Guidelines for Eco-efficiency in the UNESCO Site of Cinque Terre: An Example of Good Practice

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Abstract The paper discusses the results of a recent research focussed on the formulation of criteria of landscape and architectural compatibility to set up Guidelines to achieve eco-efficiency and install renewable energy source applications for domestic or agricultural use in the rehabilitation of traditional rural buildings within the World Heritage Property of Cinque Terre, Porto Venere and the Islands. The research was commissioned by the Regional Directorate of Liguria to the Universities of Genoa and Pavia and faces a new challenge for this type of sites due to the highly sensitive landscape and heritage values in place. Two factors oriented the research: a continuous passage of scale, from the territorial level to building detail and the continuous exchange among specialists within a trans-disciplinary team. The results of theoretical models of calculation of energetic behaviour and requirements applied by experts in Building Physics have been compared with the evaluation of the actual state of conservation of the buildings, with the local conditions of weather and sun exposure, with the data on relative climatology and on superficial and profound geology, with the possible energetic exigencies and with the reasons for heritage preservation and protection so as to select the possible solutions able to respond to all identified needs.

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1 Guidelines for the Eco-efficiency in Sensitive Historic Contexts: A Path Between Technical Awareness and Cultural Appropriation

The World Heritage property "Cinque Terre, Porto Venere and the Islands Palmaria, Tino and Tinetto", in the extreme eastern Liguria, represents one of most renown examples of protected cultural landscape. Thanks to its morphology, to the relatively difficult accessibility and to a protection policy began well before World War II, the territory was spared from the great transformations of the 20th century which have impacted most part of the Italian countryside (Besio 2003; De Marco 2005; Micoli and Palombi 2006).

Nonetheless, since the 1970s, Cinque Terre assisted to a progressive and rapid abandonment of the agricultural activity which had shaped profoundly this territory and given it its character for which it is appreciated worldwide. In parallel, its notoriety as a tourist destination had continued to grow, inducing, as a consequence, innumerable apparently minor transformations to the rural built heritage to meet new comfort and functional exigencies, or just for taste choices. Although modest in size, these widespread modifications have caused evident changes to villages, hamlets and the landscape, through minor or major maintenance/upgrading interventions, which have escaped an effective govern of the territory, despite the control activity by the bodies responsible for landscape protection. With a view to readdress these trends, in 2001, thanks to a special fund for landscape active safeguard projects, the Regional Directorate of Liguria, in agreement with the competent Soprintendenza, the National Park of Cinque Terre and the Regional Government of Liguria, commissioned a research, which was developed by the University of Genoa (prof. S.F. Musso and G. Franco), aimed at drawing up a Guide for the maintenance and the rehabilitation of rural buildings in the National Park of Cinque Terre, published in 2006 (Musso and Franco 2006; De Marco and Musso 2008). This guide contained already first elements to approach the problem of the energetic supply necessary to any type of consumption, a crucial issue in a context which is only episodically reached by the energetic grids.

In parallel, the growing consciousness of environmental issues and the issuing of laws and norms at the national and regional levels promoting the use of systems to reduce energetic consumption and the exploitation of renewable resources encouraged the adoption of technologies which have caused further modifications to the traditional built heritage and to the landscape of the World Heritage property.

Taking into account the increased number proposals of installation of these devices, aiming at ensuring the protection of the World Heritage site and, at the same time, at exploring possibilities of their insertion in ways compatible with the character of both the traditional rural architecture and of the landscape, the Regional Directorate decided that specific guidelines were needed, first, to increase the awareness on the wide theme of energy supply, saving, efficiency and use of renewable resources in existing traditional buildings and protected setting and then to provide an instrument that can assist owners and professionals in decision-making when facing the technical and architectural problems of energetic upgrading.

These guidelines should be read as a specific follow-up of the above mentioned Guide for the rehabilitation and shall become, along with it and other manuals and guides already elaborated (i.e. the Manual for the construction of the dry stone walls—Guidelines for the maintenance of the terraces of Cinque Terre) or yet to be prepared (i.e. in the agricultural and forest sectors), one of the operational tools of the management plan for the World Heritage property. They may also represent useful orientations for other highly sensitive areas within the region, i.e. regional parks, protected landscapes or areas.

The Regional Directorate of Liguria, therefore, submitted a research project to a call for proposals opened by the Ministry of Cultural Property and Activities to allocate the funds made available by the Law n. 77/2006, promulgated by the Italian State to sustain the protection, management and enhancement of Italian World Heritage Properties. The research was approved and funded (72.000 €) and the Universities of Genoa and Pavia (with the scientific responsibilities of the authors, G. Franco and A. Magrini) have been chosen to develop the research and to verify the real applicability of systems for the eco-efficiency of the buildings and of their compatibility with the landscape values. The outcomes of the research constitute the base for the Guidelines by the Offices of the Regional Directorate of Liguria.

Considering the high visibility of the terraced landscape, mostly exposed towards the south and the sea, the most recurrent exigencies and the legal trends pushing towards a simplification of authorisation regimes for small interventions, the Regional Directorate has reputed strategic focussing on individual buildings, first to improve their energy performances and only then to consider the installation of technical systems for energetic supply.

The scope of the research, therefore, has been limited to individual buildings and has not examined the possibilities and criticalities of larger facilities for energetic production with respect to the features and vocations of the territory. In this regard, it is worth mentioning that the Italian legislation in force only permits to select areas not suitable for the collocation of these installations but does prevent to identify the most convenient ones, thus limiting the possibility to orient the localisation of these equipments. However, wide scale planning, in this sector, remains strategic for an effective energetic policy which takes into consideration the vocations of any territory to the use of these sources, with a view to optimize their positioning and to reduce as much as possible drastic alterations to the historic built heritage and to the landscape (Fig. 1).

The cultural heritage sector, which has been slowly approaching the themes of sustainability and of technological innovation, can contribute to a much needed overturn of the objectives and of the cultural references so far adopted in the field of energy efficiency, underlining heritage safeguard considerations beyond resource saving goals, thus stimulating the search of new forms and levels of compatibility. At the same time, the goals of sustainable development and of energy efficiency may become an opportunity to strengthen and to make more specific the objectives of architectural and landscape preservation.

For these reasons, in addition to a survey of the legal instruments in force at the national and regional levels (Baldesco and Barion 2011; MIBAC 2006), attention

Fig. 1 PV cells already installed in the world heritage property

has been given to the most updated Guides for the sustainable conservation of the historic heritage elaborated in Europe and North America (Advisory Council on Historic Preservation 2011; Canada's Historic Places 2010; U.S. Department of Energy 2011; Grimmer et al. 2011; Changeworks 2008; Advice Series 2010; Vancouver Heritage Foundation 2011). This survey has made clear that laying out criteria for the admissibility of interventions represents a methodological issue which requires be resolved in a clear manner, not in a reductively normative or excessively technical way, but grounded on safeguard principles beyond technical feasibility.

On these bases, the work has been developed following some general principles, already adopted for the above mentioned Guide and articulated as follows:

- managing effectively natural resources (rainwater collecting and water recovery through integrated herbal depuration, wind, sun, biomass) in relation to territorial vocations and to landscape compatibility;
- Conjugating aesthetic perception with scientific research, by setting up reliable calculation methods to assess the real energetic behaviour of the target building, which, by virtue of its status, is not to comply with energetic standards but could undergo energetic rehabilitation interventions;
- Ability to verify/repeat necessary energetic audits for buildings within the WH property or to relate correctly to the representative case studies, so as to help the user read the analytical results;
- Adopting simple methodologies, available on the market and economically sustainable, with regard to costs/benefits ratio and to building/installation integrated systems, explaining the most advantageous conditions so as to orient the choice of different installations, including those exploiting renewable resources;
- Maintaining/repairing rather than substituting, especially when installing new technical devices becomes necessary, and hence assuming the conservation of the edifice and its components as one of the fundamental criteria for the admissibility of the interventions;
- Aspiring to a constructive dialogue between technical innovation and architectural enhancement, focusing on sensitivity and creativity, specific of design, and shifting the vision from the mimetic level to one more deeply linked to the values of architecture and of the landscape.

Specifically, the study has been articulated in the following phases, set up at the intervention level scale, from the territorial up to the architectural detail level. These phases have been developed in parallel and integrated as follows:

1. a systemic landscape analysis has been carried out: environmental resources, territorial vocations and sensitivities, settlement systems and the recurrent building morphologies have been examined in an integrated manner;
2. the thermal characteristics and of the energetic needs of the sparse rural built heritage have been analysed and criticalities due to settlement and constructive features have been identified;
3. the technical operations to improve energetic performance of buildings have been identified and architectural compatibility and non-compatibility criteria have been defined to ensure the respect of traditional building features;
4. energetic savings of the adopted solutions have been evaluated and quantified in a combined manner;
5. landscape compatibility criteria have been defined for the insertion of technologies based on the use of renewable resources.

2 Reading the Landscape as a System. Vocations, Territorial Resources and Architectural Quality of Built Artefacts

On the base of the body of knowledge accumulated along the years through previous studies, the research selected some examples which could be considered highly representative of the territorial system, the settlement morphologies (aggregated houses, rural buildings, isolated structures) and the building technologies.

At the territorial scale and for the different settled areas, resources, vocations and sensitivities (orography, exposition, superficial and profound petrology, land use, presence of terraced systems, accessibility…) were examined in order to select the installation typologies most apt to be integrated with natural resources (water, sun, biomass).

In some sample sites analyses of climatic and geomorphologic conditions aimed at understanding the effective applicability of innovative technologies for individual production and energy consumption (solar panels, photovoltaic panels, geothermal or hydrothermal installations, biomass, heat pumps…). Also at this level, more territorial in nature, the importance of landscape and architectural value was taken into consideration. The improvement of the energy efficiency and production for residential use, agricultural or tourist activities was approached in a systemic manner, pointing out the relations among different systems (geo-morphological, climatic, environmental, constructive, anthropic…) and identifying the possible solutions and the consequences of their application so as to optimize the relation among systems and to achieve the most effective mix of technologies rather than maximizing the use of one in respect to others.

At the territorial scale, the most significant public paths and panoramic views were identified, with special regard to famous or traditional views which have become part of the collective imaginary of these places, so as to assess the visual impacts of the most recurrent interventions on the landscape and to outline criteria for the positioning of new technical installations that ensures an acceptable performance and minimizes the impacts on the landscape and on the built heritage.

3 Thermal Characteristics and Energetic Exigencies of the Sparse Traditional Built Heritage

The calculation of the energy performances of the sample buildings was carried out considering the climatic conditions of the localities in which these are located. With regard to the indoor temperature of the target buildings, as requested by the procedures set up by the technical norm *UNITS 11300 part 1—Determination of the thermal energetic exigencies of the building for its summer and winter air conditioning*, a winter temperature of 20 °C, constant along the 24 h, was adopted as project data.

The first two examples are located in Cacinagora, near Riomaggiore, and feature 1,437 Degree Days, in climatic zone D, corresponding to a heating season of 166 days, from 1st November to 15th April (Figs. 2, 3, 4 and 5).

Fig. 2 Case study n. 1 located in Cacinagora. View of the double-cellular building

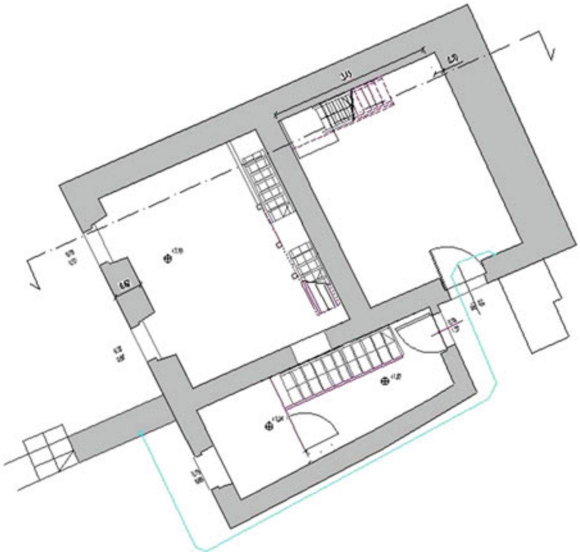

Fig. 3 Case study n. 1 located in Cacinagora. Plan of the double-cellular building

The third case study is situated in La Costa, near Monterosso al Mare, which features a value of 1,321 Degree Days, in climatic zone C, corresponding to a heating season of 137 days, from 15 November to 1st April (Figs. 6 and 7).

For the calculation of the average monthly external temperature, an interpolation has been necessary, as indicated by the norm *UNI 10349—Heating and air conditioning of buildings. Climatic data*, of the data concerning the province of La Spezia, where the municipalities of selected examples are located.

First, the thermal needs were assessed, and it emerged that these are similar for all three cases and depend exclusively from the envelope characteristics, since the three groups of buildings have currently no heating system.

Energy performance index during heating season for building envelope EPHenv [kWh/(m^2 year)] is: in case study n. 1 160,90, in case study n. 2 136,25; in case study n. 3 140,16.

Assuming as hypothesis low-efficiency technical installations, in relation to the examined case studies, the Theoretical global performance index of the buildings has been determined and associated to the energetic class of the building—installation system for winter air conditioning and hot water production, which is presented below with the energy performance index (Table 1).

EPH_{env} energy performance index during heating season for building envelope, it represents the energy needs for the building envelope. EPH energy performance index in the heating season; it represents the primary energy needs of the building-heating system (it does not include the domestic hot water). EPgl global energy performance index (EPH + EPw), it represents the primary energy needs during the heating season for the heating system and for the production of domestic hot water.

Fig. 4 Case study n. 2 located in Cacinagora. View of the multi-cellular building

Fig. 5 Case study n. 2 located in Cacinagora. Plan of the multi-cellular building

Fig. 6 Case study n. 3 located in Monterosso. View of the manor house

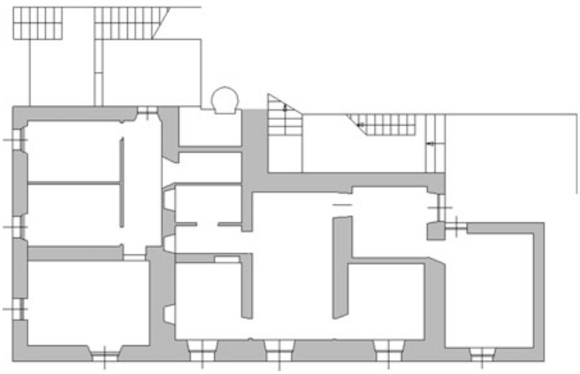

Fig. 7 Case study n. 3 located in Monterosso. Plan of the manor house

Table 1 Energy performance index of the three examined case study. EPHenv Energy Performance of the building envelope; EPH Energy Performance for Heating; EPw Energy Performance for Hot Water; EPgl Global Energy Performance

Energy performance index [kWh/(m^2 year)]					
	EPH_{env}	EPH	EP_w	EP_{gl}	Class
Case study n. 1	160,9	320,5	36,1	356,6	G
Case study n. 2	136,2	251,3	21,8	273,1	
Case study n. 3	140,2	271,8	22,06	293,82	

4 Interventions for the Improvement of the Energetic Performance (Insulation and Technical Installation)

An overview of interventions for thermal improvement was prepared, including the adoptable technical solutions (insulation systems and installations for the production of hot water through solar energy, for the winter/summer air conditioning through heating pumps and biomass, for the production of electric energy and the recycle of rainwater). For these interventions, the impacts on the architectural system—i.e. possible modifications to the constructive system due to the real modalities of application of insulation technologies—were assessed, and their effectiveness, in terms of resource saving, compared to the reduction of volumes and surfaces, caused by insulation systems.

For the critical points of the buildings, source of thermal dispersion and humidity infiltration, the most compatible insulation solutions were indicated and the most suitable technical systems, also in terms of economic sustainability were identified. Alternative combined solutions for the building—installation system were evaluated, through the selection of different types of insulating products and of different thickness (verifying the formation of interstitial condensation and surface mould), and the results were summarised in graphics illustrating, for the alternative solutions, the percentages of improvement for the energetic performance indexes of the envelope.

Departing from an energetic exigencies as high as 300 kWh/(sqm per year), corresponding to an energetic class G, it is possible to achieve very efficient energetic classes if the rehabilitation encompasses integrated actions on the envelope and on the technical systems through the use of renewable energetic resources.

The interventions have a different percentage incidence according to the examined configuration and on the base of its geometric and structural features. In particular, for the multi-cellular configuration (case 2), interventions on the roof result more effective than the solutions foreseeing the insulation of the walls, in relation to the higher bearing of the horizontal surfaces in this type of edifices. On the contrary, for the configurations 1 and 3, the insulation of the walls appears more advantageous, in that they weigh on more on the global envelope surface.

Also in the case of transparent envelopes, substantially different percentage of improvement are registered in relation to the percentage of window surface out of the global building envelope; in particular, substituting the windows with new ones appears more advantageous for configuration 3, which is featured by a window surface wider than the other configurations.

5 Architectural and Landscape Compatibility of New Technical Installations

Finally, the criteria of landscape compatibility for devices fed by renewable energetic resources have been made explicit also through photo-simulation. Compatibility depends on location factors (in respect to the territorial vocations and the panoramic views), quantitative (i.e. if they are isolated or repeatable/aggregated systems, on the base of the covering of the soil or orography) or qualitative factors (i.e. device morphology, its colour, possibilities of visual impact mitigation). The impacts have not been assessed only from a perceptual point of view: also the state of conservation of building materials and systems subject to intervention, and the subsequent possibility to remove decayed traditional materials have been considered, the level of invasiveness of the structure on the ground and on the terraced system. Photo-simulations visualise possible interventions integrating solar technologies with traditional roofing (in case of complete replacement due to advanced structural deficiency, in agricultural or residential service structures, in projecting roofs, in improper existing additions) so as to build the richest picture of possible interventions to be considered admissible, admissible under particular conditions or, on the contrary, unacceptable.

The compatible insertion of innovative technical systems that can be integrated, possibly on added components, rather than on traditional roofs, pose in the foreground the role of creativity, in mimetic, non- mimetic or contrasting forms.

Fig. 8 Photo simulation of the substitution of a plastic shelter with PV glass cells

Creativity can find expression through the design of components that can be easily integrated with traditional architecture, hand in hand with the most recent experiments in the field of new materials, i.e. the production of organic photovoltaic cells, of films or thin wraps that can be transferred on other surfaces through a photographic print process, of photovoltaic elements on flexible membranes, therefore more suitable for the realisation of canvases or added elements (Fig. 8).

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