Classification of buildings in Cyprus based on their energy performance

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Abstract

This paper describes the work that will be done in a research project, which will facilitate the implementation of the EPBD through the calculation of the existing Cyprus Building Stock energy behaviour. This will be achieved through the selection of a representative sample of 500 housing units and the collection of data through questionnaires, followed by statistical analysis of the data and the interpretation of the results. The key parameters that will form the different clusters are climatological zone, type, age and size of each housing unit. The statistical interpretation of the collected dataset will provide insights with regards to the energy behaviour of the building stock for each class. The ultimate goal is to suggest the number of classes for the Energy Performance Certificate and the upper and lower energy consumption limits for each class. Moreover, the formulation of an energy behaviour map, the consideration of the historical development of the buildings behaviour and the improvement of the insulating materials and solutions, will lead to the readjustment of the values, particularly for the best two classes, so as not only to reflect today's reality, but also to show the intent of the state to improve the level of the construction industry. In this study, the various types and quantities of thermal insulating materials utilized in Cyprus, for the time interval 01/01/08–30/09/08, are also reported. The data were extracted from applications made by individuals who claimed financial subsidy. A random specimen of 400 applications was evaluated: 55% refer to existing housing, and 45% to new buildings. The different kinds of materials used for insulating floorings, walls and roofs, in different regions of the island were evaluated. The principal observation made is the extensive use of double glazing for doors and windows.

Keywords: building classification, energy performance, directive 2002/91/EC, insulating materials, double glazing.

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1 Introduction

Buildings consume about 40% of the final energy in the EU and this consumption is responsible for 30% of carbon dioxide emissions [1]. Specialized studies showed that there is a large potential for the saving of energy in this sector [2]. In particular for Cyprus, the fact that until recently there was no legislative regulation concerning the insulation of buildings, the potential for savings is even larger [3]. Under the target of the general scope of increasing the safety of the energy supply [4], the reduction of greenhouse gas emissions [5] and the general policy for improving energy performance, the European Commission issued the directive 2002/91/EC - energy performance of buildings [6]. According to this directive, member states are required to specify their national methodology for the estimation of the energy performance of buildings and to establish the energy certification of buildings, following the specification of the highest limits of energy consumption per category of buildings [7]. The above directive was harmonized in the national law system with the Law N142(I)/2006. In addition to this directive, Cyprus has to adopt directive 2006/32/EC [8], which deals with the energy performance at the final use and the energy producing companies that, among others, requires member states to establish and achieve a national indicative target in energy saving.

The establishment of the highest limits of energy consumption and the specification of energy classes, for the purpose of applying directive 2002/91/EC, but also the drafting of a national plan for the achievement of the target set by 2006/32/EC, requires knowledge of the energy behaviour of the building stock of Cyprus, which however has not been done until now. For this purpose we proposed, and managed to undertake, a research project under the 2008 call of the Research Promotion Foundation of Cyprus, which will attempt to cover this deficiency and which deals with the classification of the existing building stock of Cyprus according to their energy performance and finally the total mapping of the stock.

The innovation of the project relies on the fact that this is the first time the total footprint of the energy performance of the building stock of Cyprus is attempted. This footprint will constitute the base that will support the application of a number of contractual obligations of the Republic of Cyprus that deal with energy efficiency and the energy performance of buildings. Additionally, the further processing of the obtained results will lead to the drafting of measures and targeted actions for the improvement of energy efficiency [9-12] which finally will support the central target of energy saving and the reduction of greenhouse gas emissions. At the same time it will support the basic target of independence of the economic development of Cyprus from the non regulated and unjustified increase of prices of conventional fuels [13]. It is expected that the results of this research project would create the circumstances and the required basis for the development of a research core of knowledge in the area for the proper and rational development of the urban building environment and the establishment of subsidization plans and other actions for the sustainable design and the energy conservation in buildings.

2 Objectives

The general objectives of the project are the following:

- The development of cooperation between research centres, government departments, non-profit organizations and companies in a high level project with the purpose of producing innovative ideas.
- The rational confrontation of the environmental problems, the promotion of sustainable development on a national level and the improvement of the quality of life.
- The sustainable management of the building stock and the prevention of environmental destructions.

In parallel the project aims to contribute to the materialization, the modernization and the development of environmental policy, particularly concerning the incorporation of environmental research into the political decisions for the sustainable development of Cyprus focused on the structure and policies of the EU. The specific targets of the project are focused on:

- The recording and evaluation of the energy performance of the building stock of Cyprus. This mapping is of particular importance as will be the prerequisite for the specification of the highest limits for each category of buildings, which is also prerequisite of the directive 2002/91/EC.
- The classification and estimation of the upper and lower limits of energy consumption per category of buildings based on today's consumptions, which finally will lead to the specification of the various classes.
- The formulation of specific proposals for the re-establishment of the limits, particularly of the two best classes, as well as to the assessment of the optimum time for the materialization of the application of these limits so as not to simply reflect the present situation but to show the willingness of the state to improve the level of constructions.
- The collection of data which will be further examined so as to lead to the undertaking of measures and to the establishment of targeted actions for the improvement of the energy performance as well as to the support of decision making in the area of energy policy of Cyprus with respect to the building construction industry.
- The transfer of knowledge from and to the European and international environment and the creation of a dataset which will concern the Cypriot reality.

3 Existing knowledge

Energy conservation is one-way road to Cyprus, which is an island with an isolated energy system away from interconnected circuits of electrical energy or natural gas and has very limited energy resources. The import cost of energy for the year 2005 was of the order of 820 million Euro, representing 16.2% of the cost of all imports in the Republic of Cyprus or 67% of the value of all exports of goods [17].

The application of the Law mentioned above assumes among other things the specification of requirements of the minimum energy performance and the issue of an Energy Certificate, which will include reference values of energy consumption and criteria of comparative evaluation, so as to allow the consumers to compare and evaluate the energy consumption of their building. These actions however, assume that a comprehensive recording and evaluation of the building stock of Cyprus will be done which will give a picture of the particular consumptions for heating, cooling, lighting, hot water etc.

In addition to the support for the application of the directive, which eventually will lead to the conservation of energy and the reduction of the carbon dioxide emissions from the activities related to the use of the buildings, such a recording will help the drafting of particular measures and targeted actions for the improvement of the energy performance of existing buildings. It will also be a point of reference and comparison and a supporting tool for the drafting of an integrated energy policy in the building sector.

4 Innovation of the project

The innovation of this research project is the fact that this is the first time such an integrated recording and evaluation of the energy performance of the building stock of Cyprus is attempted. This footprint will be the base and will support the application of a series of contractual obligations of the Republic of Cyprus concerning the energy efficiency and energy performance of buildings. Additionally, the further analysis of the results obtained will lead to the development of measures and targeted actions for the improvement of the energy performance [12-14], which finally will support the achievement of the final target of energy conservation and the reduction of greenhouse gasses emissions, while at the same time will support the basic requirement of independence of the economic development of Cyprus from the non-controlled and irrational increase of imported conventional fuels [15].

Finally, it is expected that the results of this research will create the prerequisites and basis for the development of a critical research and educational core of knowledge in the area of development and design, energy policy and the drafting of subsidization schemes and other targeted actions for the energy conservation in buildings. It is also expected that the integrated recording of the energy performance of the building stock of Cyprus will be the reference point for comparison and a supporting tool for the drafting of an integrated energy policy in the buildings area.

5 Methodology

Under this research project the elaboration of the database of the Cyprus building stock will be carried out on the basis of Statistics of Constructions and Housing [9], so as to classify the buildings according to the climatological zone, type, age and size of each housing unit. This will determine the building statistical weighted sample on which the research will be undertaken. The selection of the

data will be carried out, based on questionnaires and in situ measurements in selected cases so as to find the actual consumption per category. The processing of the data that will be collected from above will lead to the creation of clusters and will support the calculation of the upper and lower limits of energy consumption per category, based on today's consumption. Finally, we will conclude on the number of classes and their upper and lower limits of energy performance, which will be the basic characteristic of the Energy Certificate. Having the map of the Cypriot building stock, based on the energy performance, and taking into consideration the historical development of the behaviour of the buildings [3] and the improvement of the insulating materials and solutions [11, 16], will lead to the suggestion for the readjustment of the values that will be obtained, particularly for the two best classes, so as not only to reflect the today's reality, but also to show the intend of the state to improve the level of the construction industry. More analytically, the following methodology will be followed:

- Elaboration on the database of the building energy stock, based on the Statistics of Construction and Housing of 2004, so as to classify them according to their contribution.

Concerning the research into the energy behaviour, and provided that we have a building stock of about 242.000 houses [9], this research will be based on a sample of about 500 houses for which the necessary collection of data will be required. The research will be based on the most current data of the Statistical Service.

- Collection of data and conducting of measurements for the energy performance of buildings, based on the statistical weighted sample, so as to take the real energy consumption per category.

The collection of data will be done with the method of the formulated questionnaire, which will be filled by trained groups of researchers. In parallel, selective particular measurements will be carried out in a specific sample of buildings, which are used as houses, concerning the basic characteristics of their energy behaviour, that cannot be easily extracted from the data in the questionnaire, e.g. heat transfer coefficient of the building envelope with thermo-camera, degree of efficiency of the central heating boiler with a gas analyzer, conditions of thermal comfort, etc. These results will validate the data in the questionnaires and will give valuable information for the quality of the indoor environment in the houses.

- Creation of clusters, so as to analyze the upper and lower limits of the energy consumption per category based on today's consumption.

The results of the questionnaires, after statistical elaboration for their validation and normalization will constitute the base for the development of clusters of buildings, based on their energy characteristics, so as to be able to determine the magnitude of the consumption of energy for each representative group of buildings, based on the rules of statistics and the use of appropriate tools.

- Determination of the limits, based on the readjustment of the values that will be collected, particularly for the two best cases A and B so as the limits

should not only reflect the current reality, but also to show the willingness of the political leadership for the improvement of the level of the constructions.

The limits that will be determined from the previous work package, and based on the willingness to improve the quality of constructions, will be readjusted so as to push the new constructions towards better energy performance in relation to the today's data. In addition, the new limits will reflect the possibility of improvement of the behaviour of existing buildings, so – with proper interventions – to be able in a reasonable cost to be substantially improved, approaching the two best categories for the newly built buildings.

6 Added value and benefit

The added value of the project is expected to have a multiple benefit, both concerning the strategic development of the energy sector and the social and financial level. The specification of the energy classes of the building stock of Cyprus will help for the correct implementation of the directive 2002/91/EC, particularly to the issue of Energy Performance Certificate of buildings. The project gives an important opportunity to the partners who are directly involved, to specify the energy classes of buildings through a detailed and scientifically documented research work. This fact is expected to improve drastically the buildings construction section, as through the results it will be revealed which are the best design and building techniques and the selection of proper insulating materials that will be applied in the future. Additionally, concerning energy economy the added value of the project is very important as it will reveal the optimum techniques for the rational design of buildings and it is expected to lead to substantial benefit concerning energy conservation particularly at the macro-economic level.

Additionally through the project, an integrated bibliographical reference will be created, which will concern Cyprus and the energy performance of the building stock. This fact is expected to play an important role in the introduction of Cyprus in the European bibliography for the energy performance of buildings and research centres in Europe and abroad could consider Cyprus in future research projects and case studies.

Finally, the results of this project and their dissemination will help to improve substantially the technological development of Cyprus as through this project it is expected that a comprehensive dataset will be created which can be used in the future by researchers in the area of urban design.

7 Survey on the use of insulating materials in Cyprus

According to the Law for (N.142 (I)/2006) for the energy performance of buildings, the Ministry of Commerce, Industry and Tourism adopted supporting programs in order to promote and extend the use of insulation materials in the construction field. Within this Law, a grand scheme titled "Saving energy with new investments in private building units", is announced by the Ministry, which allows each individual owner of a building unit, to receive funding in order to

apply thermal insulation materials. Acceptable applications refer to insulation of both existing and new buildings. In terms of this scheme, a subsidy equivalent to 30% of the eligible cost of the investment is provided to individuals, whereas the maximum amount available for each building unit is €1700. In this work a review of the application of the regulations concerning the thermal insulation of buildings in Cyprus was performed. The various types as well as the amount of thermal insulating materials applied in Cyprus, from 01/01/08 to 30/09/08 was determined by means of data obtained by the Energy Service of the Cyprus Ministry of Commerce Industry and Tourism. Particularly, records in the form of individuals' applications that were submitted with the intention of claiming financial subsidy for insulating their buildings were processed. Subsequently, a random specimen of 400 applications was evaluated; 55% of these applications concerned existing buildings, whereas 45% was related to new constructions (see Table 1).

Table 1: Evaluation by type of building and region of 400 subsidy applications for thermo-insulating materials in Cyprus.

Type	Material	Region					
		Nicosia	Limassol	Larnaca	Paphos	Famagusta	Total
Existing building	Extruded polystyrene	15	3	2	1	1	22
	Stone wool	1	0	0	0	0	1
	Double glazing	68	52	12	6	2	140
	Screed	1	0	0	1	0	2
	Polyurethane	18	2	10	0	14	44
	Reflective surface	1	0	0	0	0	1
	Glass wool	0	0	0	0	0	0
New building	Extruded polystyrene	4	0	0	2	0	6
	Stone wool	0	0	0	0	0	0
	Double glazing	66	42	16	0	4	138
	Screed	0	0	0	10	0	1
	Polyurethane	0	1	1	1	0	2
	Reflective surface	0	0	0	0	0	0
	Glass wool	1	0	0	0	0	1

Based on the evaluated data, it is obvious that the thermo-insulating materials are used, both in existing and new buildings. In existing buildings, apart from the use of double-glazed windows, extensive use of polyurethane is observed. On the other hand, in new buildings, double-glazed windows appear to be the most used measure. Furthermore, the different kinds of materials used for insulating floorings, walls and roofs, in different regions of the island were considered. The

highest amount of applicants appears to be in Nicosia, the capital, and Limassol, whereas applications from Larnaca, Paphos and Famagusta regions are significantly less. This is due to the fact that the regions of Nicosia and Limassol are subjected to high development rates. Another popular insulating material was found to be polyurethane followed by extruded polystyrene. Screed, stone wool, glass-wool and reflective surfaces were not found to be extensively applied as shown in Fig. 1. Other well known insulating materials, such as insulating plaster and insulating bricks, which are also used by the Cyprus construction industry, could not be detected through the data obtained from the Energy Service.

The extensive use of double-glazed windows as a measure to improve the thermal performance of buildings is not considered to be representative, since it results from the terms of the grand scheme and the fact that the subsidy which may be provided to an individual in order to perform thermal insulation works does not exceed 30% of the total costs with a maximum of €1700. Therefore, the majority of the applications only referred to one insulating measure, mainly the double glazing, neglecting other possible insulation works which may have to be carried out. Comparatively, in Europe the most extensively used insulating material is stone wool (35%), whereas, in Greece expanded polystyrene is mostly used (48%). This comparison indicates that in Cyprus there might be poor know-how and certainly lack of experience regarding the options of thermal insulating materials. Additionally, the local industry that produces insulating materials is small thus most of the materials used are imported and their cost might be significantly higher.

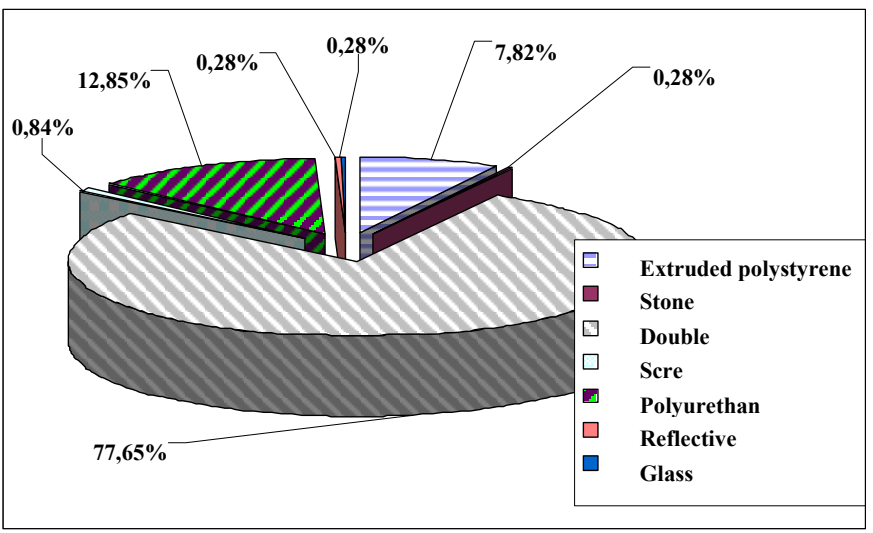

Figure 1: Evaluation by type of material of 400 subsidy applications for thermo-insulating materials in Cyprus.

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References

[1] European Commission, *Doing more with less*, Green Paper on energy efficiency 22.06.2005 COM(2005), 2005.
[2] European Commission*, Action Plan for Energy Efficiency: Realising the Potential*, Brussels, 19.10.2006 COM (2006)545, 2006
[3] Florides, G., Kalogirou, S., Tassou, S., Wrobel, L., Modelling of the modern houses of Cyprus and energy consumption analysis, *Energy-The International Journal*, **25(10)**, pp. 915-937, 2000.
[4] European Commission. *A European strategy for sustainable, Competitive and secure energy*, Brussels, COM(2006) 105, 2006.
[5] *Kyoto protocol to the united nations framework convention on climate change*, UNFCCC, 1997.
[6] *COM 2002/91/EC: Directive on the Energy Performance of Buildings*, EC, 2002.
[7] Papadopoulos, A.M., On the implementation of the Energy Performance Directive in a real world, *Proceedings of the 26th AIVC Conference – Ventilation in Relation to the Energy Performance of Buildings on CD-ROM*, Brussels, 2005.
[8] *COM 2006/32/EC: Directive on energy end-use efficiency and energy services*, EC, 2006.
[9] *Statistics of Constructions and Housing*, Statistical Service, Republic of Cyprus, 2006.
[10] Florides, G., Tassou, S., Kalogirou, S., Wrobel, L., Evolution of domestic dwellings in Cyprus and energy analysis, *Renewable Energy*, **23(2)**, pp. 219-234, 2001.
[11] Papadopoulos, A.M., State of the art in thermal insulation materials and aims for future developments, *Energy and Buildings*, **37(1)**, pp. 77-8, 2005.
[12] Florides, G., Tassou, S., Kalogirou, S., Wrobel, L., Measures used to lower building energy consumption and their cost effectiveness, *Applied Energy*, **73(3-4)**, pp. 299-328, 2002.
[13] Papadopoulos, A.M., Theodosiou, T., Karatzas K., Feasibility of energy saving renovation measures in urban buildings: The impact of energy prices and the acceptable pay back time criterion, *Energy and Buildings*, **34**, pp. 455-466, 2002.
[14] Papadopoulos, A.M., Energy cost and its impact on regulating the buildings' energy behaviour, *Advances in Building Energy Research*, **1**, pp. 105-121, 2007.

[15] Maxoulis, C., Kalogirou, S., Cyprus energy policy review: The road to the 2006 World Renewable Energy Congress trophy, *Renewable Energy*, **33(3)** pp. 355-365, 2008.
[16] Papadopoulos, A.M., Stylianou, A., Oxizidis, S., Impact of energy pricing on buildings' energy design, *Management of Environmental Quality*, **17(6)**, pp. 753-762, 2006.
[17] CEN, EN 15217 Energy performance of buildings - Methods for expressing energy performance and for energy certification of buildings, 2007.