allow maintenance* and *allow change* aim at reducing life cycle cost of buildings. They are applicable to major restorations.

3.8 *Reduce site impacts*

Avoid pollution refers to action able to minimize the pollution of surface or underground water both during the construction of the building and during its life.

4 CONCLUSIONS

Further analysis should be conducted to evaluate the upgrade level. Different evaluation technics could be used. According to Manfron (1995) there are various control methods grouped in families depending on the adopted measurement procedures. Among these, two families seem to be especially interesting for the assessment of the above-mentioned strategies. The first one uses *mathematical models* of the physical performance. It can be used for example to determine how many liters of rainwater will percolate through a unit of outdoor paving in a period of time. The other family of evaluation technics is the *judgment method*, which verifies if a specific requirement has been fulfilled, or not. These technics can be used for example to assess if and to what grade the refurbishment design fulfills the exigency to *avoid the risk of Legionella*.

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