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Energy redevelopment of historical centres in the pursuance of the cost-effectiveness principle

Maria Fiorella Granata[1]

Abstract. In historical centres the search for architectural and plant design solutions for the achievement of higher energy and environmental performances of buildings has to reconcile the preservation of the peculiarities of the building stock on the one hand and the economic efficiency of the interventions on the other one. The cost-effectiveness principle, which is adopted by European policies for the improvement of energy performances of the building stock, may be satisfied through the use of specific macro and micro-economic valuation models.

Keyword: cost-effectiveness; energy redevelopment; historic centres; operational model.

1. Introduction

The improvement of efficiency in energy use is a global objective for the need to combat climate change [1] and handle the critical issues related to energy supply in many countries [2]. Negative effects of non-efficient energy use impacts also on human health and quality of life [3].

Climate change is an ominous phenomenon affecting rural, natural, and urban areas on all sides of the world. Main risks of climate change for urban areas concern air pollution, heat waves, extreme precipitation and storm events, inland and coastal flooding, landslides, increased drought and water scarcity [4]. Other damaging effects are also the distributive impacts on poor populations in both rich and poor nations due to the less capacity to respond to them [5].

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It is recognized that cities are responsible for the global climate change owing to their important contribution to the production of greenhouse gases, but they have great opportunities for reducing it nevertheless [1, 6]. In particular, the urban stock of building is considered a key sector for its potential in reducing the impacts of cities on climate change [6].

Almost all the nations of the world have recognized the importance to manage the worrying aforesaid phenomena and recently committed themselves to tackle the problem [1].

The European Community has integrated the improvement of efficiency in energy use into policies on buildings and recognized, since the initial directives for energy efficiency (93/76/EEC and 2002/91/EC), the strategic importance of the economic factor in energy improvement, proposing the cost/benefit principle as a criterion for decision in the definition of measures to improve the energy performance of the stock of buildings.

After anticipating the Community regulation on the Energy efficiency with the law no. 10/1991, which was not mostly accomplished for a long time, Italy provided itself with a National Energy Strategy and a National Action Plan for Energy Efficiency, which involve the civil building sector whose final energy consumption is about a 39.1% of the global national one [7]. Since 2005 Italy has adopted a series of measures for the implementation of EU directives in energy efficiency matter, which require the identification of optimal levels of energy performance based on the criterion of the global cost.

This work focuses the energy redevelopment of historic centres, since almost a 50% of the Italian stock of residential building was built up before the year 1961 [8]. The improvement of the energy performance of buildings can be an objective compatible with the needs of conservation even of historic buildings, provided that the specificities of each case are taken into account.

This paper is organized as follows. First the identifiable relationship between energy improvement and the real estate market in Italy (section 2) and the role of the cost-effectiveness principle in energy policies for the management of the stock of buildings according to the macroeconomic and microeconomic points of view (section 3) will be outlined. Then the specificities of the energy redevelopment in the historic centres will be discussed, also in relation to the applicability of Italian tax and financial reliefs (section 4). Finally an operational model for the energy requalification of historical centres will be proposed (section 5) and some concluding remarks will be given (section 6).

2. Energy redevelopment and real estate market in Italy

The market value of a building is made up of a natural component, resulting from the cost of production factors and services used and covering a rate of normal profit, and a speculative component resulting from a complex of micro and macroeconomic factors [9] influenced by cultural, political and socio-hermeneutical tendencies [10, 11].

Empirical evidence shows that, in general, buildings with higher energy performance have higher cost of construction [9], but also a value advantage of the order of 5-12% on the Italian real estate market [12], with a market price premium for increase of energy class that is stronger between lower classes that between the higher ones [13].

The energy certification of buildings, introduced by the Law no. 10/1991, Article 30, has become mandatory in Italy for the alienation and the lease of the properties since 2007 as a result of the Legislative Decree no. 192/2005, Article 6. The data above mentioned confirm that the "energy performance" of buildings, as it is defined by the Ministerial Decree of June 26, 2015, assumes an explicit role in the real estate market. While the analysis of the financial feasibility of an investment according to the different points of view of the manufacturers, the owners and the users of the buildings would lead each of these actors to focus their interest to the energy aspects of different stages of the life cycle of buildings [14], the certification of the energy performance, giving an economic role to the energy quality in the real estate markets of sales and leases, has the merit to converge the different positions, involving directly or indirectly the economic actors in all phases of the life cycle of the buildings.

3. The cost-effectiveness principle in the energy policies for buildings in Italy

The need to contrast the global climate crisis cannot escape the consideration of the economic and financial feasibilities of interventions on buildings. Otherwise, the search for the optimal solution in terms of energy savings profile could result in an unnecessary dissipation of financial resources diverted from other public and private uses.

The reconciliation of the improvement of energy performance with economic and financial feasibilities has assumed full centrality in Directive 2010/31/EU on the energy performance in buildings, which was implemented in Italy with the Decree Law 63/2013. The Directive 31/2010/EU introduces, by the Regulation (EU) no. 244/2012, a benchmarking mechanism to determine optimal levels of cost to be used to formulate energy prescriptions for buildings, taking into account the outdoor climatic and local conditions (Article 1, paragraph 1). In order to define regulations applicable at national level, the Regulation requires the identification of optimal levels of energy performance based on the criterion of the overall cost, relative to the reference buildings which represent the whole typological and constructive categories of buildings.

The "'cost-optimal level' means the energy performance level which leads to the lowest cost during the estimated economic lifecycle"[1] (Article 3, paragraph 14). In economic and estimative terms, it needs to identify the highest level of effectiveness of interventions for the energy quality of the buildings achievable with permissible levels of cost, taking into account the local climatic conditions. Where subsequent modest energy efficiency improvements would result in higher incremental financial commitments there would be less investment opportunities.

The Directive founds the calculation of the optimal levels of energy performance in a function of cost on the energy "global cost" methodology (UNI EN 15459: 2008), and proposes to adopt the "microeconomic" ("financial") approach or the "macroeconomic" approach. The first one corresponds to a private perspective, whilst the second one fits the public point of view.

The global cost includes the initial investment cost, the annual costs (running and replacement cost) and the final value, or, where applicable, the disposal cost. Moreover, in the "macroeconomic" view, the cost of greenhouse gas emissions in terms of the monetary value of environmental damage caused by the building must be added (figure 1).

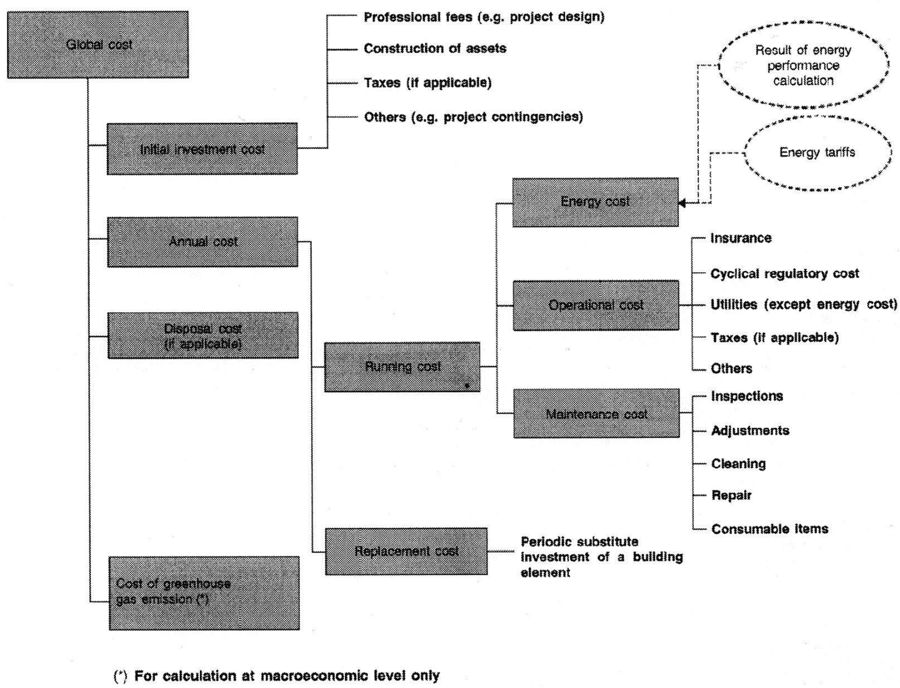

Fig. 1 - The global cost according to the framework methodology
Source: European Commission, Communication 2012/C 115/01, p. 16.

In the microeconomic evaluation approach, we consider only the costs and monetary benefits arising directly from an investment, taking into account market prices, applicable taxes and subsidies, but excluding the costs of environmental damage caused by greenhouse gases and other pollutants. In view of the provisional nature and, however, of the variability of energy incentives, the Regulation allows the possibility of calculating the total cost from the microeconomic point of view neglecting the subsidies for private investors. In this case, any gains arising from the energy produced will not be considered. Discount rates consistent with market conditions will be used.

In the public or "macroeconomic" perspective the costs and benefits indirect and induced by a certain investment in energy efficiency must be considered, which apply to other entities different from investors. In this case all the taxes, incentives and applicable subsidies are excluded from the calculation of the total cost, while the costs generated by the emission of gases that alter the climate and other pollutants are included. Discount rates compatible with the strategic priorities and the general economic conditions of member states will be adopted.

In the financial and public approaches, the discount rates to be used for the sensitivity analysis must be expressed in real terms.

For the operational purposes it is relevant to note that the estimate of the overall cost in both types of calculation provided by the Regulation have restrictions of validity. In general, the financial analysis carried out for the reference building does not necessarily provide the best results for the individual investment decisions: The sustainable solution for energy improvement actually depends on the specific building and on individual financial perspective of the investor. With regard to the macroeconomic analysis, the monetary approach is not able to seize all the externalities of an investment for energy improvement to society, since some benefits are intangible and cannot be monetized or may still entail in significant difficulties for monetary quantification.

4. Energy redevelopment and historical centres

4.1. Peculiarities of energy redevelopment of ancient buildings

The improvement of the energy performance intends to contain the operating costs of buildings. This objective is not considered feasible only for recently built or new buildings, but it is compatible with the needs of conservation of historic buildings, even under a protection regime. In fact, the Legislative Decree on the energy performance no. 192/2005, Article 3, paragraph 3a, recently amended by the Law no. 90/2013, limits the derogation to its application to cultural heritage, including the historic centers, in the one case in which it is ascertained that the fulfillment of energy requirements involves substantially distortions of their character or appearance, with particular reference to historical, artistic and landscape patterns.

In general, the energy redevelopment of buildings in historic centers poses particular constraints arising from compliance with traditional forms, materials and building techniques. The identification of redevelopment interventions presents even greater difficulties in the cases where protection restrictions on built heritage are in force, imposing the respect of the original buildings to preserve their "expressive authenticity" (Venice Charter for the restoration and preservation of monuments and sites, 1964).

To deal with the specificities of the energy qualification of the historic buildings, the Ministry of Heritage and Culture and Tourism prepared special guidelines aimed at combining the optimization of energy performance with any existing constraints on the building [15]. The guidelines provide direction on methods for conducting the energy audit, the identification of opportunities for energy savings, and the operational phase of the intervention on historic buildings.

4.2. Applicability of the Italian tax and financial reliefs for the energy redevelopment of historic buildings

The European Community regulations provide that the calculation of the global cost of energy redevelopment interventions can be conducted according to the two ways in which the active tax and financial reliefs are taken into consideration or are disregarded.

Tax deductions for energy redevelopment of buildings for civil use have been introduced in Italy by the Law December 27, 2006, no. 296, for the year 2007 and, even if they have undergone several revisions, are still in force (Law December 28, 2015, no. 208). For the current year they consist in a tax deduction equal to a 65% of the expenditure incurred for interventions increasing the level of energy efficiency of existing buildings, regardless of the intended use.

The interventions subsidized are both the overall upgrading of buildings and individual interventions on the wrappers of the buildings, the replacement of winter heating systems, the installation of solar panels for the production of hot water, the installation of home automation systems for control of heating, hot water production and air-conditioning plants. For each type of intervention the maximum limit of deduction is set.

For small size interventions for increasing energy efficiency and the production of thermal energy from renewable sources, private entities can also take advantage of the so-called "thermal account" (Conto Termico), regulated by D.M. December 28, 2012. The incentive consists of a contribution to the implementation of interventions for the increase in energy performance of existing building envelopes and of existing equipment for space heating and for the installation of plants using renewable sources.

The continuity with which the tax relief has remained active after it was introduced suggests the possibility that it might become a structural advantage [7]. This promises the utility to consider the facilitation in guidelines for the energy redevelopment of a given historical center. Since in the cases of the global redevelopment of buildings and of works on building envelopes the deduction is subject to the achievement of pre-established energy efficiency requirements, the compatibility of these limits with the interventions that can be made on the special historic buildings in question must be verified.

5. Proposal for an evaluation model for the energy requalification of historical centres

The recovery of historical centers must frequently deal with specific problems, for example the difficulty of movement of modern means of transport in narrow and/or winding streets, which can help to increase the heaviness of interventions. Another economic limit may result from the difficulty of access to the tax incentives for energy improvement, which are subject to the achievement of predetermined energy performance levels.

In old centers, since the buildings are often characterized by highly variable types of construction, volumetric shapes and spatial orientations, the adoption of the minimum performances of the reference buildings nationally defined does not appear viable[2].

As it was recalled above, in the legislation on the matter, the financial evaluation of interventions poses into relation the possible actions for the improvement of energy performance with their discounted global cost, calculated in the two modes in which the final value is included or excluded. ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development adopted the second hypothesis in the procedure developed for the "Strategy for the Energy Requalification of the National Real Estate" ("STrategia per la Riqualificazione Energetica del Parco Immobiliare Nazionale", STREPIN) prepared for the Ministry for economic development. The model proposed by ENEA solves an evaluative problem of classification of the redevelopment interventions considered in order to identify the actions that meet the criterion of the optimal cost. Developed in compliance with the requirements of European Regulation no. 244/2012 and the relevant non-binding guidelines, the model refers to the whole Italian territory. As required by legislation, for each category, the reference building represents "the normal and average" building and must be representative of the most common physical, technical, construction, and use parameters [7]. The reference buildings considered in the ministerial strategy are not always comparable to those of the cities into account, since they do not consider the huge variety of physical shapes and construction techniques in the national territory. This problem is even more significant for buildings in historic centers, where peculiar architectural styles, construction and urban morphologies techniques affecting the energy performance of buildings may be found.

In view of the technical, construction and climate characteristics of each place, it could be appropriate to prepare ad hoc studies identifying actions suggested on the basis of a cost-effectiveness evaluation, in order support the financial efforts of the actors implementing them.

With reference to a specific stock of historic buildings many of the parameters indicated by the above national guidelines on the definition of subcategories of buildings are sufficiently homogeneous. It is the case of the age, the size, the protection constraints, the construction products used in load-bearing structures and other components. The reference buildings to be considered will therefore be limited to the number required to define the variability of orientations and shadings induced by natural or constructed barriers to solar radiation that can have a significant impact on energy demand.

The ad hoc approach proposed here aims at reconciling the opportunity to have a realistic picture of the stock of buildings in question with the need for a smaller computational burden of primary energy requirement resulting from the energy efficiency measures and packages of measures that can be adopted in the historical urban areas considered[3]. The financial evaluation of investments for improving the energy behavior related to specific reference buildings for the urban context into consideration can, with good approximation, reflect the investor convenience, unless of subjective characteristics in relation to the expectations and willingness to invest.

Although the European Community regulations on energy efficiency of buildings are actually addressed to the Member States, even in the definition of guidelines to be applied at the municipal level, it could be useful complementing the financial evaluation with the public one, in which the economic and non-economic costs and benefits associated to the interventions are considered.

The financial and macroeconomic evaluations constitute an overall information system able to better direct the redevelopment of buildings, even at the local level. The micro and macroeconomic evaluations should also be developed in two versions in which the available financial and tax reliefs are taken into consideration or are overlooked.

For a given historical center, it would seem useful for the above purposes the preparation of a specific evaluation model, based on the principle of cost-effectiveness, which could support decisions on upgrading the energy efficiency. As it was shown in the case of the urban areas of more recent formation [16], the model should put into connection a dual system of evaluations through a related system of spreadsheets. The one should allow the calculation of a set of financial indicators (investment costs, operating costs, global cost, revenues or savings, discounted payback period), the other a system of energy-environmental indicators (energy consumption, self-production of energy, emissions of CO_2 and other pollutants saved). Given an energy upgrading category of intervention, the integration of the two systems of indicators will allow the identification of its costs in the different phases of the life cycle[4] of buildings, the level of energy performance achieved, the tax and financial reliefs accessible in the specific case and the global cost, integrating or not the public help. The system of energy-environmental indicators in the macroeconomic part of the evaluation model supplements the cognitive framework, providing additional elements for the choice of interventions. Since the externalities, or effects not directly attributable to the investment, are not all translatable into monetary terms for the calculation of the overall macro-economic cost, and the environmental externalities are minimally included in market values and supplemented with difficulty in accounting prices, the analysis of economic efficiency prescribed by European directives could be usefully conducted through a system of non-monetary indicators that can provide a comprehensive information framework on the effects generated by the intervention itself, on the model of the cost-effectiveness analysis in which the environmental costs and benefits are measured in physical terms[5].

Given a reference building and subsequent levels of energy performance achievable by the different categories of intervention, the combination of the results provided by the model in its financial and macroeconomic parts will enable to establish the preferable interventions on the base of the cost-effectiveness principle. The overall analysis of the results will allow extrapolating reasoned guidelines for energy upgrading of the urban context under consideration.

The main steps of the analysis proposed include: the identification of the building types recurring at the local level, defined by the spatial conformation, the volume, the constructive techniques and exposures; the identification of eligible interventions in accordance with the existing architectural and technical constraints; the calculus of energy performance (in terms of savings in energy consumption) and environmental performance (reduction of CO2 and other pollutants emissions), of the investment cost and the management costs of the "building-facility system" to achieve, if possible, the minimum level of energy efficiency required by current legislation; the calculation of the above indicators corresponding to further improvements in energy performance; the identification of the recommendable interventions for each building and construction type found in a perspective of analysis of the building lifecycle.

6. Conclusions

The EU Regulation no. 244/2012 requires Member States to identify optimal levels of energy performance on the base of the global cost criterion.

The achievement of lower energy consumption in the buildings is the result of a complex system of factors involving the disposal of urban spaces, the spatial and technical-constructive shape of the buildings and the same behaviour of the users. In addition, in the consolidated cities the objective variables on which it is possible to intervene are reduced to only those related to the horizontal and vertical enclosures of buildings and technological installations.

The particular characteristics of the urban plots and construction methods in town centres define their architectural identity on the one side and create specific constraints on possible interventions for energy improvement on the other. Despite these difficulties, there is a need to reconcile the conservation of the historical areas with the performance standards of the indoor spaces required by the contemporary users and, with regard to energy performance, by current legislation.

The search for architectural and plant design solutions for achieving higher energy performance of buildings has fueled numerous studies. Nevertheless, the theme of the relationship between energy/environmental performance and economic efficiency [17, 18, 19, 20] requires further investigation, since the quest of cost-effective design solutions in the field of energy quality of buildings cannot be separated from the specific macro and micro-climatic context [21, 22], from which they are heavily dependent, and from the specific building types and construction techniques locally in use in new buildings [14, 16] and in the historical buildings [23]. Therefore, in general, the adoption of the results of studies concerning different climate, urban, architectural and structural contexts is not effective. Decisions on interventions for the rehabilitation of the stock of buildings in a given historical center can only be adequately supported by specific investigations adhering to local peculiarities.

The definition of specific guidelines, designed for the energy redevelopment of a given old town, appears a useful tool to provide basic indications that, although perfectible in relation to individual buildings with the help of technicians, can provide guidance for the real estate owners' investment choices and support the public management of urban transformations. In such a context, the use of integrated assessment of energy redevelopment interventions [11, 24] is particularly effective.

The model proposed for the evaluation of the sustainability of the energy redevelopment interventions is based on a fundamental system of ecological and economic-financial impact indicators, calculated for an adequate number of reference buildings that represent the majority of the buildings of a given historic center. The assessment model is capable of providing an adequate information support to orient the intervention choices on the buildings on the basis of the relationship between energy-entropic quality and private/public costs. In particular, the additional information supplied by the energy-environmental indicators of the macroeconomic part of the evaluation model will provide local authorities with elements useful to establish the preferable interventions on the base of the cost-effectiveness principle and to identify the need for possible special forms of stimulation of investments for energy improvements of historical buildings.

Notes

[1] The lowest cost is determined taking into account the investment costs related to energy improvement, the maintenance and operating costs (including the energy costs and savings and the earnings from energy produced) and, where applicable, any disposal cost. The "estimated economic lifecycle" refers to the remaining estimated economic lifecycle of a building where energy performance requirements are set for the building as a whole, or to the estimated economic lifecycle of a building element where energy performance requirements are set for building elements (Directive 2010/31/EU, Article 2, paragraph 14).

[2] In ancient centres energy performance levels of the buildings can be improved but not always the thresholds of access to incentives can be reached [Baldi G., Collura S., Iuliano L., Karra M., Mandracchia S., Linee guida per il recupero e la valorizzazione del centro storico di Modica. Il tema della riqualificazione energetica del patrimonio edilizio (Guidelines for the reclaiming and the improvement of the historical centre of Modica. The theme of the energy redevelopment of buildings). Supervisors: G. Trombino, G. Rizzo, M. La Gennusa, M.F. Granata. University of Palermo, academic year 2014-15].

[3] A general list of possible energy efficiency measures on buildings that are not protected is provided by the European Commission in the Guidelines accompanying Commission Delegated Regulation (EU) No. 244/2012, paragraph 4.1.

[4] In assessing the energy efficiency and related costs, the energy embodied in the building can be neglected and the only phase of use of the building can be included in the analysis, because of the difficulties of retrieval of the primary data [25] related to the construction process and prediction of the complete life cycle of buildings due to their susceptibility to suffer physical and functional changes [26]. This simplification is assumed in the ministerial model elaborated by ENEA [7].

[5] The cost-effectiveness analysis compares in a public perspective the effects of an action with the associated costs, refusing to monetize the benefits generated by the same action. The cost-effectiveness analysis can be usefully applied when the effects of an action are monetized with difficulty, as it occurs in interventions for redevelopment of buildings

whose consequences concern the protection of ecosystems and human health, the well-being of users, the mitigation of climate change and the prevention of other undesirable environmental effects.

Bibliography

[1] United Nations (2015) *Paris Agreement under the United Nations Framework Convention on Climate Change*, Paris

[2] International Energy Agency (2015) *World Energy Outlook*, International Energy Agency, Paris

[3] World Health Organization (2013) *Review of evidence on health aspects of air pollution — REVIHAAP project technical report*, WHO Regional Office for Europe, Copenhagen

[4] IPCC (2014) Summary for policymakers, in: Field, C.B., et al. (eds.) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*, Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York, 1-32.

[5] Kamal-Chaoui L., Robert A. (eds.) (2009), *Competitive Cities and Climate Change*, OECD Regional Development Working Papers No. 2, OECD publishing

[6] EEA (2015) *The European environment — state and outlook 2015: synthesis report*, European Environment Agency, Copenhagen

[7] Ministero dello sviluppo economico e ENEA (2015), *STrategia per la Riqualificazione Energetica del Parco Immobiliare Nazionale*

[8] ENEA (2013) *RAEE 2011. Rapporto Annuale Efficienza Energetica*, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Roma

[9] Granata M.F. (2006) Valore e costo dell'architettura sostenibile, *Estimo e territorio* 5, 12-23

[10] Rizzo F. (1984) *La dinamica dei capitali. Saggio di economia monetaria*, Facoltà di Ingegneria dell'Università di Catania, Catania

[11] Rizzo F. (1999) *Valore e valutazioni*, FrancoAngeli, Milano

[12] Granata M.F. (2010) *Economia dell'informazione energetica nella società capitalistica*, FrancoAngeli, Milano

[13] Bonifaci P., Copiello S. (2015) Price premium for buildings energy efficiency: empirical findings from a hedonic mode, *Valori e valutazioni* 14, 5-15

[14] Granata M.F. (2008) *Economia eco-sistemica ed efficienza bio-architettonica della città*, FrancoAngeli, Milano

[15] Ministero dei Beni e delle Attività Culturali e del Turismo e Associazione italiana Condizionamento dell'Aria, Riscaldamento, Refrigerazione (2015) *Linee di indirizzo per il miglioramento dell'efficienza energetica nel patrimonio culturale. Architettura, centri e nuclei storici ed urbani*

[16] Granata M.F. (2009) A cognitive/decision-making model of evaluation for ethical urban and building renewal, *BDC. Bollettino del Dipartimento di Conservazione dei Beni Architettonici ed Ambientali* 1, 544-565

[17] Cohen S., Goldman C., Harris J. (1991) Energy savings and economics of retrofitting single-family buildings, *Energy and Buildings* 17, 297–311

[18] Sadineni S.B., France T.M., Boehm R.F. (2011) Economic feasibility of energy efficiency measures in residential buildings, *Renewable Energy* 36(11), 2925–2931

[19] Morissey J., Horne R.E. (2011) Life cycle cost implications of energy efficiency measures in new residential buildings, *Energy and Buildings* 43, 915–924

[20] Famuyibo A.A., Duffy A., Strachan P. (2013) Achieving a holistic view of the life cycle performance of existing dwellings, *Building and Environment* 70, 90–101

[21] Mangan S.D., Oral G.K. (2016) Assessment of residential building performances for the different climate zones of Turkey in terms of life cycle energy and cost efficiency, *Energy and Buildings* 110, 362–376

[22] Stazi F., Tomassoni E., Bonfigli C., Di Perna C. (2014) Energy, comfort and environmental assessment of different building envelope techniques in a Mediterranean climate with a hot dry summer, *Applied Energy* 134, 176–196

[23] Cardinale N., Rospi G., Stefanizzi P. (2013) Energy and microclimatic performance of Mediterranean vernacular buildings: the Sassi district of Matera and the Trulli district of Alberobello, *Building and Environment* 59, 590–598
[24] Fusco Girard L., Nijkamp P. (2004) *Energia, bellezza, partecipazione: la sfida della sostenibilità*, Franco Angeli, Milano
[25] AA.VV. (eds.) (1993) *Guidelines for Life-Cycle Assessment: A "Code of Practice",* SETAC, USA
[26] Kotaji S., Schuurmans A.Q., Edwards S. (eds.) (2003) *Lyfe-Cycle Assessment in Building and Construction: A state-of-the-art report*, SETAC, USA