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The contribution of the ITACA Protocol in the control of the environmental quality in residential buildings and the subsequent contribution to the adaptation to climatic change.

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Abstract

During the last years the aim to reduce environmental impacts in the building sector has led to the development of assessment methods called protocols, to certify the sustainable quality of the building, such as the ITACA Protocol. In the present work the national version 2011 of the ITACA Protocol has been applied to several residential buildings study cases, and the resulting performances have been compared with a reference building with the same geometric shape and performances within the limit of the law. These results have been compared with the average energy performance of an Italian residential estate, to evaluate the contribution to climate change adaption. Furthermore, the comparison has also been carried out from the costs point of view, to verify the necessity of long-term subsidizing policies. The criteria used to analyze the effective impact reduction are: primary energy for heating and hot water and related CO_2 emissions. The average value of savings in energy consumption obtained in the evaluated building (designed and certified with the ITACA Protocol, compared to reaching the law limit value) is 51.25 kWh/m^2·y, with corresponding 8.52 kg CO_2/m^2 ·y emissions saved. Intervening on 22 % of the current Italian housing estates with the performances of the study cases, results in a reduction of the energy load of 20.10 %. Whilst from the technical point of view the application could be easily adopted, the high costs of these interventions still have a long payback period, and it could be necessary to provide a durable public incentive.

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Keywords: Green building; Energy efficiency; Itaca Protocol; GHG reduction; Multicriteria evaluation system; sustainable certification.

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1. Introduction

The impact of the building sector on energy consumption in Europe is widely recognized. The civil building sector accounts for 30% of whole energy consumption [1] and these data concern only the operational phase. In compliance with the European [2] and Italian [3] regulations building energy performance certificates have been made compulsory. Both in Italy and abroad, systems have been developed to assess building environmental performances by assigning scores according to the performance degree achieved [4]. In Italy, an assessment method called "ITACA Protocol" [5] has been devised and used in several ways by institutions. ITACA Protocol is a multicriteria method to evaluate the environment and the energy performance of building, derived by SB Method [6]. ITACA Protocol consists of 35 criteria, each one regarding an environmental or energy aspects of the system building-plant and the site. The criteria are divided in 5 category:

1. Quality of site
2. Resource consumption
3. Environmental load
4. Indoor environmental quality
5. Quality of the service

For each criteria, a score is assigned from -1 to +5. Score 0 represent the benchmark (law limits if available or typical acceptable practice) and positive score correspond to better practice. Negative score means that the building in a particular aspect is poor of quality, less than the benchmark. The total score is calculated by multiplying the score of each criteria by its appropriate weight and then adding the scores of all criteria. Beside considering the energy performance as provided for by the law, the method also takes into account the building-to-site relationship, water consumption, materials used, indoor quality, and the preservation of performances in the time to come. The aim of resorting to these assessments, which give access to building certifications, is to encourage environmental performances that are higher than the standards set by law, both in the new construction and the restoration of existing buildings, so as to contribute effectively to the reduction of the environmental impact of buildings and, especially, of climate-altering emissions.

In this paper, the ITACA Protocol system (version 2011) has been applied to through the analysis and comparison of the performances of 20 real case studies eco-friendly designed to be founded with Regional incentive based on ITACA Protocol evaluation (16 newly constructed and 4 building refurbishment of designed and built in Italy residential buildings). The goals of the present work are: 1) Check the efficiency of the study cases assessed with ITACA Protocol and the possibility of extending similar construction methods in the energy recovery of the dwelling estate; (2) Determine the amount of existing buildings that will be affected by similar action in order to achieve the objectives of Europe 20/20.[7]

2. Method

The methodology used for the present evaluation is subdivided into the following phases:

1. Collecting and evaluating 20 (16 new construction and 4 refurbishment) housing projects with ITACA Protocol 2011.
2. Singling out analysis criteria in order to check their effectiveness in impact reduction. Those criteria are taken into consideration that are in close connection with environmental impact such as primary energy consumption for heating and the production of domestic hot water (DHW), greenhouse gas emission (GHG).
3. Singling out the performances related to the above-mentioned criteria and, above all, the saving achieved on energy, GHG emissions, in comparison to a reference building. The reference building is the same size as the project, with energy performances and on-site production of energy from renewable sources within the limits set by the law or minimal acceptable practice, no materials from renewable sources and/or recycling, no water recycling/saving strategy.
4. Estimating – through the weighted average of decreased energy consumptions and reduced emissions – a "standard" performance that can be obtained by applying the system and through the projection of decreased consumptions and emissions achievable by retrofitting the Italian housing estate. Comparing

the hypothesis of the application of the study cases performances to the 22% of building stock before 2002 with the statistical data on consumption and emissions relating "20/20" targets, in order to guarantee the achievement of the aforementioned European targets [7].

5. Identifying the increased costs of interventions in comparison to the costs of the reference buildings, and evaluating the payback period (PBP) of decreased energy consumption.

Although several other criteria aspects evaluated can potentially result in a reduction of the environmental impact, in the absence of more specific benchmarks or reference (i.e. sustainable materials or water consumption) in this paper have not been used for comparison.

2.1. Case studies – Building types

The building types are characterized by small dimensions, typical in Italian provinces; they don't have special architectural qualities, are one - or two-family buildings, or buildings with up to a maximum of ten dwelling units, (only one has 35 units) and pay no attention to bioclimatic issues and form factor – as a matter of fact, the S/V ratio is rather high for all of them: for just one building it is 0.42, the others are above 0.7, and one is 0.93. Attention has only been paid to the layout, with living spaces to the south and services to the north, and to shading, with fixed shades to the south in some cases and movable external solar shading systems in all but one. The study cases came from environmentally oriented regional buildings programmers. The case studies are listed in Table 1.

Id (City)	Type *	Climatic Zone [Italian leg.]	Degree days	Number of dwelling	Heated floor surface [m^2]	Ratio S/V	ITACA score	Energy efficiency class
1. Maiolati S.	N	E	2149	10	776	0.77	2.79	A
2. Montemarciano	N	D	1826	9	580	0.89	2.73	A+
3. Senigallia	N	D	1737	8	559	0.54	2.85	A+
4. Santa Maria Nuova	N	D	1988	10	788	0.61	2.44	A+
5. Mogliano	N	D	2006	2	342	0.79	3.03	A+
6. Polverigi	N	D	1876	5	307	0.88	1.95	B
7. Gallo di Petriano	N	E	2336	35	1190	0.49	2.09	A
8. Altamura 1	N	D	1858	2	290	0.71	2.07	A
9. Altamura 2	N	D	1858	6	357	0.62	2.03	A
10. Altamura 3	N	D	1858	1	199	0.72	2.08	B
11. Perugia	N	E	2289	1	161	0.93	1.95	C
12. S. Giustino	N	E	2132	10	870	0.56	1.45	D
13. Assisi	N	E	2198	1	388	0.70	2.30	A
14. Città di Castello	N	E	2347	8	667	0.42	2.05	A
15. Bassano del G.1	N	E	2473	3	292	0.79	2.53	A
16. Quinto di Treviso	N	E	2409	1	127	0.60	2.16	C
17. Macerata	R	D	2005	1	218	0.61	2.38	B
18. Gabicce	R	E	2114	2	203	0.50	2.37	C
19. Camerano	R	D	1969	2	336	0.59	3.30	C
20. Bassano del G.2	R	E	2473	1	294	0,61	1.32	E

*N=New construction – R=Refurbishment

3. Result and discussion

3.1. Analysis of energy and GHG emissions performances

These analysis have been carried out using the values calculated for evaluate the scores of criteria “Primary energy for heating” (B.1.2), “Primary energy for DHW” (B.1.5) and “GHG emissions in operational phase” (C.1.2). Sum of values calculated in criteria B.1.2 and B.1.5 are used to evaluate the non-renewable primary energy, while the values of GHG are taken in criteria C.1.2. Results of the analysis show that in the case studies, the energy performances related to the primary energy requirement for heating and the production of DHW generate smaller consumptions than the reference (law limit), allowing a primary energy saving of 54.78 kWh/m^2·y (the new construction cases) and 24.43 kWh/m^2·y (the refurbishment cases) on a weighted average basis. (Fig. 1a)

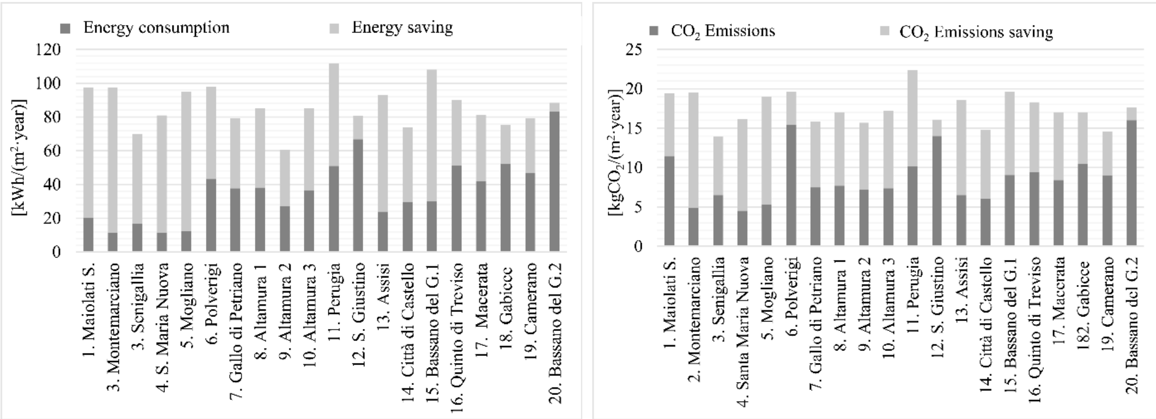

Fig. 1. Energy consumptions saving (a); CO_2 emissions impact reduction (b).

By considering the saving on CO_2 emissions, the following emission values are obtained, which, compared to the law limit values, considerably reduce the impact on global warming. For the new buildings the average emissions amounting to 8.24 kg $CO_2/m^2 \cdot y$, meaning a reduction of emissions by 8.95 kg $CO_2/m^2 \cdot y$ (the average of law limit emissions being 17.20 kg $CO_2/m^2 \cdot y$). Also for the recovered buildings the average value is 5.24 kg $CO_2/m^2 \cdot y$ as the difference between the average resulting of the study cases, 11.12 kg $CO_2/m^2 \cdot y$, and 16.36 kg $CO_2/m^2 \cdot y$ average of law limit values. (Fig. 1b).

Therefore, the construction of residential buildings featuring technical performances like these is easily feasible because building techniques, technologies, and plants are employed that are already widely used in the building market.

3.2. Estimating obtainable performances by applying the system by retrofitting the Italian housing stock

The aim of this analysis is to identify the percentage values of retrofitted building that lead to reach the European target 20/20 in term of primary energy and GHG reduction, using the values obtained in paragraph 3.1.

In order to verify the effectiveness and possible effects at a national level of a growing, widespread use of performances as resulting from the study cases verified, the respective average values of expected smaller consumptions of primary energy and decreased CO_2 emissions have been projected by hypothesizing improvement interventions on residential buildings, taking into account ISTAT (National Statistic Board) official data concerning the number of residences and useful surfaces built in Italy before 2002 [8] and comparing results with the national data on consumptions and emissions into the atmosphere published by ENEA (National Agency for the new technologies, energy and sustainable economic development) ISPRA (National Institute for the Protection and Environmental Research) [9-10].

The residences built and occupied in Italy before 2001 were 21653288 equalling an estimated useful surface of 2064626118 m^2. Several researches have been evaluated the energy consumptions of a large number of buildings, but actually does not exist a national database in which to take the data used for a more precise analysis. For this reason, an average energy consumption (heating and DHW) of existing residential stock has been taken account of 170 $kWh/m^2 \cdot y$ [11] and this value was compared with the average resulting on study cases evaluated with ITACA Protocol. The whole yearly consumptions of energy in domestic sector was estimated in 26.52 Mtoe/y.[9]

In order to comply with the European legislation aimed at meeting the 20/20 targets set against climate change, assuming retrofitting is performed on existing residential buildings. A reduction of 20,10% on energy consumption could be achieved through the refurbishment of 22% of the Italian residential estate by intervening similarly to the case studies assessed with ITACA Protocol (Table 2), while a similar results could be obtained if the retrofitting involves on 35% of residential building, using the minimum practice (limit law level).

The yearly CO_2 emissions (referred to the year 2011 as the latest available datum) from civil estate account for 86.2 Mt .[10], due to whole supplies (natural gas and electricity). If 35% of the housing stock built until 2001 were subjected to renewal and energy-efficiency enhancement measures in order to abide by the limit values set by law, could reduce the GHG emission in the whole civil sector of 14.14%, while using the study cases performances ITACA protocol in 22% of existing building could achieve a reduction of 13.38% (Table 3).

Table 2. Potential primary energy saving

		Potential primary energy saving using limit law values in 35% housing stock	Potential primary energy saving using the study cases performances in 22% housing stock
Saving energy average	[kWh/m^2·y]	85.22	136.48
Housing stock	[m^2]	7228011967	454332181
housing stock consumptions	[kWh/y]	61.599.444.054	62.006.220.722
Potential saving with refurbishment	[Toe]	5297509.81	5332492.32
2012 -Total housing stock consumptions	[Toe]	26524000	
Saving toe by housing stock %	[%]	19.97	20.10

Table 3. Potential GHG emissions saving in housing stock

		Potential GHG emission using limit law values in 35% housing stock	Potential GHG emission saving using the study cases performances in 22% housing stock
Value GHG emissions	[kg CO_2/m^2·y]	17.10	8.58
Total emissions civil estate	[M t CO_2/y]	86.2	
GHG emissions housing stock	[kg CO_2/m^2·y]	33.97	
Potential GHG emissions saving	[kg CO_2/m^2·y]	17	25.38
Housing stock surface m^2	[m^2]	722801196	45433218
Potential GHG emissions saving	[kg CO_2/y]	12187632	11532184
Potential GHG emissions saving	[%]	14. 14	13.38

3.3. Analysis of costs

At present, the application of environmental sustainability criteria to buildings involves increased costs affecting the envelope more than the systems. Considerable cost increases are observed when comparing the cost estimates for the envelopes, floors, and power systems of buildings analyzed with those for reference buildings with reinforced concrete structure, concrete and masonry slab floors, and brick vertical walls with expanded polystyrene insulation useful for complying with limit values for thermal transmittance. According to ITACA Protocol, which evaluates energy and environmental performances at all levels, the best performances are obtained by employing materials from renewable sources that are often more expensive than insulating materials of fossil origin. In the case studies examined, the average cost increase amounts to about 148 €/m^2, subdivided on average into 93.62 €/m^2 for the envelope and 54.38 /m^2 for the systems.

The percentage cost increase ranges from a minimum of 6.9% to a maximum of 22.4%. The considerable fluctuations depend on the different building modes; the greatest increases are observed in wooden-structure buildings, while in traditional-structure buildings, i.e., reinforced concrete frame and concrete and masonry slab floors, cost differences are smaller.

The increased costs mainly derive from the envelope, while systems are a smaller contributing factor.

If looked at from a financial perspective only – that is, the recouping of single investments through cash flows generated through the saving on natural gas due to the improvement intervention – the length of time for recovering the costs is considerable, with the net present value being still negative after 25 years.

However, for example, the Protocol's criteria include the evaluation of the absence of condensation water in the interstices of the envelope (Italian regulations allow the presence of condensation water during the winter months, provided that it can evaporate completely in the summertime). It is well known that the presence of humidity in interstices has a negative effect on the thermal resistance of components, impairing the energy performance in the end and causing the deterioration of the envelope itself through molds and chipping.

The evaluation of the envelope's performances over time is one more element of extra quality that generally is not taken into account when assessing buildings (not even from an economic point of view). Anyway, postponing the maintenance of envelopes means achieving a saving, also at the economic level.

The higher costs deriving from the construction of buildings with better environmental performances are not directly absorbed by the lower costs of fuel consumption. However, it has to be considered that the higher costs of the envelope and horizontal structures are also meant to meet global warming and other environmental criteria aimed at reducing the consumption of non-renewable materials and the consequent impact.

4. Conclusion

This study was meant to identify, through the analysis of some case studies, a methodological path enabling to reduce environmental impacts deriving from the application of the ITACA Protocol in residential building. Of the whole system, organized into 35 criteria for analyzing the various performances, the fundamental criteria concerning the consumption of energy and GHG emission have been considered. If widely applied in building refurbishment, it can contribute considerably to the achievement of the European targets of consumption and emission reduction by 20% by the year 2020. The analysis of the smaller impacts in energy terms produced a positive result. It should be emphasized that, in ITACA Protocol, energy consumption and emissions are dealt with from multiple points of view, i.e., not only the consumptions of buildings in the operation phase, but also the impacts deriving from the materials used, the consumption of water and the transportation due to the decentralized location of buildings in relation to urban services. This regards the consumption of non-renewable raw materials (the evaluation based on ITACA Protocol can encourage both the use of materials of local provenance, from renewable sources, and from recycling, and the introduction of innovating building systems) as well as the reduction of impacts due to transportation. Concerning the higher costs in comparison with the provisions of Italian regulations, certainly the resources invested are not immediately offset by the economic saving deriving from reduced consumptions because payback period is too long. However, costs decrease if a more comprehensive assessment is made by taking into account general environmental costs. Hence the need for incentive-based policies, which are still uncertain and not well established.

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