Technologies, strategies and instruments for energy retrofitting of historic cities.

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ABSTRACT: The buildings in the historical centres of small to medium-sized towns throughout Italy are generally constructed with homogeneous technological characteristics based on their geographic position and have specific cultural values. With regard to retrofitting there is a high demand for the integration of energy saving systems especially in light of the economic crisis.

These elements conflict with the public administration’s responsibility to preserve listed buildings and cultural heritage artefacts and their regulatory. Another issue we have to address is the economical one, in particular the one referred to homeowners’ need to install these systems in order to save on their electricity bill. We need to analyse these aspects because of the numerous variables involved in energy retrofitting operations in historic buildings using appropriate systems and software.

The objective is to define possible guidelines in the field of retrofitting of historical buildings also analysing practical examples and case studies in the Italian territory. In this regard it is necessary to look at the issue from a technical managerial and economic point, taking into consideration the technology used and financial and economic instruments for private sector housing.

1 INTRODUCTION

Minor historical town centres in Italy are characterised by a built and social fabric with common and similar characteristics. Depending on the region, north, centre or south, there are distinctive and common connotations at the architectural and morphological level, which strongly characterise the context of reference and contribute to the definition of a precise identity at local level.

The populations living in minor historical town centres consist mainly of the lower middle and middle classes. The average user group of small towns, which at one time were much more homogeneous in terms of social and cultural characteristics, today has connotations that are very different due to the migration that has taken place the towards small towns from the major cities by the middle class who once resided in urban centres but who have been progressively impoverished by the economic crisis. This population, no longer able to bear the costs and dynamics of the big city, find in small towns a more comfortable and affordable place to live.

The built heritage of the small towns, while often retaining valuable characteristics in terms of cultural and landscape value, does not respond adequately to the needs of energy efficiency required by current legislation. These are buildings, above all with reference to residential buildings, which also require periodic and widespread maintenance.

Over the past decade, because of the evolution of the environmental emergency, there has been an increase in the number of households that pay particular attention to the issue of energy saving and the containment of consumption, as well as to the production of energy from private plant for their own exclusive use. Thanks also to the incentive system introduced in Italy, the dissemination of technologies related to solar thermal and photovoltaic has seen a major growth in recent years. This growth has also involved a greater awareness on the part of the middle class regarding the issue of energy production. A growing interest has also involved the resident population of the historic dispersed fabric of smaller towns, especially with regard to the possibility of installing solar thermal and photovoltaic plant, about whose benefits in terms of saving energy and money, the average user has gradually acquired more and more information.

The willingness to redevelop, also in terms of energy, the built heritage of the historic centres is contrasted, however, by the difficulty in being able to make a choice about what is the best solution.

Different aspects contribute to this difficulty, resulting from the intersection between the peculiarities of the building fabric in question, the characteristics of the resident users and the solutions proposed by the operators in the market. To this is added the limitations imposed by regulations from the public administrations in terms of landscape protection, which tend to preserve the heritage of the historic centres from high-impact operations in a general sense.

2 HISTORICAL DISPERSED BUILDINGS IN ITALY AND THE QUESTION OF ENERGY ISSUES

2.1 *Protection and energy retrofits*

The housing stock of the dispersed historic centres in Italy is generally composed of buildings with important characteristics from a historical and architectural point of view, and is constrained by the tools of landscape protection insofar *as it is a complex of buildings that form a characteristic view that has aesthetic and traditional value* (Article 136 Legislative Decree No. 42/04 - Code of Cultural Heritage and Landscape).

From this point of view, the activity of protecting historic centres, as stated, for example, in the technical norms of implementation of the Landscape Plan of Lazio Region, is directed at the maintenance of "*the physical integrity through the conservation of the heritage and historical fabric and of the views to and from the old town centres also through the prohibition of transformations which are prejudicial to their safeguarding*".

With reference to operations of energy retrofit, this notion of protection involves the prohibition of a whole series of operations of installing technological systems of a visible type for energy saving.

These devices, in fact, involve a visual intrusion on the building which, if not controlled, might lead to a depreciation of the overall image of the historic town centre as it has been established over time.

The urban fabric of these settlements (minor historical centres), in fact, still has a strong historic and architectural value due mainly to their typological constructive characteristics and obviously unitary materials and which are still clearly evident and of strong visual impact.

The type of construction of houses is that which is typical of the Mediterranean area, characterised by buildings of medieval origin, with a masonry structure which can also be irregular, sometimes with conserved facing with high thermal inertia with wooden roofs and wall tiles.

The chromatic and material totality of construction materials and finishes used provides that identifying character of the historic centre that leads the authorities responsible for their protection to assume conservative attitudes and strong suspicions regarding the installation of the most widespread technological devices: photovoltaic plant, micro windmills or solar collectors.

The demand for technology implementation for the purposes of energy saving by users in fact requires the presence of high-impact technologies both from the point of view of visual intrusion and the storage of the technical elements of the building to which the regulatory instruments of protection recognise a documentary value and which, in retrofit operations, could be replaced or partially modified.

Upgrading energy efficiency in these settings, which make up a large part of the inhabited fabric of our country and which, in recent years, because of the economic crisis, have seen a substantial increase in population, it is not supported by any regulations specifically regarding energy retrofitting.

The tools of landscape protection provide only sparse and generic information without any guidance on the most appropriate technological choices.

To this has to be added that the few indications in national legislation relating to energy savings and energy upgrading of existing buildings, in the case of listed buildings, only provide the possibility of derogation from the requirements of the law.

This is an operation that relegates the requirements of energy saving, compared to the protection of the building, and allows for a wide margin of discretion on whether or not to adopt such systems.

The result is that the authorities responsible for the protection do not accept the insertion of visible plant in historical contexts and proposals are in fact delegated to the sensitivity and training of the professional planning the retrofit project.

A planner who does not always possess valid tools to assess the alternatives available.

2.2 *Building and users. Typological and constructive characteristics in relation to the energy issue*

Following the widespread recognition of the urgency of environmental issues, the concept of energy efficiency and energy upgrading, is interpreted and altered in architecture as a fundamental prerequisite and goal to be pursued. A renewed design is required now that is able to ensure indoor environmental quality through the means of technical-innovative construction.

By energy-efficient building what is meant is a building structure that can guarantee inside a state of wellbeing and in which, by minimising the use of non-renewable energy sources, the achievement of thermal-hygrometric, acoustic, lighting comfort and indoor air quality, are not delegated exclusively to the plant, but are obtained through appropriate environmental, typological and technical-constructive solutions.

The awareness on the part of an increasing number of planners and users of the urgency of environmental and energy issues has allowed, in recent years, the building and redevelopment of buildings with high energy efficiency. This is the result of a slow cultural evolution, which began in the late '60s, with the first solar buildings, and developed over the years, up to the development of integrated design strategies, innovative technologies and high-performance envelope systems.

It is essential today to focus above all on upgrading the energy efficiency of the heritage of historical buildings that too often and for too long has been neglected and which are in need of "progress" in energy terms precisely because they represent a large-scale reality in many Italian cities.

In fact, the movement of people into buildings of the historic fabric, with the encouragement of the incentives provided by the various editions of the Energy Account, has led to a growing demand to include systems for energy saving in traditional housing.

We must therefore consider a type of user which is profoundly changed and diversified compared to the one that has been present until today. In fact, in Italy as in most of Europe, research has been conducted and pilot projects carried out on the redevelopment of the residential social housing stock, in many cases on publicly owned property. The field of social housing has been the subject of experiences and experiments for several reasons: to try to provide a solution to a problem of obvious social emergency, for the possibility to manage the redevelopment of the built environment with a single large owner, avoiding the obstacles arising from the fragmentation of the property, to make it easier to try technological and managerial solutions in the absence of historical restrictions.

In fact it should be noted that the stock of historical buildings in our country has in many cases similar characteristics, whether referring to multi-purpose building or diffuse residential housing, and these similarities can be found not only in the morphological-constructive characteristics, but also in the characteristics of the user group of reference.

It is a fragile though solvent class, that which acquires bargaining power in small towns but lives in conditions of economic hardship in large cities. This type of user, who makes up the new lower middle and middle classes in the Italian social fabric, is characterised not only by cultural and social heterogeneity, but it is united by the need to reduce their energy costs.

Reducing energy costs also involves rethinking the way in which the energy service is offered. This question should deal with the capability to choose the technical and technological solutions, the means of operating the service and the related economic and financial aspects, with the most appropriate choice, which too often translates into measured and timely interventions usually resolved in the replacement of traditional fixtures in favour of others with high energy performance, the installation of solar collectors and photovoltaic panels.

These interventions are designed as plant operations to be superimposed on the building and not as operations of upgrading energy efficiency that can provide the same with added value especially from the point of view of architectural quality.

The desire to pursue energy efficiency at all costs has often led to solutions of low architectural quality and the standardisation of building types that are correct from an energy point of view but architecturally not very convincing or effective.

The trends in the construction industry can be divided into two types:

a) that of current building, which sees the integration of elements and plant systems in the envelope or façade. In these cases, the solution most often adopted for upgrading interventions on the built is that which sees the inclusion of photovoltaic panels or solar collectors, with scant attention to architectural quality;

b) that relating to high-level design experiments of exemplary value, where the quality of the experimentation goes hand in hand with architectural quality.

The challenge for today's architecture in the field of upgrading energy efficiency is not to be limited to the application of energy-saving systems through added installations, but the declination not only in terms of technology and performance, but also artistically and figuratively.

3 INSTRUMENTS AND TECHNOLOGIES FOR ENERGY SAVING

3.1 *Materials and innovative technologies for energy saving*

In the setting of diffuse historical buildings the intensification of the activity of redeveloping and "management" of the real estate stock in terms of energy efficiency, sustainability and urban well-being measures the real regeneration of city centres; activities which are flanked by interventions of conservation or restoration for those contexts of particular value which are affected by restrictions to protect the landscape. An approach to the project which is as attentive as ever to the energy upgrade of buildings but which, at the same time, suggests a protection of the particular cultural value of those nuclei of urban settlements of high environmental quality and historical importance.

Finding ourselves operating in the area of the life cycle of historic buildings, the success and difficulty of the project thus consist in the ability to communicate with the technological and plant qualities that that the building already offers and which, in each case, will be preserved, enhanced or integrated.

The multiplicity of adaptive interventions on existing buildings affects different parts of the building and today has to deal with today, in compliance with the current regulatory framework, solutions, methods, technologies, innovative materials and certification systems that redefine, in a new synthesis, the concept of quality in the planning intervention.

The interventions aimed at enhancing the energy efficiency of historic buildings can be traced to three main operational strategies that can simultaneously find a reference both in the market for new constructions and renovation. In particular:

1. Reduce heat exchange with the outside of the building and reduce energy consumption and non-renewable natural resources;

2. Introduce innovative plant components with a high technological value, low enthalpy and which serve as sources of renewable or recoverable energy for the functioning, production of heat, heating and cooling.

3. Adopt technical solutions, materials and certified products that meet the requirements of the environmental and energy certification protocols, and that represent the quality parameters measurable by the quality achieved and the sustainability of the construction.

The first category refers to the adoption of all the technical solutions for the building envelope provided by the current construction market, which can improve the thermo-hygrometric characteristics of the vertical and horizontal, opaque or transparent components which bound the heated volume.

The recent Legislative Decree no. 63 of 4 June 2013 transposes European Directive 2010/31/EU on the energy performance of buildings, the so-called “nearly zero energy building” Directive.

Altering Legislative Decree 192/2005, the Law by Decree introduces the new national methodology for calculation and the minimum requirements for the energy performance of buildings, and provides for facilitations for energy upgrading that involves existing buildings of all cadastral categories and those interventions that enable the achievement of an annual energy demand for winter heating not exceeding the values defined by the Ministerial Decree of 26 January 2010.

The activities of addition and substitution indicated in the Decree define the different operative strategies that can be pursued, while the distinct performance responses are defined by the climatic zone in which the building is situated. According to different design assumptions it will be possible, on the one hand, to define the modalities of integration and the thickness of new insulation in the facades, envelope and intermediate floors, and, on the other, to move to the replacement of windows that do not satisfy the transmittance values required by national regulations.

The particular connotation of certain historic buildings and their intrinsic cultural value directs the creation of false internal walls through dry solutions involving the juxtaposition of plates glued or attached to a frame that incorporates a layer of insulation in the cavity thus formed. This solution favours the respect of the existing architectural external image without having a significant impact on the existing structures which in this case would not be significantly stressed. A disadvantage would be a partial reduction of the internal areas and the limited elimination of thermal bridges on the façade. In the case of deterioration of the external surfaces it will be possible to replace only the exterior plaster and individual decorative characteristics of the façades without distorting their original impact on the context of their setting. A worthwhile alternative technique to the internal false wall is instead the realisation of a ventilated external “coat” consisting of an exterior insulation and a ventilated air chamber inside a substructure of stanchions and beams which support the lightened concrete slabs of the exteriors. The slabs are reinforced by a glass fibre mesh and subsequently have a thin plaster finish applied, not unlike the original traditional solution.

On the envelope, the usual maintenance of the protective mantle, or of the coverings in the case of inclined envelopes, can be combined not only with the increase of insulation, but also to the realisation of a layer of ventilation which considerably improves the level of thermo-hygrometric comfort of the closure without changing the surface appearance.

In the absence of specific landscape restrictions, national regulation provides for the possibility of intervening with the demolition and partial or total reconstruction of buildings allowing a total redefinition of the technological choices for the envelope and the structures; this last solution is clearly an intervention of great economic significance.

In both cases, different financial arrangements, updated annually, provide incentive formulas for building interventions aimed at improving energy efficiency of existing buildings through the partial tax deductibility of the costs incurred. The facility consists of a deduction from the gross, both IRPEF and IRES (personal and corporate income tax), of an amount equal to 65% of the costs incurred up to a maximum of €153,846.15.

Among these interventions is the adoption of plant solutions listed in the second category above. The most widespread example is that of the integration of solar panels to produce hot water or photovoltaic panels and amorphous films for the production of electrical energy from the envelope, or the replacement of all or part of the winter climate control systems with plant with condensing boilers. The special character of the settlement context and the precarious economic conditions of private individuals do not provide for easily implemented energy generation solutions on an urban scale which instead would allow a substantial reduction in the cost to users for energy and would reduce the impact resulting from the installation of solar collection modules.

This solution, although desirable, requires financial planning and a significant amount of initial expenditure that can be sustained only by enlightened public operators, or private monopolies attracted by the effective convenience of the intervention, along with financial support for the total reconstruction of energy distribution networks which would only be only sustainable with substantial financing.

Interventions on the energy efficiency of buildings are in general accompanied by the introduction of solutions that take into account the sustainability of the production process.

Through energy and environmental sustainability certification, the principles of environmental sustainability translate into a significant opportunity for the renewal and transformation of normal building practices both in the planning stage as well as during construction and operation.

In light of this new opportunity, businesses - at a time when the market has significantly shrunk - are called on to invest in the research and development of products targeted at energy and environmental sustainability, products and building systems that use natural or low absorbed energy materials for which it is fundamental to attest to their objective certification of conformity and environmental quality.

4 THE MANAGEMENT OF THE ENERGY QUESTION THROUGH GIS SYSTEMS. PROBLEMS AND POTENTIALS

4.1 *Management and control of GIS data at the level of building and territory*

The management of a problem of energy supply cannot be separated from an initial assessment the needs and capacity or cost of the supply itself. It can be deduced how the possibility of producing in situ energy is the most economically advantageous solution that has least impact on the urban fabric. The problem remains of the protection of the built, both from an aesthetic point of view and from a static/structural one to evaluate the effective residual bearing capacity of roofs in the specific case of photovoltaic systems.

The first step for a geostatistically correct approach, which allows the creation of an efficient tool for the evaluation of the economic viability of the project and the design itself, is to inventory the data related to a building with indices that describe its structural state and energy requirements (also in relation to the period of the year).

The same approach will have to be taken with the existing network of energy distribution, considering the technical-economic possibility of a hypothetical strengthening to satisfy the needs required.

At this point it is possible to map out the condition of needs and capacity to procure energy for a core of buildings; whenever a condition of homogeneity between adjacent blocks of buildings occurs it will be possible to assess the problem in a unique way, ensuring uniformity in the design to the advantage of the planning cost-quality relationship.

The basic idea is to avoid the spreading out of mini plants scattered over a number of roofs, without an idea of overall design, and evaluating the possibility of using surfaces even if they are not present in the immediate vicinity, taking advantage of existing networks and logistics.

The methodology of work follows a survey of the multicriteria type managed through a GIS tool that will compare data derived from the analysis. The data brought into play in the proposed methodology will have to be summarised and correlated in line with exacting processes of reading and archiving.

The choice to work with a geographical GIS database stems from its ability to use different tools for the cataloguing and numerical management of the building that is subject to the intervention. The system allows spatial operations on multiple data that define an area of land, evaluating them together with data for aesthetic-landscape, historical-economic, demographic-cultural, and technological aspects, without of course neglecting all the regulatory and restrictive aspects present.

The proposed spatial database combined with a set of spatial functions and algorithms that will be designed and created in this project will allow the creation of decision-making models which will not be conditioned by the background of the “decision-maker” thus lowering the risk of subjective error, which very often is recurring in a subject.

The goal is that of creating an IT support that systematically analyses the data that characterise a problem, proposing a series of alternative solutions arranged according to values and weights strictly dependent on the context under analysis.

5 CONCLUSIONS

Retrofit operations on historical buildings have been conducted to date with isolated interventions and solved on a case-by-case basis. The result of these experiments is an extensive array of literature on the solutions of wall insulation and sealing glass walls, but little attention has been paid to large-scale management and of large segments of urban centres and, above all, the complex management of data and the variables involved with appropriate IT tools.

The assessment that is made on the intervention on the built was said to be related to judgments characterised by a high degree of uncertainty. What “is beautiful” or “architecturally correct” on a historical building is a judgment that is difficult to support with objective parameters.

We can measure the degree of efficiency of the plant and its cost, but which parameters and instruments that might be used are best suited to support the judgment of the technicians involved? The purpose is to create a useful tool both for users and public administrations in order to measure and therefore assess the level of compatibility between the need to upgrade the urban centre energetically and to safeguard its special characteristics in terms of consistency and documentary value.

This instrument has to provide the ability to effectively assess, in quantitative as well as qualitative terms, to what extent the introduction of elements and technologies for energy efficiency impacts overall.

Overall impact means not only understanding to whatextent the historical asset is changed in a negative sense (considering the impact of elements that are not in line with the nature of the asset in terms of visual appearance, etc.), but also emphasising to what extent the introduction of the changes are a reason to enhance the asset for a variety of reasons.

For this reason, both aspects (data) regarding the energy efficiency implementation as well as those relating to the aspect of the protection of the asset will be compared, in an attempt to understand which is the ideal point of intersection between the two.

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