LA MEDITERRANEA VERSO IL 2030

Studi e ricerche sul patrimonio storico e sui paesaggi antropici, tra conservazione e rigenerazione

a cura di Marina Mistretta, Bruno Mussari, Adolfo Santini

Risparmio energetico negli edifici mediante adozione di eco materiali e tecniche di Bio Edilizia.

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Obiettivo. L'obiettivo di ridurre i sovra consumi energetici negli edifici e promuovere le città post-carbone può essere raggiunto adottando diverse misure ad opera di individui, imprese, costruttori, governi. L'isolamento termico degli edifici, o "passivazione" risulta essere uno dei più importanti investimenti per raggiungere questi risultati.
*Metodi e Soluzioni. L'isolamento termico (o "passivazione") può essere realizzato con pannelli di sughero, che è un materiale naturale e rinnovabile. Esso stesso è il risultato dell'eliminazione (*sequestration*) della* CO_2*. Non solo, è un depositi di C. Può quindi efficacemente contribuire a realizzare concretamente lo Post Carbon City migliorando l'isolamento ed eliminando lo spreco di energia. Ampliare le aree occupate da sugherete aumenta in modo permanente l'assorbimento e la eliminazione definitivo ovvero il sequestro della* CO_2*.*
Risultati e Benefici. Solo alcuni dei primi benefici derivanti dalla policy *integrata* natura-based *sopra sintetizzata.*
(a) La CO_2 *non solo si sequestra e si elimina dall'atmosfera ma addirittura viene utilizzata dalle sughere per crescere e per produrre il sughero; (b) Si rendono disponibili nuovi quantitativi di sughero grezzo, come materia prima versatile; (b) Utilizzando i lavorati per la passivazione dei Bio Edifici Verdi, non solo si risparmia energia, ma anche si abbattono le conseguenti emissioni di* CO_2*.*

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Building Efficiency Adopting Ecological Materials and Bio Architecture Techniques

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Planet and mankind are facing the extreme risk of ecological crisis caused by Global Warming, a consequence of severe Climate Change on the Earth, originated by pollution and fossil energy over burning.

Hundreds of scientists have been working hard setting up systematic knowledge and incontestable proofs concerning the extreme risk of the present negative ecological trends, collected in several Reports[1] of the IPCC, Inter - governmental Panel for Climate Change.

Following directions of IPPC, hundreds of country governments try to tackle pending environmental disaster, pledging to lower down planet global warming by emission mitigation during the decades following. Consequently, governments signed Kyoto Protocol (1997: 144 countries over 192) and Paris Agreement (2016; signatories: 195).

Additionally, to tackle, mitigate and solve climate change tragedy and prevent potential Planet destruction, world leaders adopted (2015) the "United Nations 2030 Agenda for Sustainable

The authors contributed equally to the article. The introductory paragraph; *Research Problem*; *Research Methodology* are to be attributed to Mariangela Musolino. The paragraphs *Aim of Research...; Compare Building Energy...; Estimate of Energy Consumption...* are to be attributed to Alessandro Malerba. The paragraphs *Cost of Cork...; Results* are to be attributed to Pierfrancesco De Paola. The paragraph *Conclusions* is to be attributed to Carmelo Maria Musarella.

1. IPCC 1990; IPCC 1995; IPCC 2001; IPCC 2007; IPCC 2014; IPCC 2018.

Development", encompassing "17 Sustainable Development Goals" or "17 SDGs". The Goal 13 is devoted to: *Take urgent action to combat climate change and its impacts*.

Specific sub Goal 13.01. is devoted to: *Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries*.

Specific sub Goal 13.02. is devoted to: *Integrate climate change measures into national policies, strategies and planning*.

The present paper would be a research, a valuation experimentation and a design simulation devoted to fully implement "United Nations 2030 Agenda for Sustainable Development" under the Goal 13 *Take urgent action to combat climate change and its impacts*, the sub Goal 13.01. *Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries*and the sub Goal 13.02. *Integrate climate change measures into national policies, strategies and planning*.

Today fossil energy consumption has increased dramatically, especially in urban areas. Buildings are among the largest consumers of energy. Recent research has shown how energy consumption in the world has increased also because air conditioning in urban buildings has increased significantly in order to reach comfortable living temperature.

Energy policies must be based on the more efficient use of energy, especially in construction, planning to regenerate existing settlements.

Consequently, common goals of individuals, people, society, economy, Institutions must be, first, the physical rehabilitation of the buildings through restoration interventions, instead of new development and novel constructions, and, second, the implementation of an ecological process of building energy structural permanent saving through bio ecological retrofitting.

Research Problem

The Planet's environmental crisis is caused, among others, by fossil energy over consumption after people metropolitan concentration: more than 50% of the population live in urbanized areas and this will rise to 66% in 2050. Consequence of over fossil energy consumption is unequivocal Climate Change in direction of Global Warming and its negative spillovers: increasing of global air and ocean temperatures; rising of global average sea level; reductions of glacier, ice and snow surfaces. The forecast for the end of the century is: temperature increases of 3 to 6 °C, extreme weather phenomena intensification, reduced levels of regular rain in various areas. The sectors that consumes this 40% of total yearly used energy are the civilian and the building industry. Contemporary

Prototype	l (m)	w (m)	h (m)	S (m²)	V (m³)
01.SuberType BAS	5,05	5,05	3,19	25,50	81,35
02.Subertype BAS + Cork	5,12	5,12	3,19	26,21	83,62

Table 1. Comparison between the BAS prototype and BAS + Cork prototype dimensions (Author's own compilation).

buildings (80% of the existing total) are mostly to blame because they have an excessive consume of energy. They consume (per unit) much more energy than historical buildings with thick walls. The metabolism of modern building is different that of historical building, which used larger thicker walls and natural materials. Consequently, it is important to decrease energy consumption specially in modern buildings.

Aim of Research: Prototypes of Alternative Scenarios[2]

This research aims to verify, in advance, the possible positive impact of insulation using cork panels in terms of energy efficiency in common buildings and to estimate both initial investment costs, and the permanent saving in energy management. The scope of this research is focused on integrated ecological - energy - economic valuation of buildings. The research includes the innovative comparative test of a shelter built in two different modes of construction (usual=common *versus* sustainable=ecological) and the research consider two virtual different buildings. In fact, testing will not be carried out on a single case study, but on two virtual prototypes buildings which are equal in size but alternative in the materials used and then in the respective thermal behaviors. The virtual two "alternative" prototypes used are very small (Table 1), simply built units where the building energy performances can be easily checked. These are the minimum units of meters (5x5x4) that can be valued for multiple residential, tertiary and productive uses including agricultural, zoo-technical and forestry. The prototypes are simplified architectures with extreme characteristics, like single-storey cubes. The use of bio cork panels is in the underlying conditions of certain energy assessment instruments (BEPSP). Use of bio cork shall constitute a general advantage for: society, economy, ecology, energy balance, all actors of the process. These prototypes, previously designed, are described below (fig. 1).

2. Crawley *et alii* 2001; Yilmaz 2007; Crawley *et alii* 2008; Stoakes 2009; Rallapalli 2010; Sousa 2012.

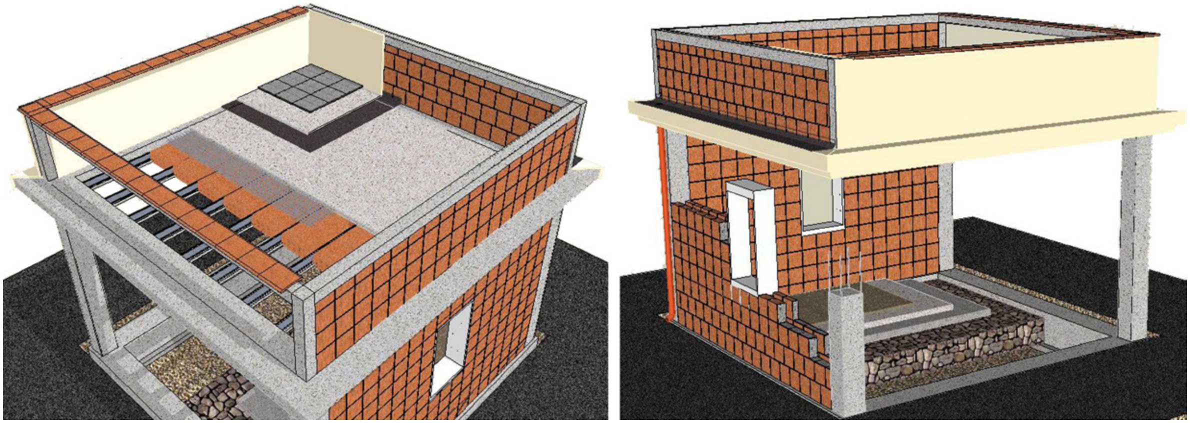

Figure 1. Prototype Building. “Common” (Business As Usual = BAS) scenario (Author’s own compilation).

First Scenario. “Common” (Business as Usual = BAS)

The “Business As Usual, BAS” building units have been constructed adopting the commonly–used procedures and the materials of southern Italy. It consists of a common punctiform structure in reinforced concrete (base beam, pillars, flat roof slab) and the usual buffering in common bricks (flanked, not confined, non-cooperative).

Commonly – used (external - internal) plasters is in cement-based mortar, or in industrial hydrated lime plus cement – based mortar.

This plaster is made up of three or four layers (bridge of adhesion; plaster = rustic; civil = shaving = finish; eventual putty or smooth finishing with American metallic spatula) plus the generally synthetic color.

Second Scenario. Sustainable “BAS + Cork”

It is the same of BAS without plaster, unless a flat surface for panels around 1 cm. There is therefore an addition of cork panel components with a thickness of 6 cm (6+1 plaster = 7cm), both horizontal (above the floor or attic, under crawl space) than vertical (external walls) either: or during the new construction or as an ecological retrofitting of the same BAS unit.

Research Methodology

The research activity carried out is structured in four main steps shown below.

- The design of the two different architectures or mode of construction (buildings; units; details) in order to simulate: adoption of the components in cork; against their failure to adopt.

- The creation of a first module containing all the information machining necessary for construction, including a relative micro-economic Analyses of the Elementary Factors (EFA) such as manpower, materials, machineries.

- The market price repertoires of these factors employed.

- The estimating the total monetary costs of the resources needed for the initial investment, for the realization of two alternative buildings.

The research involves the set up of the databases which will allow the researchers to forecast:

- the different thermal behaviors of materials used in the buildings to be compared;

- the ecological footprint in terms of emissions of the different alternative prototypes.

In order to obtain scientific quantitative results this information was translated into purely monetary and financial terms of induced impacts (or not) of taking into consideration the adoption and implementation of cork panels for passivation *id est* thermal insulation and moisture condensation regulation.

There are several aspects to the impacts that the use of cork can make, the most important and the most immediate of which are physical and financial:

- the increased energy efficiency, i.e. lower energy consumption, expressed in kWh per m^2, and then perpetually smaller energy bill

- the consequent increased health and sustainability of the everyday life into ecological shelter, and the more effective climatic management of buildings.

Compare Building Energy Performance Simation Programs, BEPSP

Research performs the valuation of energy consumption in kWh and CO_2 emission in kilos, per m^2, per year in two different scenarios: Sustainable *versus* Common. This will be performed by means of three very different Building Energy Performance Simulation Programs, below described.

Energy Plus. (Version 8.3.0) Together with Design Builder (Version 4.5.0.178) it is one of the best known energy simulation software tool. It is a software for thermal simulation and energy diagnosis in

Scenarios	Energy Plus		Termus		Blumatica energy	
	EPgl kWh/m² y	CO_2 Kg/m² y	EPgl kWh/m² y	CO_2 Kg/m² y	EPgl kWh/m² y	CO_2 Kg/m² y
01.BAS	129	15	114	24	116	11
02.BAS + cork	73	9	69	15	71	8
Δ	–56		–45		–45	

Table 2. Comparison of output from three various simulation software tools (Author's own compilation).

	Energy Plus D	Termus Δ	Blumatica Energy Δ
EPgl	0,44 %	–40%	–39%
CO_2	0,43 %	–36%	–26%

Table 3. Differential (kWh/m²/year consumption, Kg/m²/year emissions) between BAS and Bio Eco Scenarios (Author's own compilation).

dynamic building arrangements. There are external graphical interfaces, like Design Builder and others, that facilitate the creation of the thermal model of the building and the inclusion of its characteristics.

TerMus. (Version 30.001) Is an Italian software used for the thermal engineering and energy performance of buildings. Energy certification (APE-AQE), calculation of transmittance and drafting Protocol Itaca are some of the outputs of this software. It is regarded as standard (and popular) software in Italy.

Blumatica Energy. (Version 6.1) It is an accessible software that allows the planner to design the thermal insulation of buildings and the management of their energy certification.

Estimate of Energy Consumption and CO_2 Emissions of Prototypes

Estimate of energy consume kWh/m²/year were carried out on two prototypes (BAS and BAS + Cork), using the three BEPSP above cited, each having its own characteristics (Table 2).

Valuation compares energy consumption (kWh) and CO_2 emissions (Kg) assesses (Tables 3-4) and compare them with the monetary costs of construction and insulating materials (Table 5). The software provided the following output regarding:– Global Primary Energy (EPgl) which demonstrates the efficiency of the building and the system used for the heating and hot water; – CO_2 that the building and the systems release in the environment (Table 3).

Yearly difference in consumption is in Kwh: 3.289-1.913=1.400.

Given a 0,40 €\kWh final cost, year saving or year monetary difference is: € 560.

Scenarios	A m²	EPgl kWh/m² y	EPgl kWh	CO_2 Kg/m² y	CO_2 Kg
01.BAS	25.50	129	3,289	15	382
02.BAS + cork	26.21	73	1,913	9	235

Table 4. Total energy consumption (kWh) and CO_2 emissions (Kg) in Scenario 01 and Scenario 02 in the year (Energy Plus tool) (Author's own compilation).

Prototype	01.BAS	02.BAS + cork	Δ	%
Tot €	37,156	40,378	+3,221	08,66
Tot €\m²	1,456	1,540	+83	
Tot €\m³	364	385	+20	

Table 5. Comparison of the building costs of the 2 prototypes. Light Δ cost of sustainability (Author's own compilation).

Cost of Cork in the Construction and Pay Back Time

Based on analytical and detailed estimate, this research has forecasted the financial costs involved in the construction of the two alternative scenarios (Table 5).

€ 3.221 is the difference to be paid back by saving. Following financial estimate define the pay back period.

Given different interest rate of from 4% to 2% to 0%, the light extracost for bio eco passivation of building in second scenario will be paid back in few years (Table 6).

Results

Passivation using bio cork paneling have multiple impact.

The research carried out here shows in quantitative terms that the adoption of cork panels creates saving and a measurable positive difference in the energy and ecological management of building, even in though there is an initial higher technical cost in construction. In this way the planner can succeed in achieving multiple perpetual benefits, regarding energy saving and consequent CO_2 emission reduction that can be quantified: in Case Study energy consumption, [kWh\m²\Year], in theory can be reduced from 129 to 73, the difference in saving being −44%, with conventional class improvement from F to C; CO_2 emissions can be reduced from 15 to 9 kg\m²\Year, i.e. −6 minus which is − 43% (Table 4, fig. 2).

extra cost 3.221			i=4%.		saving	i=2%.		saving	i=0%.
year	saving				npv i=4%	5		npv i=2%	npv i=0%
1	590		0,9615	567,285	567,29	0,9804	578,436	578,44	590,00
2	590		0,9246	545,514	1.112,80	0,9612	567,108	1.145,54	1.180,00
3	590		0,8890	524,510	1.637,31	0,9423	555,957	1.701,50	1.770,00
4	590		0,8548	504,332	2.141,64	0,9238	545,042	2.246,54	2.360,00
5	590		0,8219	484,921	2.626,56	0,9057	534,363	2.780,91	2.950,00
6	590		0,7903	466,277	3.092,84	0,8880	523,920	**3.304,83**	**3.540,00**
7	**590**		**0,7599**	448,341	3.541,18	0,8706	513,654	3.818,48	4.130,00
8	590		0,7300	430,700	3.971,88	0,8535	503,565	4.322,05	4.720,00
9	590		0,7000	413,000	4.384,88	0,8368	493,712	4.815,76	5.310,00
10	590		0,6800	401,200	4.786,08	0,8203	483,977	5.299,73	5.900,00
11	590		0,6500	383,500	5.169,58	0,8043	474,537	5.774,27	6.490,00
12	590		0,6200	365,800	5.535,38	0,7885	465,215	6.239,49	7.080,00
13	590		0,6000	354,000	5.889,38	0,7730	456,070	6.695,56	7.670,00
14	590		0,5800	342,200	6.231,58	0,7579	447,161	7.142,72	8.260,00
15	590		0,5600	330,400	6.561,98	0,7430	438,370	7.581,09	8.850,00
16	590		0,5300	312,700	6.874,68	0,7284	429,756	8.010,84	9.440,00
17	590		0,5100	300,900	7.175,58	0,7142	421,378	8.432,22	10.030,00
18	590		0,4900	289,100	7.464,68	0,7042	415,478	8.847,70	10.620,00
19	590		0,4700	277,300	7.741,98	0,6864	404,976	9.252,68	11.210,00
20	590		0,4600	271,400	**8.013,38**	0,6730	397,070	**9.649,75**	**11.800,00**

Table 6. Payback of differential initial cost € 3.221 . Energy saving Net Present Value at 4%, 2%, 0% interests (Author's own compilation).

Researches detected that bio eco green buildings have selling price higher (if compared to common building, no green) in the real estate market[3].

Green building strategy extended at urban level allows to start the Post Carbon Historic Centers, University and City built up.

Using Cork enlarge area devoted to Cork Oak forest and enhances landscape.

In conclusion, research shows that just the only one improvement of the cork panels adoption has several significant positive impacts even in landscape shaping[4].

Conclusions

The comparison of the two prototypes buildings allows for a quantitative valuation of their different energy consumption, in terms of kWh, and CO_2 emissions. At the same time it provides proof of the effectiveness of Cork in its application in construction as a thermo-insulating and phase retardant material. Healthiness and energy efficiency are the final goals of the Strategy. From the

3. Musolino, Massimo 2013; Massimo 2015; Massimo, Cefalà 2016; Massimo *et alii* 2016; Malerba, Massimo, Musolino 2018; Del Giudice *et alii* 2019; De Paola *et alii* 2019; Malerba *et alii* 2019; Massimo *et alii* 2019; Musolino, Massimo 2019; Spampinato *et alii* 2019.

4. Massimo *et alii* 2019.

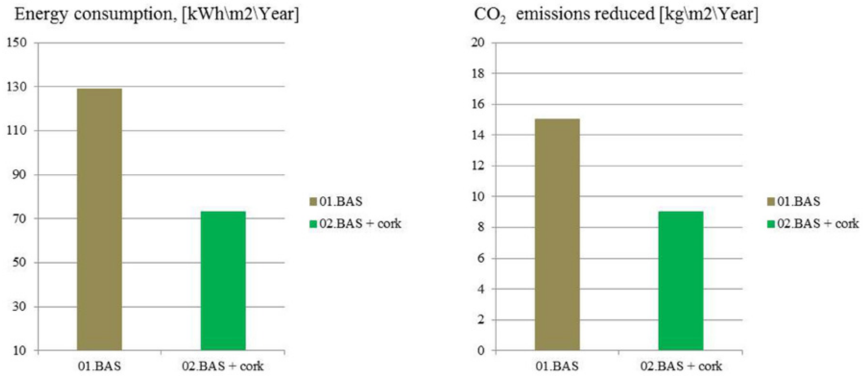

Figure 2. Differentials (Δ) annual Energy consumption (- 44%) and CO2 emissions (- 43%) in the two scenarios (Author's own compilation).

energy and economic valuation the high positive impact of the use of cork panelling (or granulated in mortar) in buildings is evident when compared to its non-adoption. The two most visible results are the consequent: lower energy consumption; lower ecological emissions. Future developments in research will valuate in multi-dimensional terms healthier indoor and outdoor environment due to mitigated pollution and geo strategic independence from the cycle of oil due to radical saving above demonstrated (it is the import substitution). All the above possess a relevant economic and ecological value. This research ascertained the very important coherence, convergence and similar outcomes of three very different "Building Energy Performance Software Program", or BEPSP, namely EnergyPlus, Termus, Blumatica.

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