Energy efficiency principles in Portuguese vernacular architecture

J. Fernandes
University of Minho, Guimarães, Portugal

R. Mateus
University of Minho, Guimarães, Portugal

ABSTRACT: Vernacular architecture is characterized by formally expressing several constraints – geographical, climatic and economic – from the places where it is. In its plurality, it manifests several constraints from places and communities who built and inhabit them. Those constraints are reflected in regional differentiation of the strategies used to mitigate the climate effects. Portugal, despite the small size of the country, is profuse in these manifestations of architecture. The strategies adopted in these buildings have potential to evolve and to be adapted to contemporaneity. Future should seek to integrate tradition and modernity, in order to explore new aesthetics and functional buildings. In this sense, Portuguese vernacular architecture has a knowledge that matters to be studied and classified from a sustainability point of view. When world seeks for cleaner energy and more sustainable buildings, it is pertinent to revisit the past in order to understand these forms of construction intrinsic to places, shaped over the time to deal with scarce resources.

1 INTRODUCTION

During the last years, the concept of energy efficiency and LCA became a dominant subject in Architecture and construction debates. This issue is particularly relevant in a moment when building sector represents almost 40% of the total energy consumption in the European Union (EPBD, 2010), being the construction industry sector one of the biggest and most active sectors in Europe, representing 28,1% and 7,5% of jobs in the industry and in European economy, respectively (Torgal & Jalali, 2010). In terms of environmental impact, this energy-intensive industry is responsible for about 30% of all carbon emissions (Torgal & Jalali, 2010). Additionally, at worldwide, the construction industry consumes more raw materials (almost 50% by weight) than any other economic activity. In order to mitigate this impact, the European Union has outlined a path to achieve a more efficient construction, setting medium-term objectives as: 50% reduction in energy consumption; 30% reduction of raw materials; 40% reduction of waste production (Torgal & Jalali, 2010). This objectives are aimed at promoting efficient use of natural resources — in many cases with reserves just for a few dozen years — and consequently the adoption of solutions on its major cause of depletion, the building industry (Bellanger & Lallement, 2008). During the last decades, this problem has been shaped with the pressure caused by the exponential growth of world population and the consequent need for construction of buildings and other infrastructures.

To complement the above mentioned objectives is urgent to find new ways of building. Nevertheless, it is pertinent to think the future of construction based on reflection on what was its past, according to some authors, more sustainable.

The vernacular architecture is an example of past building design approaches that must be studied. Based on the repetition and improvement of solutions over successive generations, the vernacular architecture is a reflection of a time where people knew how to deal with the scarce resources that were available. Based in the possible technologies and local materials, these buildings become elements that characterize the places, assimilating "the context of men and sites" (Ribeiro, 2008). In the “Charter on Built Vernacular Heritage”, this type of architecture is characterized as "the expression of the culture of a community and its the relationship with its territory," representing "the traditional and natural way by which communities lived" in a "continuous process including necessary changes and adjustments in response to ongoing social and environmental constraints "(AAVV, 1999).

In an era of globalization - that began with the Industrial Revolution and was intensified with the Modern Movement - which contributes to the homogenization of cultures and, consequently, their ways of building (Ribeiro, 2008), the vernacular architecture states even more as a key element to the resumption of the discussion about cultural identity and about the advisability of returning to a construction intrinsic to sites. This could contribute to reducing waste and energy consumptions through the use of traditional techniques and local materials, developed to be adapted to a specific territory and climate (Ribeiro, 2008).

This work aims at demonstrating that vernacular architecture can contribute to improve energy efficiency in construction. The strategies used to mitigate climate effects usually have a low-tech profile and are less dependent on non-renewable energy, what makes them suitable to be applied to contemporaneity and therefore they are relevant case studies.

2 FROM VERNACULAR ARCHITECTURE TILL THE PRESENT CHALLENGES

2.1 *Context*

In the past, due to the lack of technology capable to maximize comfort, buildings were built using passive strategies. These simple and clever strategies were only based in the available endogenous resources. These strategies are based in several criteria like: geographic characteristics; insolation; orientation; geometry; shape; materials, among others. These criteria are present since Man decided to build shelters to protect himself from the natural environment. Although he did not control the concept of thermal energy, or not know the thermodynamics laws of, the man had, by sensory and empirical ways, the notion of the relationship between climate, shape, construction material and physical well-being. Many generations were necessary for people, from different cultures, to arrive empirically to the creation of forms and processes of construction. These approaches have their own styles and characteristics and are perfectly related with the different types of climate and geographical features. Some examples are those presented in Figure 1: Iran wind towers are an example of a passive cooling system in which the wind captured is cooled by contact with the tower walls and porous vases, or small fountains, containing water and subsequently the wind is distributed among the several compartments of the building, removing the existing thermal loads (Testard-Vaillant, 2007); the typical wooden houses from Nordic countries, where forests abound and therefore this material is used for thousands of years helping to protect from the summer heat and to insulate from the winter cold; the yurts, transportable houses from Central Asia and Mongolia, are made with a wooden frame covered with waterproofed tissue, and have high resistance to polar winter, strong winds and the scorching heat of the plains (Testard-Vaillant, 2007).

During thousands of years, since the appearance of the first settlements in the Neolithic, vernacular architecture sparingly evolved according the needs of populations. Those inherent skills

Figure 1. (left) Wind Tower (Gryffindor, 2008); (center) Nowergian traditional dwelling (PhotoXpress, 2011); (right) Mongolian Yurt (Adagio, 2007)

were transmitted by the communities from generation to generation until the Industrial Revolution, and the large consequential changes, broke this evolutionary line of vernacular knowledge.

In the second half of the 18th century, the Industrial Revolution marks the beginning of a new era, with profound changes at all levels. The increasing technological euphoria began to break with traditions. Rural populations, seeking a better life in urban areas, started an exodus to the cities to become workmanship in the new industries. The rural desertification has led to the disappearance of that knowledge and experience that was accumulated over thousands of years. At the same time, factories proliferated and began the need to accommodate its manpower. The working-class neighborhoods grew proportionately with factories and are characterized by having miserable and inhumane conditions of habitability. Beyond the high house density, these houses almost had no light or ventilation (Figure 2). This was a dark period in the history of human dwelling (Goitia, 1996).

Industrialization brought new materials and technological development like glass, cement and steel. The increasing use of new industrial and standardized materials homogenized the different construction approaches- as well the ways of living - until then dependent on the materials available on sites.

It was in the twentieth century when the roots with vernacular past were definitely broken. At the beginning of the century, transparency, light, air and the sun became the flags of the Modern Movement. Artists and architects promoted glass structures as ideal hygienic models in antithesis to the dirty cities of the industrial revolution. The global proliferation of this thought, revolutionary and necessary, slowly began to be assimilated by different cultures. The powerful images of an architecture assumed as being universal - applicable to any geography - and some mimicking errors of architecture models have began to erode the most traditional cultures, often the poorest, who saw on those the reflection of a better life. The inadequacy of these models in different contexts than those for which they were initially thought, led to the distortion and oblivion of vernacular design and processes of building (Cerqueira, 2005).

The Modern Architecture, based on industrialized materials with low thermal resistance, especially for large glass surfaces, was very vulnerable to outdoor temperature fluctuations. Therefore, to ensure indoor comfort conditions it is very dependent on mechanical air conditioning. However, in 1926, the discovery of freon and other cooling technologies, led to believe that the thermal comfort inside buildings could be achieved solely by mechanical means. The architecture of the 20th century achieved the “miracle” of making comfortable the interior of buildings, regardless of how adverse were the external environment conditions and the used building technologies.

The 40s were central for the dissemination of new air conditioning technologies. The discovery of new oil wells made the economy of certain countries to flourish and allowed the mass production and distribution of electricity. The easy availability and cheap fossil fuels and elec-

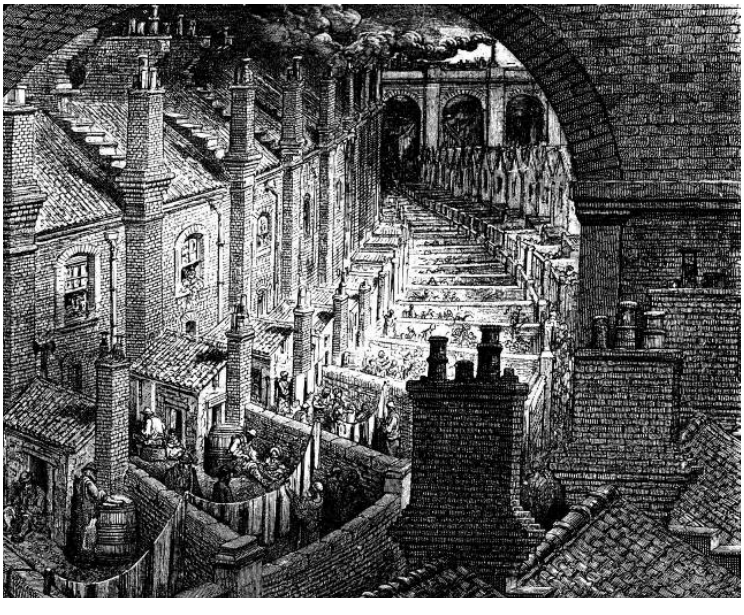

Figure 2. Drawing of the 19th century of a London’s neighborhood (Gustave Doré, “Over London by rail”, 1872).

tricity favored the quick adoption of these air conditioning technologies, destroying an architectural culture that until then was based on the direct relationship between the functional and social requirements and the adaptation of buildings to local conditions. Understood as a reflection of underdevelopment and poverty, traditional buildings have been gradually abandoned (Gallo et al, 1998).

In industrialized countries, during the beginning of the second half of the 20th century, active HVAC measures gained dominance. This situation reached its peak during the construction boom after the Second World War, in which active strategies were regarded as a simple and effective mean to meet the comfort needs in buildings. In this process, architecture has lost its connection to "site" and definitely forgot its roots.

In 1973, the energy crisis demonstrated the dependence on fossil fuels and the finiteness of resources. One year earlier, the Club of Rome published its first report with the title "The Limits to Growth" (Meadows, DL et al, 1972), gathering warnings about the need to think about the limits to growth. This report was the basis of development of the so-called "green building" concept. Its topics discussed the return to traditional ways of construction, the use of natural materials, renewable energy and solar energy. However, the discovery of new oil wells in the following years has blurred the crisis and the will to implement these ideas (Schittich, 2003).

Despite the apparent abundance of oil, research on energy efficiency has not ceased and in the 90s architecture that accompanied the trend was characterized by having a high technological content. To the large design offices was assigned the task of developing ingenious solutions aplied to promote formal quality and optimal use of energy resources, based on clean and renewable energy. Nevertheless, the goal for energy sustainability was primarily focused on developing active and intelligent solutions for the building envelope, combining sensors, new materials and increasingly complex systems (Abalos, 2009). However, sometimes this demand for technologically advanced solutions gives rise to ambiguities. The proliferation of technology without criteria created buildings controlled by the same technology, losing the relationship with the place and the local climate.

It can be affirmed that cheap industrial materials were essential to achieve economy and speed of construction. This strong dissemination allowed these materials to be imposed on the market and the traditional techniques and materials become, as still are, marginal compared to the common construction.

At the beginning of the second decade of the 21st century, is urgent the implementation of priorities to reduce CO_2 emissions and re-create a sustainable architecture. At a time when society is faced with the urgent need to reduce energy costs of buildings is appropriated to look at the strategies used in ancient times, where the energy was not readily available and machines did not exist, where builders had to study and experiment other systems that optimize indoor comfort.

2.2 *The errors of the Modern Movement.*

The Modern Movement emerges in the revolutionary context of fine arts of the early 20th century, characterized by a break with academic tradition, from which this architectural movement was not indifferent. Inebriated by new technological developments, such as the automobile, modern architecture breaked with the past and traditional ways of construction. It believed that the transformations in the living space would be reflected on the transformation of the life of every person and society in general. Animated by this belief, the modern architects wanted to teach people how to live without trying to understand in advance the specific historical conditions that shaped the ways of living of each population. They believed that all humans have the same needs, apart from their culture and geographical location (Montaner, 2001). They have assumed that the rationalistic forms and space are universal and applicable to any place on the Earth. Additionally they thought that architecture has the obligation to contribute to the mitigation of cultural and social differences , an homogeneity that would make the world a better place to live (Cerqueira, 2005). The human being was interpreted as an individual with predictable and typified behavior and whose house would be a "*machine d'habiter*", as described by Le Corbusier. The dwelling-machine, beyond the aesthetic and philosophical arguments, had in its favor the speed of construction and reduced cost, which served the objectives of the society of that time. The result was a proliferation of monotonous building types, indifferent to the places where they are built, designed only to meet the needs of an idealized inhabitant, later explained by Le Corbusier's anthropometric system of proportions "Modulor" (Montaner, 2001; Cerqueira, 2005), which is shown in Figure 3.

The main guidelines of the movement were established at the International Congress of Modern Architecture (CIAM). The Declaration of La Sarraz 1928 emphasizes the need for planned economy and industrialization, defending the introduction of normative dimensions and efficient production methods as a first step towards the industrialization of construction. This aspect is considered the initial requirement to increase building construction and to abandon traditional methods of doing it (Frampton, 2003).

Despite few examples of designing buildings to be adapted to the climate, the formal principles of the Modern Movement/International Style – transparency of façades, glass walls, the free floor plan, the architecture of the volume as a set of plans rather than as mass (Montaner, 2001) – generated buildings with low thermal performance and unsuitable to the climate of places. Analyzing these formal principles, taking into consideration their energetic consequences, it is possible to point out several weaknesses in terms of adaptation to climate conditions. The use of free floor plan allows a more direct relationship between the inner and outer environments, which leads to a greater heat loss. The separation of the façade from the building structure and the adoption of large glazed surfaces are the basis for weak inertia, resulting in higher indoor temperature fluctuations between day and night, with high solar gains (good in winter) but with high heat losses due to low thermal resistance of glass, steel and concrete (Graça, 2000). However, it should be noted that at that time the mentality believed that oil was unlimited and therefore the energy concerns were not a priority, which does not invalidate the today analysis of their errors, even if unconscious.

The absence of relationship between architecture and the place led to the rejection of the Modern Movement by citizens. From this rejection comes the need to redefine the space of dwelling taking into account the vernacular past (Montaner, 2001).

2.3 *The contribution of vernacular architecture for energy efficiency in buildings*

The vernacular architecture is one of the most significant and remarkable aspects of human intervention in the landscape, in which, in its array of types, manifest several constraints - geographical, economic, social, historical and cultural - from sites and population groups that build and inhabit them (Oliveira & Galhano, 1992). This kind of construction is characterized by being an immediate product of man's relationship with the surrounding environment, satisfying the basic need for a shelter and seeking harmony with nature. These implications are reflected in regional differences by using local materials and techniques, adapting buildings to the specific climate, family structure and its economic activity and to the community specific behavior (Galhano & Oliveira, 1992; Cerqueira, 2005).

This architecture shaped by multiple constraints is guided by the optimization of the scarce resources that people had. Nothing was wasted, neglected or ignored because communities had

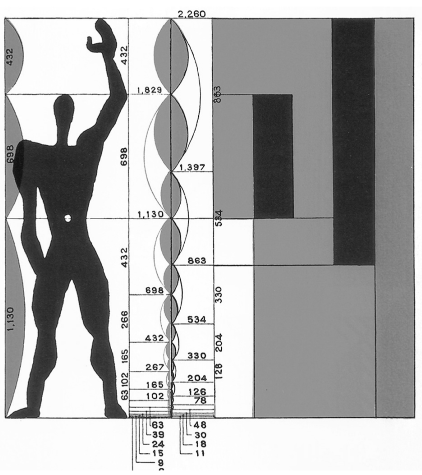

Figure 3. Modulor, Le Corbusier (1942)
(Corbusier, 1998)

the empirical notion that their welfare depended intrinsically from the equilibrium with the surrounding environment. For these reasons, the knowledge inherent to this kind of architecture should be the basis for sustainable development (Pinto, 1998; Ribeiro, 2008).

The theme of vernacular architecture continues to attract interest at international level, currently associated with the emerging consciousness of the need to promote a sustainable construction (Ribeiro, 2008). As an example, Testard-Vaillant (2007) and Martin & Cañas (2004) discussed the advantages of this architectural approach.

The recognition by many international institutions of the importance of vernacular heritage conservation is a contribution that reveals the importance of this legacy, in terms of economy and identity (MEDA-CORPUS, 2011). Examples of that include the International Council on Monuments and Sites (ICOMOS), the "Charter on the built vernacular heritage" of 1999, or the MEDA initiative with the CORPUS project - funded by the European Union - which represents a partnership between Mediterranean countries for the survey of their traditional heritage. These initiatives also enhanced the vision of this heritage, not only as a past to record and preserve, but a heritage that must evolve, as mentioned in "Charter on the built vernacular heritage" (AAVV, 1999). This document proposed general issues, conservation principles and some practice guidelines as: the importance of location; adaptation and change of uses, the importance of training professionals and communities and the exchange of expertise and experiences between regional networks, among others (AAVV, 1999).

Facing the vernacular heritage as a privileged factor of local development is the starting point to its valorization and protection. This may contribute to boost local economies through research, professional training in traditional techniques, conservation actions or adaptation of existing vernacular heritage. The spread and success of these actions may even promote the revival of small industries of traditional local materials, reducing energy needs in the production and transportation of building materials.

This relationship between the built and natural environments has long been embodied in the Roman mythological concept of *Genius Loci*, which associates to each location a divinity responsible for his fate. Therefore choosing a place to implant a building or a city would be conditioned by the characteristics and temperament of that divinity (Cerqueira, 2005). This concept was also highlighted 2000 years ago by Vitruvius. He discussed more pragmatically the importance of knowing how to choose a place to build, through the analysis of the animal's livers and plants from those locations, identifying this way the quality of water and pastures and the type of soil, among others (Vitrúvio, 2006).

The peculiarity of the place, in its holistic dimension, is probably the main constrain to the type of vernacular architectural. It was not random the way how the significant differences between the houses of northern Africa and northern Europe were coined or, in the Portuguese context, between the houses of Trás-os-Montes and Alentejo. This mutation of architectural forms emerged from the efforts to adapt buildings to provide the best conditions of comfort for their occupants. The importance of these forms on the sustainable architecture is described in a diagram created by Stefan Behling, from the Foster + Partners office, together with Arup engineering consultancy. This diagram shows two triangles questioning the future of the additive system (add layers, add expenses, add sophistication) as a support for sustainability (Figure 4). As an alternative to this system, the diagram presents a taxonomy of sustainability based on active systems, passive systems and architectonic form – with the inversion of their importance. In the inversion it is verified that the primacy is restored to the architectonic form, a change supported by architects and all those who defend the history of architectural typologies as elements that provide lessons in sustainability through the specific conditions of evolution (Abalos, 2009). However, it seems pertinent to add a new triangle to the diagram that represents the Past. This triangle is only made up of two systems: architectonic form and passive systems. This new triangle is of enormous relevance to settle the definition of the future.

The definition of the future should seek the integration between tradition and modernity, thus establishing a hybrid system that joins intelligent materials with traditional materials and allows exploring new aesthetic and functional concepts (Abalos, 2009). To ignore all the knowledge and technological potential that exists today would be a mistake, when it is aimed to achieve high-performance buildings (Leatherbarrow & Wesley, 2009).

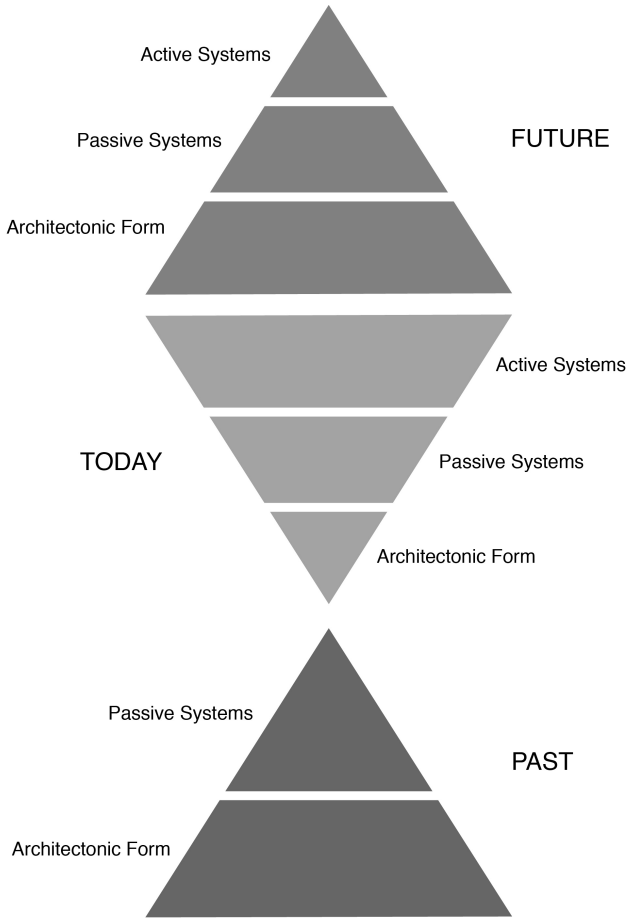

Figure 4. Behling's diagram (triangles Today and Future), (Abalos, 2009).

In the complex context in which architecture stands for, by the multiplicity of elements that generate and influence, now aggravated by the complexity of environmental issues, it is wrong to think that there is only a model of sustainable architecture (Zardini, 2009). Considering that vernacular architecture brings together in its definition the various architectural manifestations specific to each place, it is possible to say that there are several solutions to achieve a more sustainable construction. It is just necessary to look back and learn to interpret and understand the best that can be transposed to the contemporaneity, scientifically validating these solutions in order to give credibility and encourage its use.

The vernacular architecture in Portugal, for its multiplicity of types, features a profuse variety of strategies to mitigate the effects of climate. Some of those strategies are related to the discussion of energy efficiency in buildings using passive design strategies, like for instance:

- Adequate urban planning - the choice of the construction site and the organization of the villages are a reflection of different orographic, climatic, economic and social influences, of which its inhabitants try to take advantage. An example is Montes, in Vila Real, implanted in a valley on the slope facing south (AAVV, 1980), seeking simultaneous to protect themselves from wind and to capture solar gains in a region of cold winters (Figure 5). On the opposite, i.e., with the intention of reducing solar gain and promote cooling, it is possible to mention Évora. Its narrow and sinuous streets form structures of "urban-patios" that promote ventilation (air crossing) between some streets. These streets reduce the effect of strong winds and its public and private *patios* reduce the overall surfaces exposed to solar radiation. In the morning, due to their high thermal inertia, the walls and pavements of these narrow streets remain colder than ambient air temperature. Cold air is denser and therefore heavier, remaining on the streets during the morning while there's no wind. Therefore, this compact urban layout reduces the number of surfaces exposed to the sun and allows buildings to shade one another, reducing solar gains by the building envelope (Figure 6) (Fernandes, 2007);

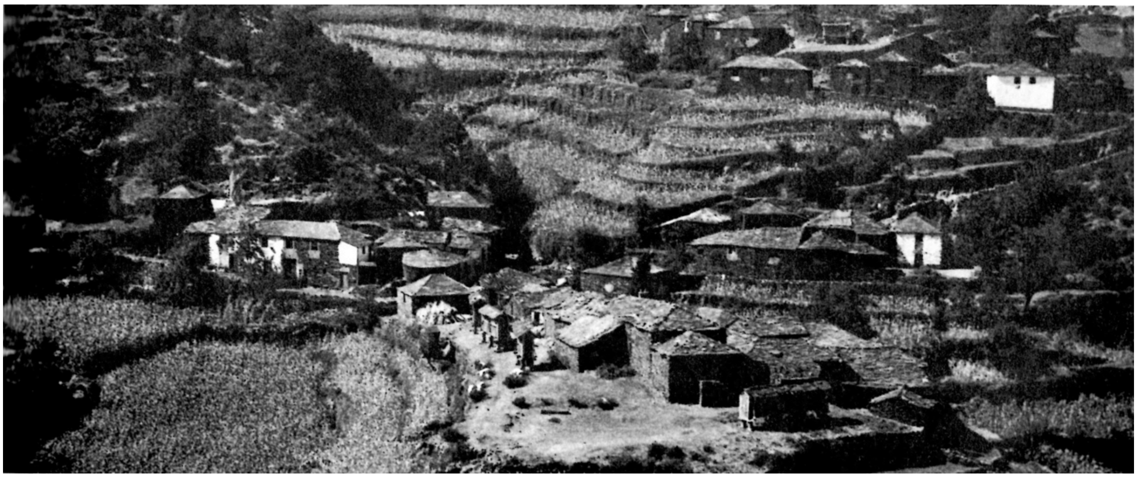

Figure 5. Montes, Vila Real, (AAVV, 1980).

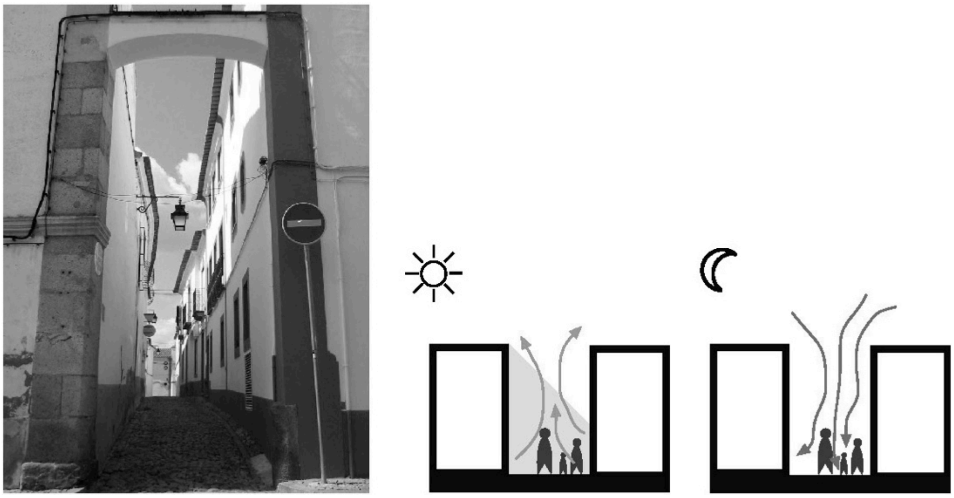

Figure 6. Street in Évora and diagrams representing the flow of air in the evening and night, dawn and early morning, respectively (Fernandes, 2007).

- Promotion of natural ventilation - the aim is to foster air circulation in the building to ensure salubrity and thermal comfort, particularly useful for overnight cooling in hot climates, without compromising security against intrusion, as shown in Figure 7 (Fernandes & Silva, 2007).
  Nevertheless, in an area with severe winters the intention is to reduce heat loss by ventilation, which explains the absence of chimneys in homes built in those areas. However, as the main source of heat at that time was the fireplace, there was the inconvenience of producing smoke that spreads through the house. One way to solve it is the strategy adopted in the houses of Paul, a small village in Beira Alta. In this village the kitchen is located on the last floor, near to the roof, in order to dissipate the smoke through the roof tiles, organizing the other rooms of the house on the floors below (Figure 7) (AAVV, 1980). A similar case, but with partially different objectives, are the houses of Malpica do Tejo. The kitchen is also located on the upper floor to evacuate the smoke, but the aim is also to avoid heat gains during the summer, something confirmed by the location of the bedroom on the ground floor (cooler area of the house);
- To reduce solar gains in summer - in the southern part of the country, in order to minimize heat gains, it is adopted several strategies, as: the reduction of the dimensions of the openings; use of a strong thermal inertia building system; and the use of light colors to reflect the excessive solar radiation. The vegetation is also often used to control solar gains and in many cases deciduous climbing plants are used to act as a thermal protector of the façades and generate a cooling effect through evapotranspiration (Figure 8) (Fernandes & Silva, 2007);

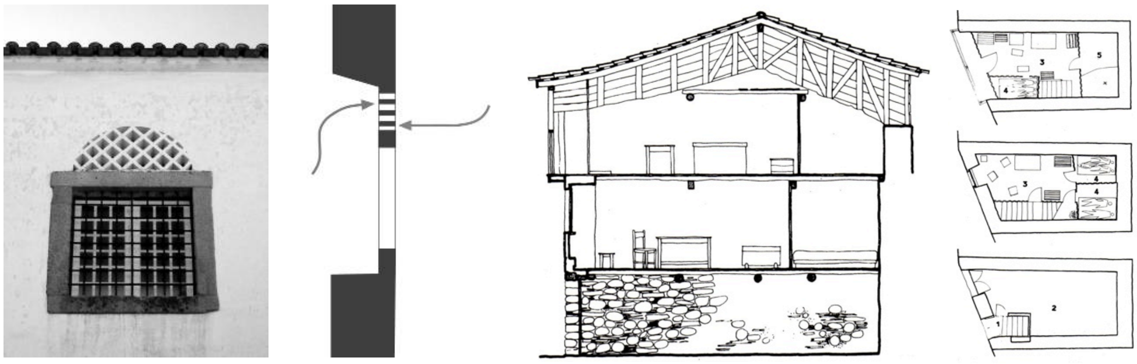

Figure 7. (left) Promotion of ventilation in a building of Évora (Fernandes & Silva, 2007); (right) Three floors house in Paul, Beira Alta (AAVV, 1980).

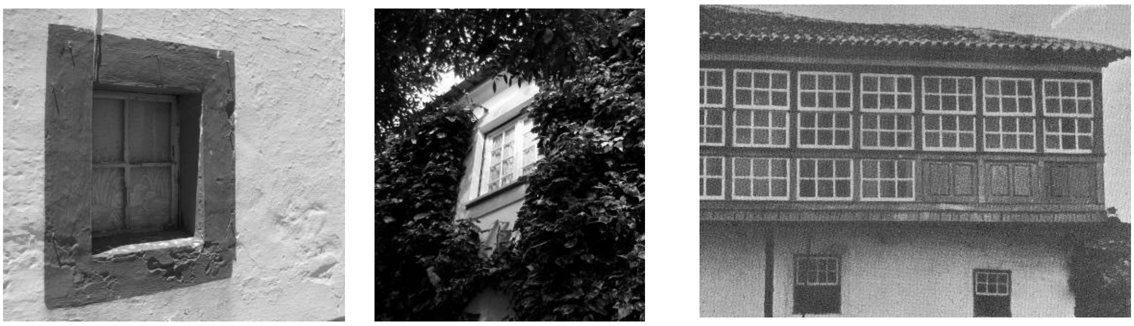

Figure 8. (left) Strategies to reduce solar gains in dwellings in Évora (Fernandes & Silva, 2007), (right) Promotion of solar gains in a house from Beiras region (AAVV, 1980)

- To capture solar gains in winter - to take advantage from the sun radiation, the balconies at Beira Alta region are elements oriented between south and west. This quadrant is the one that receives the highest number of sunshine hours with more intense radiation during the winter, and it is the most sheltered from dominant winds (Figure 8) (AAVV, 1980);
- To reduce heat losses/ to promote heat gains - the thatched roofs, by their insulating properties, are a strategy commonly used in areas with cold winters, as in the case of Bigorne in Beira Alta and Pitões das Júnias in Trás-os-Montes. The use of the culm still corresponds to the recovery of waste from the production of rye (Figure 9). Additionally, these constructions, as others in regions with cold winters, were also designed in order to limit the number and size of spans open to the outside. The example of Soajo buildings is also relevant because of their low ceilings (AAVV, 1980), which allows them to quickly warm up the indoor air.
  In Tocha, Beira Litoral region, the traditional dwellings "palheiros" had reeds inside the more exposed walls in order to perform as a thermal insulation (AAVV, 1980). However, these concerns are not limited to the building envelope and are also present in the functional organization of spaces. As example it is possible to present the case of a house in Vale de Igreja, Beira Alta region, in which the bedrooms and alcoves rarely have windows to the outside and are located around the kitchen, to take advantage from the heat generated there (Figure 9). Due to the lack of wood, right after meals families went to sleep in order to save energy (AAVV, 1980). It was also common in these regions the placement of cattle pens under the floor of the dwelling in order to use the heat generated by them.
- To promote the efficient management of resources - due to limited resources, communities tried to manage the available resources preventing waste, as exemplified by the community oven (very common in the villages of Trás-os-Montes), or the use of renewable energy by tide or wind mills. The community oven was a structure of great importance in the life of the villages. The days of operation were scaled to each family and the fire was kept constant, except on Sundays. The heat of the firewood from previous us-

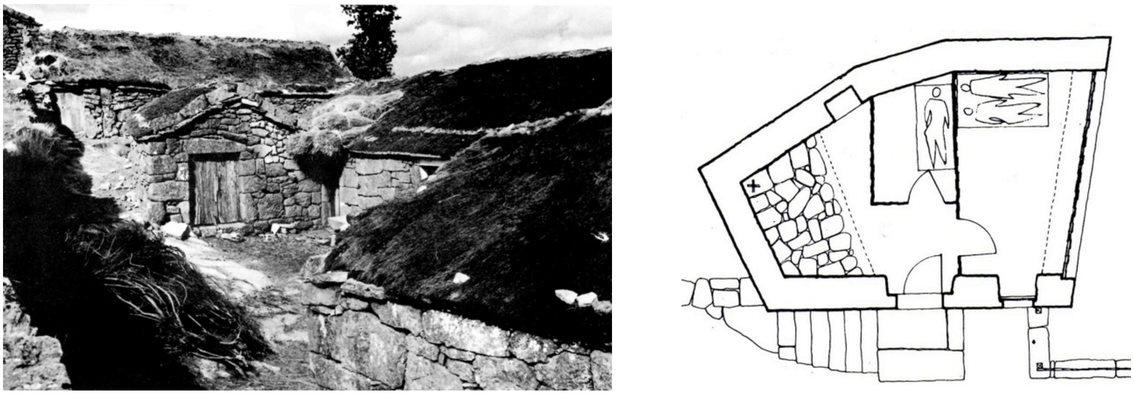

Figure 9. (left) Thatched roofs in Bigorne (AAVV, 1980), (right) Floor plan of a house in Vale de Igreja (AAVV, 1980).

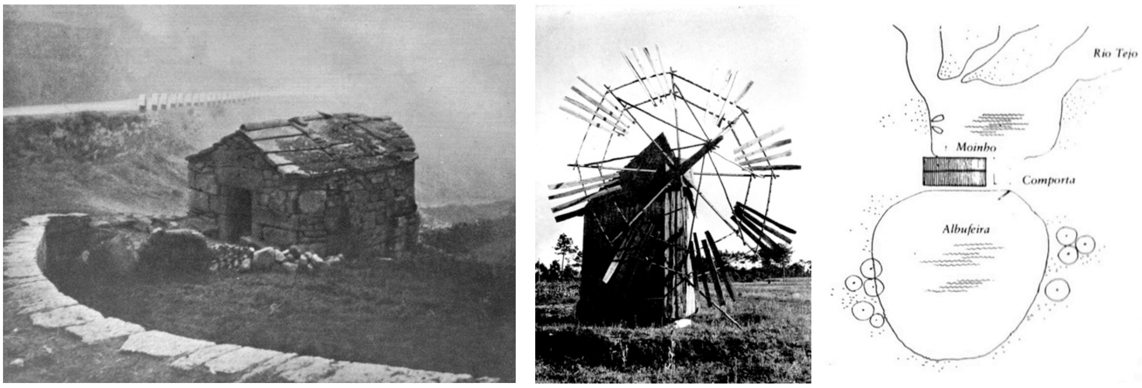

Figure 10. (left) Comunnity oven in Castanheira da Chã, (center) Orientable windmill, Tabaredes; (right) Operating plan of a tide mill in Palhais (AAVV, 1980).

ers continues to the next maintaining the optimum performance of the oven (Figure 10) (AAVV, 1980). Mills are one of the best examples of vernacular architecture that allowed exploring the use of renewable energy. This is observed in the rotation mills from Tabaredes, Cantanhede, executed in wood and with triangular shape, which allows the miller to adjust it to the wind profile. In Palhais, Barreiro, the tide mill work by the difference of elevation between the dam of the mill, which is filled with the rising tide, and the water from the stream which flows into the sea (Figure 10). When tide falls, all the water contained in the dam is forced to pass through the mill gearing up the paddles (AAVV, 1980).

3 CONCLUSIONS

Vernacular architecture is the paradigm of a close relationship between climate conditions, modeled pragmatically by the scarcity of resources. The passive strategies of environmental adaptation present in such constructions and refined over generations are particularly relevant to the challenges that the contemporary construction is facing now.

The plurality of expressions in vernacular architecture carries with it a potential of knowledge that matters to investigate and classify, from the point of view of optimizing the solar passive behavior in buildings. The application of these lessons is relevant when new buildings are known to have high energy consumption for air conditioning. In this sense, this work holistically evaluates this architectural manifestation, in the light of current knowledge, in order to find scientific justification for its knowledge in order to verify and promote its application in the future.

It is imperative that the focus is given to the design of buildings that adopt passive methods to control the indoor climate, where the mechanical systems do not be more than backup systems, used only when the endogenous resources are not sufficient to meet the comfort needs of occupants. Learning from the past, the future can use the potential of existing technology and improve it in order to change the current energy paradigm. A vernacular dwelling may not fit, in many cases, with current standards of comfort, but could give some clues about strategies to adopt to mitigate the use of non-renewable energy. Through the optimization of these strategies it will be possible to satisfy the desired standards of comfort while reducing the fossil energy consumption.

In the present context, studying the vernacular architecture is a need, as several scientific publications have come to corroborate. This type of architecture is a model of wisdom in the use of natural resources and the adaptation of building to the surrounding natural environment and therefore it could be a contribution to the sustainability of buildings. A conclusion it is possible to highlight the Indira Gandhi's inspiring reflection about traditional architecture in counterpoint with the current architecture and the need to improve and adapt the best of what has been learned over the centuries. According to this politician, *"All modern buildings require a large power consumption. Furthermore have the disadvantage of being hot in summer and cold in winter. This is not the case with traditional architecture. New techniques are needed, but we must also keep the old, bringing together the knowledge accumulated by the inhabitants for centuries, to better adapt to climate conditions, the environment and ways of life. We cannot save everything, because life evolves, but we need to adapt and improve what was acquired.*" (Gandhi, 1980).

4 REFERENCES

AAVV (1980). *Arquitectura Popular em Portugal*. Lisboa: Associação dos Arquitectos Portugueses.

AAVV (1999). *Charter on the built vernacular heritage*. ICOMOS, Mexico. Document available online at http://www.international.icomos.org/charters/vernacular_e.pdf and accessed on July 10, 2011.

Abalos, I. (2009). *Beauty from Sustainability?.* Harvard Design Magazine 30: (Sustainability) + Pleasure, vol.1; Harvard Unversity Graduate School of Design, Cambridge, p. 14-17.

Adagio (2007). Image available on the internet at http://ookaboo.com/o/pictures/picture/157771/ and accessed on July 10, 2011.

Bellanger, B.; Lallement, L. (2008). *Une Terre pourtant pleine de ressources*. Science & Vie – Hors Série, n.º 243, p. 35-54, Juin

Cañas, I.; Martín, S. (2004). *Recovery of Spanish vernacular construction as a model of bioclimatic architecture*. Building and Environment; n.º 39, p. 1477-1495.

Corbusier, Le (1998). *Le Corbusier 1910-65*. Barcelona: Editorial Gustavo Gili SA.

Cerqueira, J. (2005). *O Estilo Internacional Versus Arquitectura Vernácula: O Conceito de Genius Loci*. Idearte – Revista de Teorias e Ciências da Arte – Ano I, N.º 2 (Abr/Jun – 2005), p. 41-52. Document available online at www.idearte.org/idearte-vol-2/ and accessed on July 10, 2011

EPBD (Energy Performance of Buildings Directive), Directive 2010/31/UE

Frampton, K. (2003). *História Crítica da Arquitectura Moderna*. São Paulo: Martins Fontes.

Fernandes, J. (2007). *Arrefecimento passivo na arquitectura de Évora*. Trabalho de final d, curso. Licenciatura em Arquitectura, Universidade de Évora.

Fernandes, J.; Silva, J. (2007). *Arrefecimento passivo na arquitectura tradicional de Évora*. Coimbra: Congresso Construção 2007 - 3.º Congresso Nacional, Universidade de Coimbra.

Gallo, C.; Sala, M.; Sayigh, A.A. (Ed.) (1998). *Architecture: Comfort and Energy*. Pergamon.

Gandhi, I. (1980). Taking an 'all round attitude' to science. Nature, Vol. 285, n.º 5761, p. 127-130. May.

Goitia, F. C. (1996). *Breve História do Urbanismo*; Lisboa: Editorial Presença, 4.º Edição.

Graça, J. M.(2000). *Arquitectura e clima, por quê?*. Arquitectura e Vida; n.º 4, p. 60-62, Maio.

Gryffindor (2008). Image available on the internet at http://ookaboo.com/o/pictures/picture/25660518/ and accessed on July 10, 2011.

Leatherbarrow, D.; Wesley, R. (2009). *Frameworks of Performance and Delight*. Harvard Design Magazine 30: (Sustainability) + Pleasure, vol.1; Harvard Unversity Graduate School of Design, Cambridge, p. 84-95.

Meadows, D. H.; Meadows, D. L.; Randers, J. (1972). *The Limits to Growth: a report for the Club of Rome's project on the predicament of mankind.* New York: Universe Books.

MEDA-CORPUS (2011). Document available online at www.meda-corpus.net and accessed on July 10, 2011.

Montaner, J. M. (2001). *Depois do movimento moderno, Arquitectura da segunda metade do séc. XX.*

Barcelona: Editorial Gustavo Gili, SA.Oliveira, E. V.; Galhano, F. (1991). *Arquitectura Tradicional Portuguesa*. Lisboa: Dom Quixote.
Pinto, F. (1998) – O nosso passado terá de estar no nosso futuro. In Teixeira, G. B.; Belém, M. C.; *Diálogos de edificação: estudo de técnicas tradicionais de construção*; Porto: CRAT – Centro Regional de Artes Regionais, p. 144-149.
PhotoXpress (2011). Image available on the internet at http://www.photoxpress.com/stock-photos/tree/old/wood/3378326 and accessed on July 10, 2011. Authorship of Inger Anne Hulbækdal.
Ribeiro, V. (coord. geral) (2008). *Materiais, sistemas e técnicas de construção tradicional: Contributo para o estudo da arquitectura vernácula da região oriental da serra do Caldeirão*. Edições Afrontamento e CCDR Algarve.
Schittich, C. (Ed.) (2003). *InDetail, Solar Architecture*. München: Institut für Internationale Architektur – Dokumentation GmbH & Co.
Testard-Vaillant, P. (2007). *Architecture – Les leçons du passé*. Science & Vie – Hors Série, n.º241, p. 68-77, Decembre
Torgal, F. P.; Jalali, S. (2010). *A Sustentabilidade dos Materiais de Construção*. TecMinho.
Vitrúvio (2006). *Tratado de Arquitectura*. Lisboa: IST Press, Instituto Superior Técnico.
Zardini, M. (2009). *(Against) The Greenwashing of Architecture.* New Geographies 2: Landscapes of Energy; Harvard University Press, Cambridge, p. 139-147.