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ScienceDirect

Energy Procedia 111 (2017) 452 – 461

Energy Procedia

8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11-13 September 2016, Turin, ITALY

The recurrent characteristics of historic buildings as a support to improve their energy performances: the case study of Palermo

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Abstract

The analysis of the recurrent characteristics of the local historic architecture is useful to develop large-scale energy analyses, regulations and financial strategies, but also to support technical guidelines for an energy improvement balanced with conservation. For this purpose, a multi-scale methodology ranging from envelope components to the urban dimension is necessary. In the research here exposed, this approach is investigated by focusing on the historic architecture of Palermo. For this heritage, the collection of thermal and hygrometric data for envelope components is combined with the examination of representative constructions, based on building stock categorization. Intended as a contribution to the overall energy analysis of the architectural heritage of Palermo, this case study shows that examining the recurrent characteristics of historic architecture in a local context may promote energy improvements compatible with the material and aesthetic conservation of historic buildings.

Peer-review under responsibility of KES International.

Keywords: historic architecture; traditional building; energy efficiency; thermal properties; building categorization; Palermo

1. Introduction

The European Directive 2010/31 on the energy performance of buildings and the majority of its national implementations exempt officially protected buildings from the achievement of minimum energy requirements, if this may alter their character or appearance. Indeed many energy refurbishment techniques have been developed for recent constructions, which are not subject to conservation needs and differ from traditional buildings in thermal and hygrometric features.

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Peer-review under responsibility of KES International.
doi:10.1016/j.egypro.2017.03.207

However, for a significant proportion of historic constructions, preservation restraints are limited to the external appearance, while several constructions have to comply with normative energy requirements because not protected. On the other side, both fiscal incentives and the exemplary role attributed to public institutions by the energy efficiency Directive 2012/27/EU might stimulate the retrofit of monumental buildings, without necessary concern for conservation.

Besides these risks, several reasons foster the current interest in the energy efficiency of the architectural heritage. Since it is a relevant part of the European building stock [1] and because of the energy consumption related to the hazards of climate change [2], historic architecture could give a considerable contribution to EU sustainability targets. Furthermore, in the perspective of a growing gap of performance with refurbished recent constructions, increase in energy efficiency would support the use and consequently the conservation of historic buildings [3].

In the scientific literature, it is widely accepted that the approach used for the last decades in the fields of accessibility and structural reinforcement is appropriate to make energy efficiency compatible with the aesthetic and material features of the architectural heritage. This criterion consists in improving the energy performance of historic constructions in so far as it respects their conservation, without necessary compliance with normative requirements [4]. Consequently, it is essential to analyze the peculiarities of each building, which are also related to the construction, typology and aesthetic features of the local building tradition.

In the research here described, the locally recurring characteristics of historic buildings are examined in order to assess their current energy performances and to find energy efficiency strategies and practices compatible with conservation. This approach has been explored through an application on the historic architecture of Palermo.

2. State of the art

Scientific and normative guidelines have been recently proposed for the energy efficiency of the architectural heritage [5, 6] but, since referred to a general level, they are not connected to the peculiarities of historic buildings, which significantly influence the possibilities of energy enhancement. Two relevant paths can be observed in the scientific literature in order to fill this gap.

A first research approach consists in the analysis of case studies, usually monumental buildings, where thorough energy diagnosis is conducted and improvements of envelope and energy systems are designed or carried out. Confronting the purpose of energy efficiency with the characteristics of single buildings highlights the feasibility and compatibility of different retrofit options. These researches are intended to create a collection of case studies, aimed to inspire upgrade measures and approaches transferable to other projects [7]. From this perspective, they follow a criterion typical of architectural restoration.

The energy assessment of heritage constructions is meant also for the development of regulations, financial strategies, technical guidelines, which cannot neither neglect the upgrade restraints connected to conservation nor be based on the detailed analysis of a large number of buildings. Therefore, a second research path focuses on recurrent characteristics of the historic architecture rather than on single buildings. Within this approach different methods have been proposed, whose purposes and limits strictly depend on the scale chosen for the analysis [8, 9].

Several researches deal with the recurrent characteristics of a historic building stock by following a typology approach. By means of building categories, based on features related to energy performance, these studies aim to achieve general results for the entire stock by identifying and analyzing in detail a limited number of representative constructions. When the application of the typology approach is carried out on a large scale, for instance at national level as in the French project BATAN [10], the main outcome is an assessment of the overall stock energy demand or the development of models to be specified on a smaller scale.

On the contrary, limiting the analysis to a local context, where the construction features of historic architecture are sufficiently homogeneous, is essential to the development of technical guidelines for energy efficiency. Representative buildings may perform this function, as evident in the iterative method proposed in [11], aimed to balance the technical performances and economic feasibility of energy improvements with the protection of cultural heritage. Notably, the European project Effesus has developed a method to categorize the building stock of historic districts. This categorization is based principally on the geometric features of buildings and on protection restraints [12]. Therefore, a detailed analysis of materials and construction characteristics is necessary and is expected from the examination of representative buildings.

3. Objectives and methodology

Analyzing the recurrent characteristics of historic buildings may appear contradictory to the principles of conservation, since the simplifications it implies might result in standardized solutions. On the contrary, in the field of architectural restoration, this approach can support built heritage preservation if referred to a limited local context, where the material and aesthetic features of historic architecture are sufficiently homogeneous.

The aim of this research is to demonstrate that the knowledge framework obtained by examining the recurrent characteristics of historic buildings is a relevant basis to identify strategies and techniques for the energy improvement of the architectural heritage. On the assumption that the limited dimension of a local context is necessary, the research here exposed focuses on the historic architecture of Palermo, which is a relevant expression of the Sicilian heritage and a significant case study for the Mediterranean area.

The methodology followed in this study (table 1) has two main targets, on the one side to collect thermal and hygrometric data for envelope materials and components, on the other side to develop models suitable for the design of energy upgrade measures, through the detailed analysis of representative buildings.

By simulating the current and potential performances of exemplary constructions, the energy efficiency of the entire stock can be assessed as precisely as it is necessary to orientate regulations and urban plans, economic strategies and technical guidelines. Through in-depth energy audit, simulations and application of performance improvements, representative constructions can also be intended as design models, useful to identify energy upgrade measures adaptable to the peculiarities of single buildings. Both cases have to confront the limited availability of reliable data about the thermal and hygrometric properties of traditional envelope components. Indeed the substantial decay of a building, or conversely the impossibility to carry out destructi ve tests, may limit energy diagnosis significantly. At the same time, on a bigger scale, the collection of thermal and hygrometric data would allow a reliable assessment of the building stock performance.

The features to be analyzed, since relevant for the building energy performance and its improvement, include envelope construction and geometry, inner space functions and distribution, the interaction with adjacent buildings and surrounding environment. For this reason the research adopts a multi-scale approach, ranging from building components to the urban dimension.

In order to collect thermal and hygrometric data for the traditional materials and techniques of the analyzed architectural heritage, calculations based on the typical envelope compositions are compared with both laboratory and on-site tests. In this research, measurements have been conducted on stone walls and masonry materials. Indeed relevant uncertainties in assessing the energy performance of historic buildings, observed by several studies in different geographic contexts, affect also the case study of Palermo.

A systematic examination of the characteristics pertaining to urban and building scales is achieved through the categorization method developed by the European project Effesus. Linked to the CityGML model and to the concept of Level of Detail (LoD), it assures a common basis for the analysis of historic districts. At the same time, its flexible structure can be adapted to the peculiarities of each building stock and to the availability of data. Furthermore, in order to assess the compatibility of energy efficiency actions, this method combines historic building features with the restraints set by conservation principles and protection laws.

Table 1. Synthesis of the approach investigated in this research.

Scale of analysis	Means of analysis	Outcomes
Building components and materials	Review of scientific literature and technical standards	Collection of thermal and hygrometric data for the local historic architecture
	Laboratory tests	
	On site tests	
Building and neighborhood	Building stock categorization	Energy improvement models
	Dynamic simulations of representative buildings	Technical guidelines
	Energy improvement of representative buildings	Large-scale energy analyses

Through these building categories, a manageable number of historic constructions are identified as representative of the entire stock. Thermal simulations have been carried out on a selection of exemplary buildings, in order to assess their current performances and to compare the effectiveness and feasibility of several energy upgrade measures. Although this research focuses on the envelope improvement, the followed methodology can be used to explore the interaction between historic buildings and their systems, and to deal with energy efficiency in relation to the wider topic of indoor environmental quality.

4. The case study of Palermo

This research focuses on the building envelope characteristics. It is not intended to exhaustively describe the current and potential energy performance of the analyzed heritage. The aim is to verify the ability of this methodology to consider the peculiarities of the local historic architecture and, therefore, to support guidelines for a compatible energy improvement.

4.1. Historic materials and techniques: thermal and hygrometric characterization

Numerous studies have explored materials and techniques of the historic architecture of Palermo. Although these features remained almost unvaried over the centuries [13], the evolution of constructions was complex and building components do not have a homogeneous constitution. Consequently, several uncertainties affect the thermal and hygrometric characterization of the envelope, especially for masonry, often covered with plasters and decorations to be preserved. Furthermore, even if an early investigation on the thermal and hygrometric properties of the building materials traditionally used in Palermo was conducted in the late XIX century [14], few data are currently available.

Masonry in Palermo was almost always built by means of calcarenite stone, a sedimentary rock widespread in the town and in the surrounding areas. Several quarries were active and their period of use is generally known. Therefore, calcarenites differ from one another in physical and mechanical properties. As it was observed in the second half of the XIX century [15], density approximately ranges from 1,350 $kg \cdot m^{-3}$ to 1,850 $kg \cdot m^{-3}$ and consequently compressive strength from 20 $kg \cdot cm^{-2}$ to 100 $kg \cdot cm^{-2}$.

Besides this variety of physical properties, in the existing collections of thermal conductivity values for building materials, the data suitable for calcarenites are partially discordant. In the Italian standard UNI 10351:2015, λ-values of tuffs ("tufi"), which calcarenites are traditionally assimilated to, range from 0.63 $W \cdot m^{-1} \cdot K^{-1}$ (ρ=1,500 $kg \cdot m^{-3}$) to 1.7 $W \cdot m^{-1} \cdot K^{-1}$ (ρ=2,300 $kg \cdot m^{-3}$), while for intermediate densities it can be obtained by interpolation. On the other side, UNI EN ISO 10456:2008 attributes λ=2.3 $W \cdot m^{-1} \cdot K^{-1}$ to "natural, sedimentary rock" (ρ=2,600 $kg \cdot m^{-3}$) and λ=0.85 $W \cdot m^{-1} \cdot K^{-1}$ to "natural, sedimentary rock, light" (ρ=1,500 $kg \cdot m^{-3}$). Similarly, in UNI EN 1745:2012, λ=0.85 $W \cdot m^{-1} \cdot K^{-1}$ is provided for "limestone, very soft" ($\rho \leq$1,590 $kg \cdot m^{-3}$) and λ=1.1 $W \cdot m^{-1} \cdot K^{-1}$ for "limestone, soft" (ρ=1,600÷1,790 $kg \cdot m^{-3}$). Further uncertainties are related to the calculation of stone wall thermal transmittance. For several geographic areas, scientific studies underline that calculation tends to overestimate this parameter in comparison with measurements and, to a large extent, this discrepancy is attributed to the reliability of λ-values [16].

Investigating how the performances of calcarenite walls vary both with construction technique and stone quarry is essential to the reliability of thermal and hygrometric data for the traditional masonry of Palermo. For the analyzed heritage, this information would constitute a relevant part of the data collections, which should include all the envelope components according to the exposed methodology. In this research, a contribution to the characterization of calcarenite walls is provided by means of *in situ* measurements of thermal conductance and laboratory tests of thermal conductivity. The limited number of examined walls, although not sufficient for the variety of masonry in Palermo, is able to support some relevant observations.

In situ measurements of thermal conductance have been carried out in the monastery of Saint Anne in Palermo. Now the seat of a museum [17], it was built from the XV to the XIX century, while several reinforcement works were done over the centuries in order to repair the considerable damage of seismic events. Therefore, it is possible to observe a wide variety of calcarenite walls, different for both construction features and stone quarry, for which published archival researches, together with the documents of the building restoration concluded in the last decade, provide significant information.

Following ISO 9869:1994, thermal conductance measurements have been taken in winters 2013-2014 and 2014-2015 on thirteen walls, corresponding to six thicknesses from 0.56 m to 0.71 m. Nine of them date from XVII-XVIII centuries, while four were built between the end of the XV and the beginning of the XVI century. Thermal transmittance derived from conductance has been compared with values calculated according to UNI EN ISO 6946:2008, in which the stone conductivities reported in UNI 10351 and UNI EN 1745 have been used. Calculations based on the former standard have resulted in good agreement with measurements, with a discrepancy between -5% and +16%. Conversely, a significant overestimation ranging from +10% and +39% has been observed in the case of UNI 1745. These results are supported by thermal conductivity measurements (DIN EN 12664) carried out on three calcarenite samples, taken in two XIX-century buildings in Palermo. Also in this case, the difference between λ-values is slight in comparison with UNI 10351 (-8.3% ÷ +4.2%) and more significant with UNI EN 1745 (+12.7% ÷ +38.4%).

4.2. Building categories for the historic architecture of Palermo

The historic center of Palermo is the result of changes occurred over centuries, but recurring characteristics can be observed in urban aggregation, building morphology and the organization of indoor space, which influence indoor environmental quality and therefore the energy efficiency of historic constructions. Natural ventilation, for instance, is closely connected to the presence of courtyards, to the number and position of façades, to the features of the stairwell.

These characteristics are partially considered within the urban Plan, named "P.P.E. del Centro Storico", which regulates the building activities on the architectural heritage of Palermo. This Plan follows a typology approach, which distinguishes residences, monasteries, civil and military public buildings, according to their historical function. While in public constructions the peculiarities of each building are prevalent, constants in morphology and inner distribution, mainly related to the presence of courtyards, may be observed in religious architecture. Specific attention is turned to residential buildings, described through six typologies, which differentiate minor and monumental architecture and explicitly refer to the organization of indoor spaces and to the aggregation with adjacent constructions.

For each typology the Plan states the elements subject to protection and the ways of intervention. Notably, the most important distinction is between the typologies on which renovation is permitted and those which require restoration. Since P.P.E. typologies are related both to normative restraints and to geometric and aggregation features, the Effesus categorization method is particularly suitable to examine the integration of energy improvement actions with restoration practices. In the use of this method for Palermo [18], the aim is not to substitute the structure of the existing normative typologies, but to correlate them with the current and potential energy performances of historic buildings.

The categorization has been carried out on "mandamento Castellammare", one of the four parts which the historic center of Palermo is traditionally divided into. This building stock consists of more than five hundred constructions and excludes churches, singular architecture, ruined and recent buildings. Geometric data, which are the basis of this categorization, have been taken from existing maps and updated by means of recent aerial photographs (*Google Earth*, *Bing Maps*, accessed 2014) and external inspections. Collected in *QUANTUM GIS*, data have been processed in *Microsoft Office Excel*.

The structure of the Effesus method, adapted to the features of Palermo's historic architecture, focuses on three characteristics: the volume, to represent the building size; the ratio of free ground perimeter, to synthetically consider the presence of courtyards and the aggregation with adjacent buildings; the P.P.E. typology, as expression of normative restraints to retrofit actions.

P.P.E. typologies have been sorted into three "levels of protection", based on the distinction between renovation and restoration and on the building features which the plan protects for each typology. Subsequently, the categories are described according to the two geometric parameters, by means of thresholds defined through statistical analysis. Notably, while the presence of an inner courtyard implies a ratio of free perimeter higher than 60%, a value lower than one third (33%) is observed only in vernacular buildings. With regard to volume, 3,500 m^3 is the upper limit for vernacular buildings and the minimum for monumental architecture, whereas the 10,000 m^3 threshold identifies buildings whose peculiar features prevail in comparison with the typology characteristics.

The analysis has resulted into twelve categories, which collect 98.1% of buildings and 96.6% of the overall stock volume. The remaining constructions were excluded as part of categories negligible both in number of constructions and volume. It is acceptable to suggest that these results may be extended to all the historic center with limited changes, since "mandamento Castellammare" represents the main features of the ancient town urban fabric and contains a significant number of buildings for each P.P.E. typology. On the contrary, the traditional constructions outside the historic center, although subject to the same normative approach, would certainly require new categories in order to describe more pronounced differences about surrounding context, building aggregation, inner space organization.

Due to the necessary simplifications introduced in this analysis, the proposed categories do not consider relevant aspects such as the state of conservation of buildings, their function, the number and size of properties. Nonetheless, they can be deepened through the detailed analysis of a manageable number of constructions, chosen as representative for the respective category.

In order to identify these exemplary buildings, the average values of ground floor area, building volume and free ground perimeter have been calculated for each category (table 2). Notably, the thresholds among groups highlight that some categories, mainly related to vernacular constructions, are more suitable for a typology description, while the peculiarities of each building are prevalent in groups 2.V, 3.III and 3.IV. In the first case, the accurate examination of representative constructions provides direct recommendations for the corresponding group. In the second case, this approach is closer to the in-depth analysis of case studies.

Table 2. Building categorization for "mandamento Castellammare" in the historic center of Palermo [18].

Category	Thresholds			Incidence			Average values		
	Level of protection	Building volume [m^3]	Free perimeter [%]	Number of buildings	[%]	Building volume [%]	Ground floor area [m^2]	Building volume [m^3]	Free perimeter [%]
1.I	Level 1 Renovation	≤ 3,500	≤ 33	96	17.3	3.9	64	970	24.6
1.II		≤ 3,500	33 ÷ 60	147	26.5	9.1	101	1,488	46.4
1.III		≤ 3,500	≥ 60	46	8.3	3.3	120	1,710	71.5
2.I	Level 2 Renovation Restoration	≤ 3,500	33 ÷ 60	35	6.3	3.0	135	2,055	47.6
2.II		≤ 3,500	≥ 60	41	7.4	4.2	167	2,468	70.7
2.III		3,500 ÷ 10,000	33 ÷ 60	29	5.2	5.8	265	4,756	50.8
2.IV		3,500 ÷ 10,000	≥ 60	43	7.8	9.4	297	5,242	75.4
2.V		≥ 10,000	≥ 60	10	1.8	7.3	834	17,571	85.9
3.I	Level 3 Restoration	3,500 ÷ 10,000	33 ÷ 60	17	3.1	3.9	337	5,520	51.6
3.II		3,500 ÷ 10,000	≥ 60	36	6.5	10.5	425	6,967	74.2
3.III		≥ 10,000	33 ÷ 60	3	0.5	1.6	762	12,911	54.5
3.IV		≥ 10,000	≥ 60	36	6.5	34.6	1,284	23,027	82.0

4.3. Analysis of representative buildings

The proposed categories have been used to identify three buildings as representative for the groups 1.I, 1.II and 2.II (table 3). By means of the software *WUFI Plus*, thermal simulations have been carried out, in which the building energy demand for heating and cooling has been assessed and the influence of natural ventilation has been considered. The purpose is to verify that the approach followed in this research could be effective in investigating the possibilities of energy improvements compatible with the conservation of the architectural heritage.

The models are founded on published geometric surveys and restoration documents, while techniques and materials typical of the tradition of Palermo [13] have been assumed for the constitution of building elements. Due to the lack of direct measurements, models were not calibrated and consequently the results are qualitative. The models concentrate on the envelope performances and do not explore different system options. Notably, an ideal system for heating and cooling has been considered. Moreover, since neither hygrometric conditions nor light quality are examined, the simulations do not assess indoor environmental quality, but only thermal conditions and the corresponding energy consumption. Therefore, the conducted simulations could be a useful contribution to estimate the building stock energy performance, while their accuracy is not sufficient to represent reference models for the energy improvement of historic constructions in Palermo.

Table 3. Representative buildings.

Building	P.P.E. typology	Category	Building features		
			Ground floor area [m^2]	Volume [m^3]	Free perimeter [%]
Building in vicolo della Madonna	"Catoio semplice"	1.I	42	690	23
Building in via Argenteria	"Catoio multiplo"	1.II	99	1,660	53
Building in via Bara all'Olivella	"Palazzetto"	2.II	157	2,740	70

The first, four-storey building (1.I) contains one housing unit and is attached to adjacent constructions on three sides. The second, five-level building (1.II), where two opposite façades are exposed to the outer environment and the remaining are shared with adjoining constructions, consists of a couple of two-storey housing units. The third, four-level building (2.II), with three one-storey units, is the head of a block (fig. 1). While for the first two buildings renovation is allowed by P.P.E., restoration is prescribed in the third.

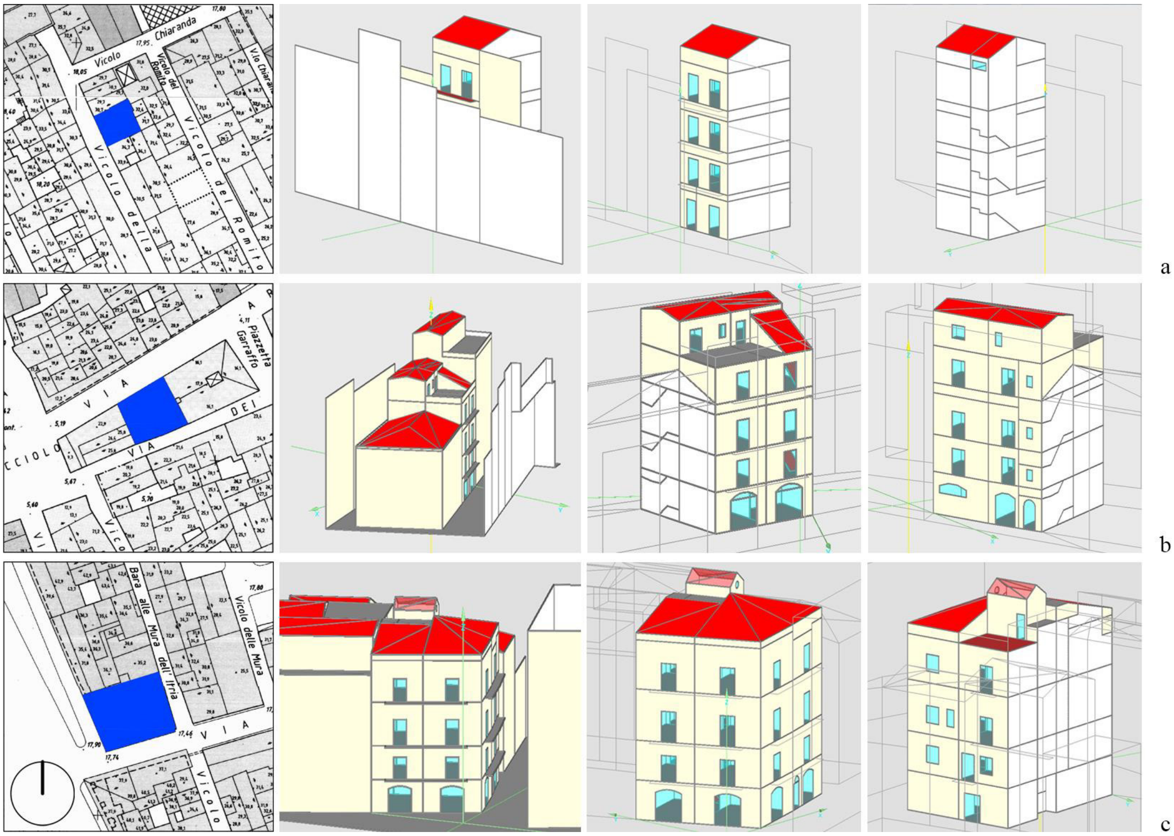

Fig. 1. Representative buildings for the categories: (a) 1.I; (b) 1.II; (c) 2.II.

The year energy demand for heating and cooling, calculated by referring to an ideal system, has been estimated at 4,424 kW·h for the first building (1.I), 15,274 kW·h for the second (1.II), 19,224 kW·h for the third (2.II). These current performances have been compared with several options of energy improvement, in which envelope components have been upgraded but the ideal system has not been modified. In detail, a first scenario examines measures that can be easily integrated with restoration, notably enhancement of window airtightness, substitution of glasses, thermal insulation of ground floor and roof. A second scenario focuses on the thermal insulation of stone walls, which is a more effective but less suitable option for the aesthetic and material conservation of historic constructions. Notably, the use of thermal insulating plasters on the internal or the external surface has been compared with the application of insulating panels on the wall internal surface. Furthermore, the reduction of summer overheating, through the use of cool paintings on roof tiles and low-SHGC glasses (SHGC=0,30) has been assessed.

The results (fig. 2), though qualitative, highlight that the energy demand for heating and cooling may be significantly reduced through a limited impact on the historic building envelope. As far as thermal insulation is concerned, simulations show the relation between measure effectiveness and the size of the building element, one of the features which the selection of representative buildings is based on. This connection is useful also for analyzing the use of cool paintings, although in these simulations the reduction in cooling demand (ranging from 10% for the first building to 25% for the third) is balanced by a similar increase in heating consumption. In the end, indoor light quality has to be considered in order to estimate the effectiveness of low-SHGC glasses in windows, which appears substantially limited by the use of traditional shading devices.

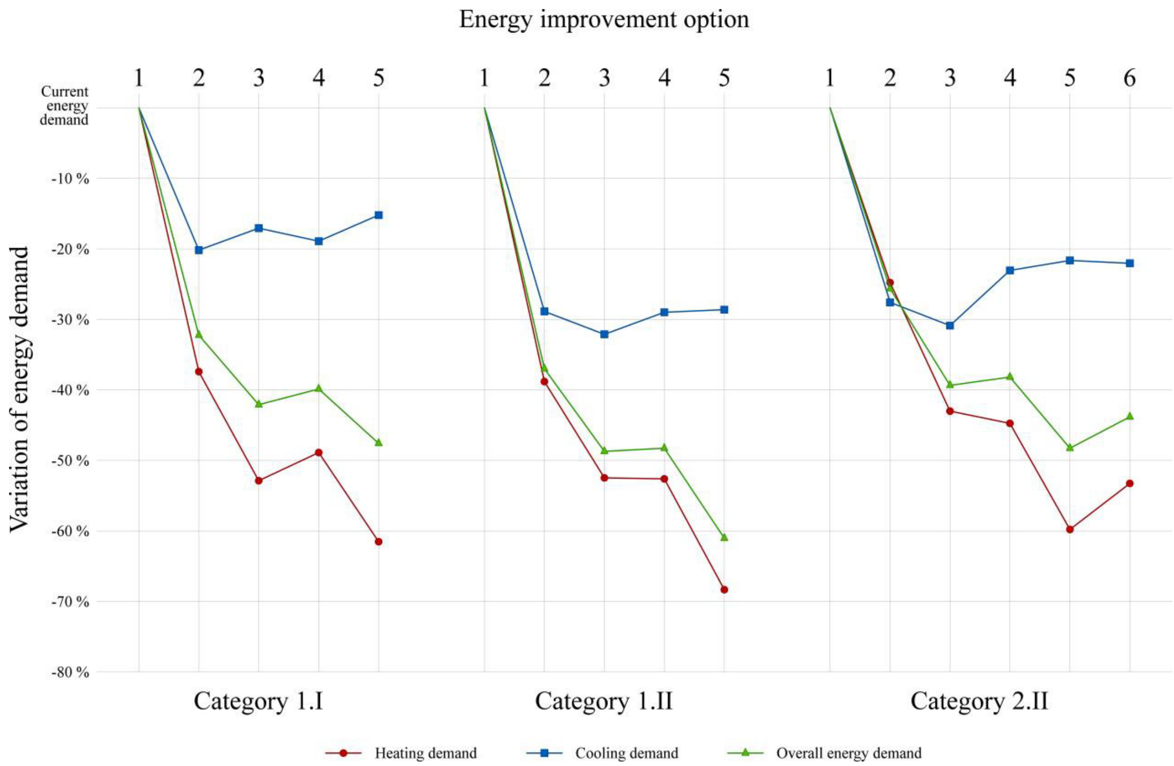

Fig. 2. Variations of energy demand compared to the current performance of the analyzed buildings (1). The simulated improvements are: (2) enhancement of window airtightness and glass thermal resistance, thermal insulation of ground floor and roof; (3) internal thermal insulating plaster; (4) external thermal insulating plaster; (5) internal insulating cork panels; (6) internal insulation with cork panels, except for spaces with false-vault ceiling, where insulating plaster is considered.

These simulations underline that the contribution of ventilation and shading strategies, as well as the feasibility and effectiveness of retrofit actions, could be assessed through in-depth analyses of representative buildings, according both to categorization features and more specific aspects, such as the number of housing units. Therefore, besides providing qualitative outcomes, the three building models show the potentialities of this research method as a tool to support the design of compatible energy improvements for the local historic architecture.

5. Conclusions

The energy performance and the potential upgrades of a historic building closely depend on its peculiarities, but analyzing the characteristics of the historic architecture which recur in a local context is a valid support to identify energy improvements compatible with conservation principles and protection requirements. For this purpose the focus on Palermo, exposed in this paper, combines the collection of thermal and hygrometric data for the historic building envelope with the detailed examination of representative constructions, based on a large-scale building categorization of the analyzed heritage.

This research does not provide an overall knowledge framework for the energy performances of historic constructions in the case study of Palermo, but contributes to its development. Notably, a vast collection of thermal and hygrometric data is still necessary both for masonry and the other building components. The examination of representative constructions has to be extended to each category, through models based on detailed inspections and energy measurements. Moreover, the case study has focused on the envelope performances of historic buildings but other relevant aspects remain to be explored, especially heating and cooling systems and the light quality of indoor spaces, which are essential to assess the overall energy demand and the indoor environmental quality of buildings.

Nevertheless, the case study of Palermo highlights potentialities and weaknesses of the methodology followed in this research. Notably, if extended to a larger number of buildings and wall features, the characterization of calcarenite masonry would be a rigorous basis to assess the reliability of current available data and a significant term for comparison with on-site measurements carried out in single constructions. Therefore, this characterization would provide general recommendations for the energy diagnosis of historic buildings in the analyzed stock, if referred to the main construction features of the local heritage.

Above all, the simulations carried out on representative constructions show that the analysis of exemplary buildings could be used to examine the applicability and effectiveness of several upgrade options, either alternative or combined. Consequently, these models may be used not only for large-scale analyses, regulations and financial strategies, but also to develop technical guidelines for the energy improvement of the local architectural heritage. Indeed, through exemplary constructions, relevant aspects can be analyzed in depth, such as the building use and state of conservation and their effects on the achievement of energy improvements. Moreover, further relevant developments for this research, namely the economic feasibility and the environmental impact of upgrade measures, could be investigated by means of representative buildings.

In monumental architecture, the significance of the peculiar features of single constructions limits the suitability of the proposed approach in comparison with vernacular buildings, where recurrent characteristics are more evident. Nonetheless, there are relevant difficulties in balancing the aim of energy efficiency with the need of heritage conservation. Therefore, also for monuments, criteria and experiences useful to design the restoration of a historic building could result from the analysis of the recurrent features of the local historic architecture.

Acknowledgements

This research was conducted at the University of Palermo, within the doctoral course in Architecture (XXVI cycle, 2013-2015). The authors are grateful to: the University of Uppsala (Prof. Tor Broström), which supported the categorization of the historic architecture of Palermo; ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Eng. Francesco Cappello), which provided the equipment for the measurements of thermal conductance; the Fraunhofer Institute for Building Physics (Dr. Ralf Kilian) for the thermal characterization of calcarenite specimens and the WUFI Plus simulations.

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