ENERGY EFFICIENCY AND RESTORATION IN THE HISTORIC CENTRE OF FERRARA, A VIEW BETWEEN CONSERVATION AND PERFORMANCE

K. Ambrogio[1], M. Zuppiroli[2]

ABSTRACT

Energy retrofit of existing buildings, as is usually defined, is a widely debated issue in literature, either both scientific and popular works.

The first part of this paper focuses on energy retrofit of existing building and presents a historic and critical digression of the cultural and normative approach, with special attention to its consequences on pre-industrial building. The energy intervention cannot be promoted in terms of transformation and adaptation that is incompatible with conservation. It is necessary to promote it as an enhacement with practices and limits similar to the current ones, e.g. the reduction of seismic risk. The core part of this analysis presents various models applied to built-up areas of Ferrara's pre-industrial building, as an example of a historical city that can be widely compared with others in Italy. This analysis is followed by a description of architecture, plant and functional characteristics of Ferrara's buildings, here defined as "factors related to the pre-industrial building energy behaviour", of which we will analyse the characteristics, the energy limits and the intervention possibilities, in terms of conservation compatibility, also in relation with the different building typologies in which they are prevalent. This description in conceived as a template for a "Guideline for energy efficiency improvement".

The last part presents a range of tools, ranging from the assessment models of large building parks (bottom-up and top-down) to quick models based on the UNI/TS 11300 calculation method, which are useful in order to manage building transformation, both at a national, regional and municipal level. These data may be useful both for the allocation of public financing, for restoration and building maintenance, and the urban regulation of each Municipality, in order to regulate interventions on historic buildings.

Keywords

Energy efficiency, historic building, conservation, urban restoration, quick assessment model, planning scenario.

1. Introduction

The present study falls within the framework of research on the urban history of Ferrara, or, more specifically, on the identification of the morpho-typological processes of formation and transformation of the urban and building structures that characterise it., The research started in 2006 inherits the experience carried out in other territorial settings by Professor Riccardo Dalla Negra and is testament to the creation of a work group coordinated by him and that has led, in recent years, to some important results in the interpretation of the formative and transformative processes of the city of Ferrara, in part described and currently being finalised [1].

Within the operative practice of energy retrofitting of existing buildings, as it is generally called, the lack of understanding of the existence of differences within buildings, in terms of materials and construction techniques, generates a widespread and senseless replacement of traditional components - particularly the building envelope - without concretely improving the energy performance of the building.

The main objective of the research is to promote the realisation of energy efficiency upgrading interventions of historic buildings combined, within the restoration process, with a view of improvement and not adjustment, that is, by balancing the needs of conservation and those of performance.

The degree of unacceptable alteration of the character or appearance of pre-existing buildings, before European legislation [2] and, only later, National [3], as discriminant for the application or not of regulatory requirements relating to energy efficiency, is here declined in terms of physiological limit of transformation. If the European and National regulations talk, in particular, about alteration of "historic or artistic characteristics", our study supports the need for an extension to the constructive and typological characteristics, such as basic illustrators of the token value of basic historical building.

The study, divided into two further investigations, identifies, on one hand, the factors determining the energy performance of the historical buildings of Ferrara and, on the other hand, elaborates some assessment models at urban scale of the current consumptions, following some hypotheses of intervention proposed only as examples.

2. The decisive factors of energy behaviour

We have defined the key factors that determinate the energy behaviour of the building, those architectural and use aspects

1 Superintendence for the Architectural and Landscape Heritage of Ravenna, Italy, keoma.ambrogio@beniculturali.it
2 CNR - ITABC, Italy, marco.zuppiroli@itabc.cnr.it

that have their own specificity in the context of the building and its scopes, but that also relate directly with the given environment. In each of these factors, therefore, technical or planning features that affect the total energy behaviour of the building in different ways can be recognized. Read in their totality, they end up describing the entire historic building, though focusing on specific details.

The division proposed aims to separate the three major components in the planning of the building and its relationship with the environment: geometric-constructive factor, use factors and technical-design factors. Within each category of factors, further sub-categories that group different families of technical or planning aspects have been identified, relating to the scale of analysis of the problem. The individual factors have been described by a textual data sheet, divided into the following fields: summary of the characteristics and of the key aspects (size, materials and construction techniques, changes over time, bibliographical references), degrees of integration/alteration, energy characterizing conditions, categories of interventions for improvement of energy efficiency admissible/inadmissible (describing briefly the salient features, the cost/benefit ratio and the degree of compatibility, with reference to the UNI/TS 11300 standards and correspondents) [4].

It should be noted finally, that energy retrofit of existing historical buildings cannot be conducted without deep knowledge of all the characters of the construction. The partial operation and reductive tendency of improving the efficiency of the single technological element, without having a clear overall knowledge of the building functioning, does not appear desirable, as is instead required by the law. Therefore, the factors described are primarily aimed to providing a guide to understanding the many and varied aspects that characterise historical buildings. Only with this knowledge a conscious planning solution may be chosen. An overall functional balance must be found within the building, restoring performances that are proper to it and introducing new ones, without forcing the architecture with incompatible and invasive measures of thermal insulation or system improvement, arbitrarily chosen.

2.1 Geometric-constructive factors.

These characters relate, on one hand, to aspects of constructive nature mainly taken into account in the intervention of performance improvement, on the other hand, issues related to the shape of the property and its morphological relations with adjacent structures.

2.1.1 Aggregate system-building.

The aggregate system-building collects the set of form and organisational distribution factors, related to compositional aspects derived from the processes of urban development and saturation. Therefore, those elements or characters of the historic buildings actualise as a result of a spontaneous process of growth and addition of parts, but they are also determined by several conditions: the location, the neighbouring architectural situations, the needs of the ownership and so on. These are factors that relate not so much as technological but more as compositional aspects, which are however a close relation to the energy efficiency of the building. The geometric-constructive factors related to the aggregate building system are: solar orientation, volumetric compactness, hallway, staircase (communal), covered balcony/porch, balcony, terrace, attic room, courtyard, light well.

2.1.2 Construction system.

The construction system collects the set of technological factors relevant to the mere structural aspects of the building. Therefore, it is one of those groups of technological units that are characterized by particular materials and execution techniques derived from a long process of experimental sedimentation. The technological solutions and finishing are very diverse in the different historical periods that have characterized Ferrara's architecture. But these variations, especially in the attics and roofs, also arise in relation to the lack of availability of raw material, wood, and costs of sourcing and processing, which lead to different profiles, depending on the context and the type of building in which they are placed. With the description of these factors and of their extreme fragility and expressive variety, one of the key points of the intervention to improve energy efficiency is developed: the integration of the casing with suitable insulation systems. The geometric-construction factors related to the building system are: perimeter wall (bearing wall), panel wall (between separate housing units), slab on-grade, slab between floors, ceiling, roofing (Figure 1).

2.2 Technical-structural factors

Unlike the geometric-constructive factors, they are no longer essential elements from the compositional or constructive point of view, or as technical elements produced and completely set up on the building site. They are components that can be produced outside the site and that meet industrial or proto-industrial performance requirements. They are installed to ensure the environmental features of the building that would not be otherwise fulfilled, such as heating in the winter, night light, etc. We could say they are dynamic elements, as they can be managed in different ways, activating them or not, increasing and decreasing the flow rate of the fluid, or managing them in function of the climatic variations and surrounding conditions.

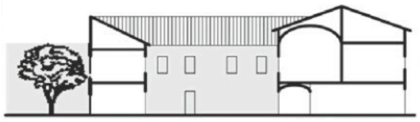
2.2.1 Finishing works.

The first family seems to direct, more precisely, to the morphological and construction aspects of the building, so in the Restoration discipline they are traditionally placed among studies regarding the construction side of buildings. However, according to the characteristics of these elements, to the construction process that produces them and to the dynamic use that is made of them, they are to be considered, for energy purposes, like a plant engineering system, acting to mitigate the environmental conditions surrounding the building. The plant engineering and technical factors related to the finished works are: front door and exterior door, window frame and window, blinds, door, roller shutter, shutter, awning (internal/external).

A.a.9. Courtyard/Garden

Courtyard | *an open space, included as a whole or in part between the buildings of a construction; the primary purpose of the courtyard [...] is to provide air and light to various parts of the building.*

Garden | *plot of land artificially organised with the use and regulation of natural elements.*



UNI/TS 11300-1:2008

2. Ventilation
14.4. Shading

DESCRIPTION

The presence of various types of private open areas is a characteristic of the urban fabric of the city of Ferrara, especially in the contexts of the more recent construction expansion or saturation, as in the areas of the various additions, where there is a less dense urban aggregate with a mainly residential character.

By definition, the courtyard house is characterised by the presence of a large courtyard, at the end of the lot or in the centre, in accordance with the parcelling that occurred over the centuries. Normally, the building to be configured encloses the courtyard in a C or L formation, creating a primary paved courtyard area and a secondary, more free, landscaped one, even including the addition of trees.

In the same way, in multi-storey buildings, which is not as deep and is more regular, the courtyard occupies the whole rear of the structure, up to the boundary wall.

In terraced or altered terraced houses, instead, there may be multiple open space solutions, which are all of limited dimensions, often deep and characterised by a predominant paved finish. In these cases, the courtyard is enclosed by boundary walls or adjacent buildings, and primarily performs the functions of aeration and lighting.

In principle, the courtyard has the function of airing and ventilating premises, especially if these are cramped or confined within the urban fabric. As it corresponds to a closed, very small area, well protected from the sun, it ensures that indoor temperatures are milder, especially in the entrance hall and stairway connected to it. Instead, sunny courtyards favour the growth of vegetation, even trees, that can provide shade to the building, as long as the species used are correctly evaluated (deciduous trees, which are typical of the area, are the most recommended for their dual role during the two seasons).

DEGREES OF INTEGRATION/ALTERATION

In its configuration of space and composition, the courtyard does not normally include geometric alterations because it is an enclosed, configured space, that cannot be encumbered, in its overall interpretation, by new objects or technical elements. Therefore, the only acceptable interventions concern correct water run-off and the ventilation of the premises overlooking it, in addition to the maintenance of trees.

In the same way, the garden's components should be preserved, since in addition to allowing the building to breathe and making it comfortable, it helps freshen the air during summer. Interventions concerning the implementation or modification of the vegetation that, where necessary for specific environmental specifications, let sunlight through during winter and provide cover against it during summer, are allowed.

ENERGY DISORDERS

From an energy standpoint, the courtyard does not present particular disadvantages in thermal behaviour, except for increasing the outer surface area, when the latter takes on very complex planimetric structures.

The presence of the garden or bad water run-off can affect the relative humidity of the surrounding openings and lead the water vapour to creep up the masonry.

TYPES OF IMPROVEMENTS

The principle that should be followed in the courtyard or garden, is the maintenance of the good functioning of water run-off, to prevent water and humidity from stagnating by soaking into the walls.

In the case of large gardens, which offer freedom of planting, and with extremely windowed façades, it is possible to include the planting of deciduous trees that can counteract the undesirable effects of excessive sunlight and, at the same time, allow spaces to be warmed by sunlight in winter.

B.a.1. Main Door and outer door

Door | *wall opening to allow entry and exit; if it has monumental value, it is called* a maind door. This term also indicated the moving panel with which the opening is closed.

Main door | *outer entryway, more important than the common entryway in terms of dimensions, functions.*

Frame | *fixed part of the finished work, that closes an opening, anchored to the elements that outline the opening: jambs, lintels and threshold. The frame is composed of a stable framework, to which a mobile part is connected, called counterframe or window frame.*

UNI/TS 11300-1:2008

5.2. Calculation of heat transfer
6.1. Data concerning the typological characteristics of the building (orientation of housing components)
6.2. Data concerning the thermal and building characteristics of the building
11. Heat transmission parameters
12. Ventilation
14. Thermal contribution of the sun

DESCRIPTION

In traditional Ferrara constructions, the main door is always in solid wood, with one or more panels depending on the size of the doorway.

In many cases, given its direct connection with the hallway opening, the main door is equipped with a transom. It is probable that the latter, which on the outside features an iron fan-window, was not originally equipped with any window frame, as it corresponded with an open environment, the hallway or loggia. However, in its current form, it is normal to find a glass window, which may also be opened, to allow a more flexible use of this element. This transom, from a figurative standpoint, was for resolving the presence of the arched fanlight placed above, in the arch that marks the opening, and to distinguish it from the rectangular panels of the main door. In contrast, in palatial buildings, the wooden panel is at full height. Following an intense substitution of main doors, typical of basic buildings, very questionable solutions became widespread, with iron, sheet metal, aluminium, even with all-glass, albeit opaque, panels being used to increase interior lighting. This latter aspect is increased by the diffusion of transformations to ground-floor end-use, where studio flats and two-room apartments were created, for which a minimum level of lighting is required and is not ensured by windows alone.

Normally, the main door is not in direct contact with the real estate unit, but opens to the hallway or the stairway.

The main door is an element of protection and separation, for preserving internal climactic conditions over the varying external ones.

Lastly, the transom can also be used to ensure a minimum of ventilation to the hallway and stairway.

DEGREES OF INTEGRATION/ALTERATION

A wooden door must undergo restoration, without modifying the opening mechanism, the elements and materials.

An already substituted door, made with incongruous materials such as steel or glass, conversely, may be substituted again, as long as the new substitution is in wood.

ENERGY DISORDERS

The main door may have air leaks, due to the absence of perfectly airtight joints and natural misalignments that the element can suffer over time. However, this aspect becomes significant only in cases where entry occurs directly outside the house, without apartment complex or private filter openings.

In the same way, still in the most unfavourable conditions and due to the reduced airtightness, it can be an element of appreciable heat loss. Especially when wooden panels are substituted with iron and glass ones.

TYPES OF IMPROVEMENTS

In the case of an original main door, opening to a non-climatised apartment area, it is believed that the only allowable interventions are maintenance, especially in the transom frame (where there is one) to ensure it can be opened during summer.

In contrast, in cases of complete substitution with a main door that is incongruous due to its typology and materials used, and especially in cases of substitution with a glass main door, substitution should be employed, as long as the new element is in wood or is coated in wood.

Figure 1 Example of some factor description

2.2.2 Proto-systems.

With this group of factors we start to get to the heart of those more typically denoted as plant design systems, used to create an environmental wellbeing inside the house. The so called proto-systems are those energy devices (dynamic) or those that allow to satisfy the deficiencies of the building, carried out together with the construction of the factory (such as chimneys) or through handicraft production (stoves, ovens). The technical plant engineering factors related to the proto-systems are: chimney or fireplace, stove, oven and cooking equipment (Figure 1).

2.2.3 Industrial systems

With this last category of technical plant engineering factors, we reach the core of a very important chapter of the facility plants of buildings: the summer and winter air conditioning systems are factor with numerous consequences in the evaluation of energy efficiency. These elements have been defined industrialised systems to distinguish them from the proto-systems, from which they have completely lost the character of spontaneity and craftsmanship that characterises the first to acquire an ever more specialised role, typical of industrialised products. The technical-plant engineering factors related to industrialised systems are: heat pumps for winter periods, summer air conditioning systems.

2.3 Use factors.

In this latter group additional factors that influence the energy performance of the building, related to the use of the same, have been classified and described.

In particular, it is believed that the two aspects that need to be taken into account and that must definitely be re-established when living in a building are the correct assessment of the intended use and the management modalities of the building.

2.3.1 End use.

The buildings of the historical centre, especially those located along the main arteries, are subject to a multi-layering of uses, as in ancient times. The energy relationship, which these conditions of use can lead to in relation to neighbouring housing units, are connected mainly to aspects of climate control and, therefore, possible heat losses between the sides. Each type of use involves different modes of air-conditioning, due to the exposure time, the usage period and the temperature, conditions that can encourage or discourage the thermal stability of adjacent units. The use factors related to the category of intended use of buildings are: residential, commercial, service and occasional use.

2.3.2 Managing the building.

In this last family of factors the behaviours adopted by the users are grouped. This can lead to positive exploitation of the resources of the building or cause a waste of energy because of poor distribution. The observations contained in the data sheet should be read in the context of an open book of good practice. The use factors related to the management of the building are: air conditioning, ventilation, automated control (home automation).

3. Models of rapid assessment of energy performance.

The localised energy policies that an administration is able to put in place, can involve more or less directly, all actors operating in the area: citizens (homeowners, consumers, service users), public authorities and private companies. The tools that a local authority can use to achieve the objectives in terms of energy saving, can go from the energy Audit of the Sustainable Energy Action Plan (SEAP), to the Regulations adaptation (RUE, waste, etc.) to the provision of financial resources aimed at achieving certain results.

The financing choices, just like the energy policies, require the identification of long-term strategies that cannot be separated from a careful analysis of the possibilities of self-financing and residual capacities of administrative debt and prior evaluation of costs/benefits, tied to the return of investment of the investment itself. Precisely due to this reason, it becomes essential for local authorities (regions, provinces and municipalities) to know the energy behaviour of their building park.

In an attempt to quantify the energy requirements at different levels, numerous models have been prepared. At macro scale, among the first used, we find those that report directly to consumption data developed at regional or national scale. At micro scale, we find the models aimed to the determination of cost/benefit relationship with reference to precise types of intervention. More complex models are able to integrate the analysis of data coming from different sources. The information required for a micro-scale modelling requires a substantial degree of detail, therefore, a more in-depth analysis of the building or buildings in question. The exponential increase in the cost of implementation and the consequent reduction of the scope of investigation make excessively detailed models unusable. It is necessary, primarily, to focus on the purpose and, secondly, to provide an evaluation model that, on one hand, allows sustainable time and costs, and, on the other hand, grants comprehensive coverage, including sample checks, of the entire field of study.

In general, there are two large families of models: top-down and bottom-up [5].

With the top-down method the sample is investigated on an extended basis with regards to the object of study. The expression top-down indicates a view from the top (top to bottom), to encompass the entire set of elements contained within the object of investigation, with respect to which it is possible to express the data in aggregated or non-aggregated manner. Top-down information is used for strategic purposes: to target intervention policies and actions, or to verify the same, or to locate a benchmarking value.

Equally, in the case of assessments with bottom-up method the sample is studied on a partial basis. The expression bottom-up indicates a view from below (upwards), with a precise selection of elements within the object of investigation. In turn, the data may be aggregated or non-aggregated. Bottom-up information is used for planning purposes for the adoption of corrective or improvement solutions compared to benchmark values.

Within the assessment models with top-down method, the possibility of calculating the primary energy requirements and the index of energy performance of a large portion of the city centre of Ferrara was verified, referring to the procedure described in UNI EN 15603 standard. The working energy assessment, also indicated as 'ex post', quantified the demand of primary energy from the analysis of real consumption drawn from the last three years energy bills. The method "operational rating" which relates directly to the legislation has been used for the evaluation of the energy performance of existing buildings with active users.

As part of the assessment models with bottom-up method, the potential of Energy Performance Certificate (EPC) was considered as a tool for programming and verifying energy policies.

Always in the field of top-down method assessment models, a method of evaluating was tested on some portions of the basic urban fabric of the city centre of Ferrara, with the aim to re-use the quick model in other cities, primarily aimed as a quantitative assessment of the need for thermal and primary energy demanded at different levels: building units, buildings and aggregates. Among the results, on one hand, the quantification of the influence on useful thermal energy need of some characteristic values which has to be reported: S/V, orientation, aggregative modality, type and, on the other hand, the ability to develop future scenarios to highlight priorities for intervention and, in particular, to quantify the real potential for energy savings. Specifically, the quick model proposed aims to quantify the useful thermal energy need only for winter heating (QH expressed in kWh) of primary energy demand (QP,H expressed in kWh) and the relative index of Energy Performance (EPI,INV expressed in kWh/m2 per year), without having to enter the individual units. This limit implies, on one side, the use of a large set of substitute tools aimed at understanding the typological-constructive characters of individual housing units (cadastral maps, front streets and openings reliefs, functional areas accessibility reliefs, photographic images from the top, etc.) and, on the other side, the generalisation of the material-technological traditional characteristics (infra § 1), hard to investigate without a direct approach to the building.

Italy, for the drafting of Energy Qualification Certificates and Energy Performance Certificates, adopted, as written in the Italian Presidential Decree 59/2009, the method of static calculation on a monthly basis and developed, starting from the UNI EN ISO 13790 standard, adapted to the Italian territory, the "UNI/TS 11300 - Energy Performance of Buildings - Part 1: Determination of thermal energy demand of the building for air conditioning in summer and winter" and "UNI/TS 11300 - Energy Performance of Buildings - Part 2: Determination of the primary energy demand and yields for winter heating and the production of domestic hot water".

Today the Energy Certification governs the transformation of the existing building park, both in terms of the real estate market, and programming, planning and verification of energy improvements. The validity of the quasi-static method adopted in Italy with UNI/TS 11300 is not the subject of discussion in the current paper. The proposed method for the evaluation of the needs of useful thermal energy for winter heating, summer cooling and the production of domestic hot water of aggregate systems of basic buildings, constructed on the basis of UNI/TS 11300, provides some important simplifications (in particular with reference to the input data and the calculation procedures) aimed to allow the expeditious acquisition of information, even at large scale. The extreme difficulty to access residential units, also observed in similar experiences, imposes an insurmountable limit to the possibilities of analysis but, on the other hand, becomes the challenging objective of the simplification introduced by the spread-sheet developed on the basis of the UNI/TS 11300.

The intervention scenarios proposed instead aim to evaluate the potential impact in terms of energy efficiency improvement, determined by the implementation of specific intervention strategies. The intervention categories proposed in the scenarios evaluated, corresponding essentially to the categories established by Italian Law for the 55% tax deduction should be read as an example and are certainly not exhaustive. They constitute primarily a check of the operating potentials of the method itself. The simplified procedure proposed, on one hand, allows a rapid assessment of the state of the basic pre-industrial building in terms of energy performance and, on the other hand, can be a useful tool for evaluating the cost/benefit ratio regarding possible strategies identified in pre-industrial buildings within a specific urban area.

The representation of the scenarios, as well as the comparison - even graphic - with the state of affairs, is the first step, even if cognitive, for the activation of so-called "projects mobilisers", which are defined programs at local level, aimed to trigger energy conscious regeneration processes even in the historical parts of town. In basic building it is possible to talk about the development of demonstrative actions, qualification of an industrial offer centred in the affected area, orientation of technology transfer activities, information and training on the market segments involved, standardisation and planning which feed demand and stimulate supply, whilst preferring those categories of intervention that can boast a low cost/benefit ratio, as well as being compatible with the issue of conservation - as required from cultural heritage buildings (Figure 2).

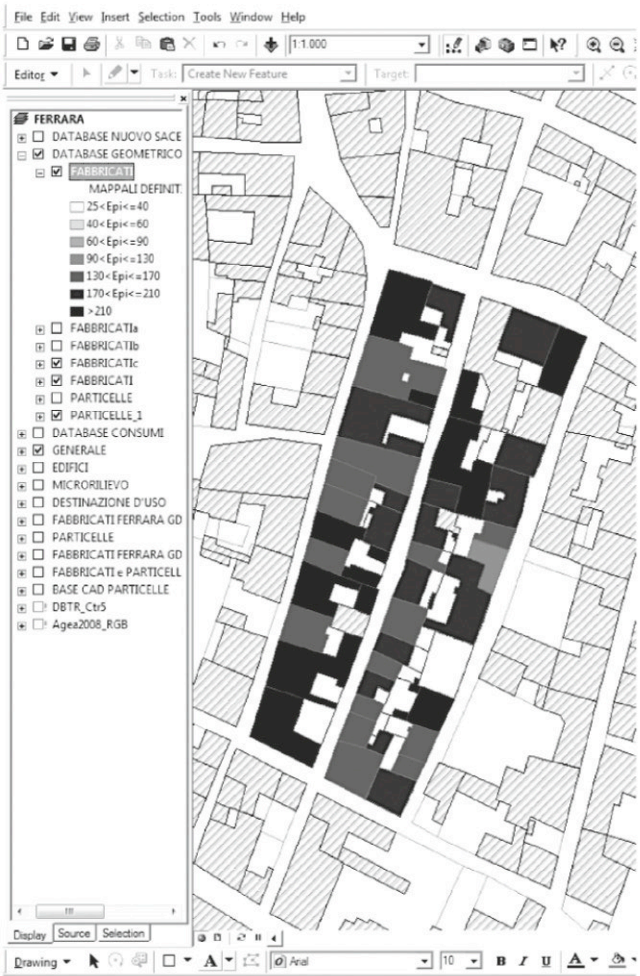
Finally, the determined efforts in safeguarding pre-industrial techniques and materials, which are important witness values, can identify intervention strategies integrated with each other.

4. Conclusions

The research presented here has shown that improving energy efficiency in pre-industrial constructions is not *a priori* or by force of circumstances an inapplicable operation that destroys the testimonial value, as much as it should be carried out within the scope of restoration and with the methodological approaches proper of this discipline. It is not possible to adopt preconceived solutions or solutions that are irrespective of the building to treat, rather, like the guidelines on seismic improvements have shown, it is

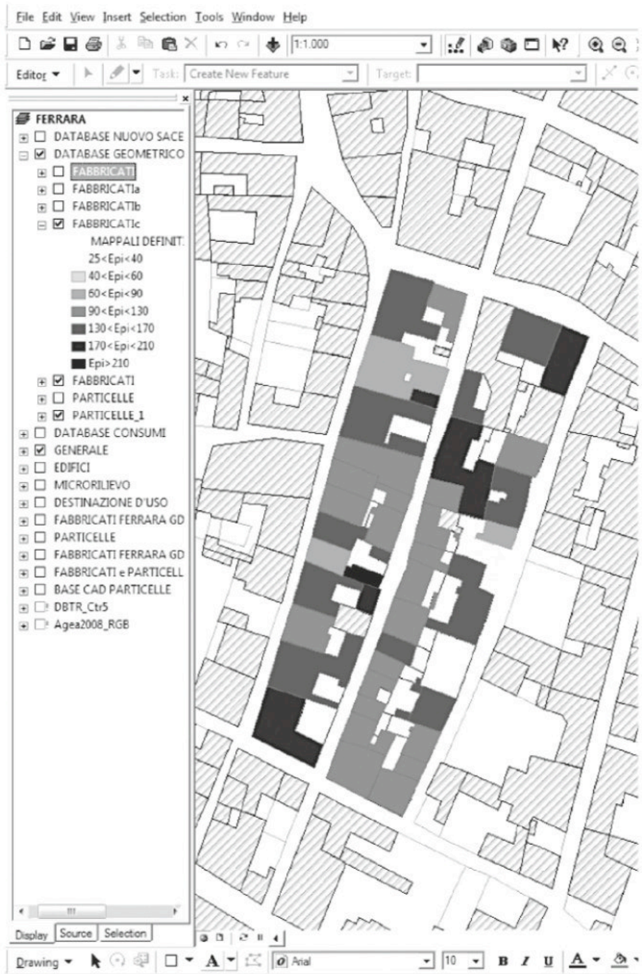
Aggregates 1 and 2 (C.S.)

Primary energy EPtot index (kWh/m^{2}year)



Aggregates 1 and 2 (Scenario)

Primary energy EPtot index (kWh/m^{2}year)



AGG_01	AGG_02	AGG_03	AGG_04	AGG_05	AGG_06	AGG_07	AGGREGATO
67,00	66,00	51,00	44,00	30,00	59,00	47,00	No. of REAL ESTATE UNITS
473.313,64	530.412,57	674.667,79	381.172,84	427.909,68	750.910,45	528.812,73	En. Useful Thermal Energy Heating (kWh)
105,13	97,70	104,93	93,83	103,62	99,28	97,28	$EP_{i,INV,XLS}$ - Useful Thermal Energy (kWh/m2year)
140,17	130,27	139,90	125,10	138,16	132,38	129,70	EP_{tot} - Primary Energy (kWh/m^{2}year
931.733,16	1.016.612,21	1.254.272,37	741.731,31	798.340,77	1.443.126,80	1.035.488,06	Primary Energy (kWh/year) Current Situation
631.084,85	707.216,76	899.557,05	508.230,45	570.546,24	1.001.213,94	705.083,64	Primary Energy (kWh/year) Scenario
289,43	308,81	288,05	257,79	290,02	254,27	262,05	COST per sq.m. of Useful Surface (€/$m^2_{useful\ surface}$)
300.648,31	309.395,45	354.715,31	233.500,86	227.794,53	441.912,86	330.404,43	PROFIT (kWh/year)
32,27	30,43	28,28	31,48	28,53	30,62	31,91	PROFIT %
4,6230	5,3714	5,4557	4,5668	5,3980	4,5941	4,5914	COST kWh/year SAVINGS (€)

Figure 2 Example of intervention scenario for some blocks

necessary to improve awareness of the *status quo* in order to identify the most adequate solutions for improvement, exploiting the positive characteristics inherent to the construction and correcting the negative ones.

The transformation for satisfying changing needs (the so-called benefits), even in terms of energy efficiency, is a normal and natural procedure that cannot be hampered, but should be targeted and focused so that it respects the characteristics of the pre-industrial building that needs to be preserved. In this sense, within the different homogeneous territorial contexts, expert transformation management strategies should be identified that allow not only inspection checks, but that are especially aimed toward good practice.

The most adequate instruments can be identified on three levels.

- updating regional legislation, in order to introduce the knowledge of the priorities of planning and implementation instruments, and the concept of improvement, as intended here, as the ultimate goal of the intervention;
- integration of planning instruments with the guidelines for professionals, to be included within urban and construction regulations of the municipalities, able to illustrate the methodological approach, deepen knowledge of the features to be preserved, and supply compatible operative recommendations;
- favouring processes of training/information of professionals and agents, through the cooperation between different competent authorities (Region, Province, Municipalities and Superintendence), professional associations and professional training schools.

In particular, one of the results of the research consists in the definition and subsequent verification of the expeditious method, a true operative protocol for the assessment of the energy requirements within basic pre-industrial aggregate building systems.

As we have stated, programming effective energy policies and organising interventions targeted towards structural planning, can only start from the real awareness of the current situation. The significant transformation that the world of public administration is crossing these days (reformation of the Agenzia del Territorio, the Land Registry Office, reformation of local administrations, etc.), could constitute a key moment for the detailing of new regulations for encouraging and making more effective the process of acquiring information concerning the territorial jurisdiction.

The relational database built on the ArcGIS® (ESRI) platform goes in this direction. In fact, we have kept in mind the new prospects that the software that today is already available to technical offices of local administrations as a primary instrument for urban and territorial planning can offer (applications such as geostatistical analyst, etc.).

The simulation of sufficiently approximate and, especially, inexpensive in terms of time and cost-scenarios of intervention developed here with a clear illustrative intent, probably constitute the result of greater interest for local administration that, for various reasons, are called to propose new policies for energy saving. For the immediate future, a first possible research development is represented by the elaboration of additional simulations. In fact, it is possible to distinguish demonstrative scenarios even in reference to other intervention categories.

As an example, it will also be possible to calculate costs and benefits for various types of measure:

- insulation of roofs directly in contact with climatised environments;
- external insulation of opaque vertical closures, eventually concentrated within the block and the street front, where the style and material characteristics of the surfaces would not allow it;
- requalification of the distributive/functional assets, targeted to allows a clearer interpretation of the typological consolidated system and that of the subsequent procedural changes (elimination of later additions, and incongruous additions or that have however gone beyond the physiological limit of transformation; interventions of functional reorganisation, etc.).

The integration of more categories and the simulation with variable percentages could allow estimates that are closer to the real savings potential in terms of primary energy.

Assessments and comparisons to the scale of the building, between buildings that are typologically similar, or between different buildings undergoing the same intervention possibilities (which here are not the subject of discussion as they are on a scale of depth that differs from that of the aggregate or the urban organism), can reasonably contribute, on one hand, to drafting the territorial guidelines described above and, on the other hand, to integrating the draft guidelines promoted by MiBAC for the efficient use of energy in cultural heritage.

The integrated control of different assessment models of the requirements at various levels, from the scale of the urban organism with top-down and bottom-up models, to the scale of the aggregate with the expeditious method offered, expressly connected to the same georeferential platform, allow on the one hand to compare the statistics of the information collected, on the other, the analysis of the results obtained and the estimate of the different degree of depth and approximation of each method.

The possibility of making estimates of consumption with this level of depth is naturally significantly interesting in the context of historical disciplines. The work made here must, therefore, be intended not so much as an end point, rather as a starting point for new possible routes of scientific study [6].

5. References

[1] The studies on the urban history of Ferrara are led by Riccardo Dalla Negra (scientific director and co-ordinator), Rita Fabbri, Marco Stefani, Keoma Ambrogio and Marco Zuppiroli. Some previews can be found in: Dalla Negra, R., Fabbri, R., Stefani, M., Ambrogio, K., Conforti, A., Zuppiroli, M. 2009. Ferrara: contributi per la storia urbana, in *Problematiche strutturali dell'edilizia storica in zona sismica*, Bondanelli, M. (editor), Contributions to the Study Seminar, Ferrara, 01-22 October 2009,, 2009, pp. 103-15. Dalla Negra, R., Fabbri, R., Stefani, M., Ambrogio, K.., Conforti, A., Zuppiroli, M. 2010. Le ricerche sulla città di

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[2] EPBD 2002/91/EU and EPBD 2010/31/EU.

[3] D.Lgs. 192/2005, integrated by the D.Lgs. 311/2006. The applicative regulation D.P.R. 59/2009.

[4] We refer to the Italian: UNI TS 11300, part 1 "Determinazione del fabbisogno di energia termica dell'edificio per la climatizzazione estiva ed invernale", anche the UNI TS 11300, part 2 "Determinazione del fabbisogno di energia primaria e dei rendimenti per la climatizzazione invernale e per la produzione di acqua calda sanitaria".

[5] The identification of these categories is discussed in Swan, L. G., Ugursal, V. I. Modeling of end-use energy consumption in the residential sector: A review of modeling techniques, «Renewable and Sustainable Energy Reviews», vol. 13 (2009), pp. 1819-1835; and subsequently in Kavgic, M., Mavrogianni, A., Mumovic, D., Summerfield, A., Stevanovic, Z., Djurovic-Petrovic, M., A review of bottom-up building stock models for energy consumption in the residential sector, «Building and Environment», vol. 45 (2010), pp. 1683-1697.

[6] The study summarized here has been recently edited by FrancoAngeli as: Ambrogio, K., Zuppiroli, M., *Energia e restauro. Il miglioramento dell'efficienza energetica in sistemi di edilizia pre-industriale, tra istanze conservative e prestazionali*, 2013.