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Current Energy Reducing Strategies for the Greek Housing Stock and the Role of the Occupant's Behaviour in Achieving Energy Efficiency

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Abstract
The present paper aims to explore the current energy performance of the existing housing stock of Greece while also examining efficient and cost effective the energy upgrades in buildings that have undergone refurbishment since the transposition of the Energy Performance of Buildings Directive in 2010. A literature review of energy performance legislation and previous surveys is presented. Case studies of dwellings with Energy Performance Certificates and dwellings that have undergone energy upgrades as well as occupancy survey of inhabitants of the city of Naousa provide an overview of the energy status of the stock as well as the cost aspect of the upgrades. The answers from the survey give an insight in the actions and the behaviour of the users within the environment of their homes.

Keywords: Energy, Performance, Consumption, Greece, Housing

1. Introduction
Since 2009, European countries have been bound to adopt stricter regulations in the building industry, in accordance to European Union (EU) directives, in order to minimise energy consumption and CO_2 emissions of buildings (EPBD, 2002).

Steps towards the direction of improving the existing stock have been taken in many European countries including Greece. Programs funded in part by the European Union and in part by the local governments, providing house owners with financial incentives in order to perform upgrades to their properties, have appeared in many countries including the UK (The Green Deal), Italy (ENEA), Spain with a number of separate schemes (Geotcasa, Solcasa and Biomcasa)(EPBD-CA, 2013).

As of 2001, the total number of dwellings in Greece, was approximately 4 million and accounted for almost 75% of the total building stock. 74.6% of the dwelling stock was built prior to 1979 [fig. 1] and had therefore no envelope insulation. Even those built after 1979 and especially the ones during the decade after the introduction of the Hellenic Building Thermal Insulation Regulation (HBTIR), cannot be deemed much better in terms of energy performance as the installation of insulation has serious constraints (Balaras et al., 2007).

Greece introduced the 'Saving at home' scheme in 2011(YPEKA, 2013), which is a partly self-funded and partly government-funded scheme. There are a number of different requirements that need to be met, most of which are mainly income based, in order to be eligible to participate. Examples of the upgrades that are subsidised include the installation of external insulation, the change of old external doors and windows and the change of the old boilers.

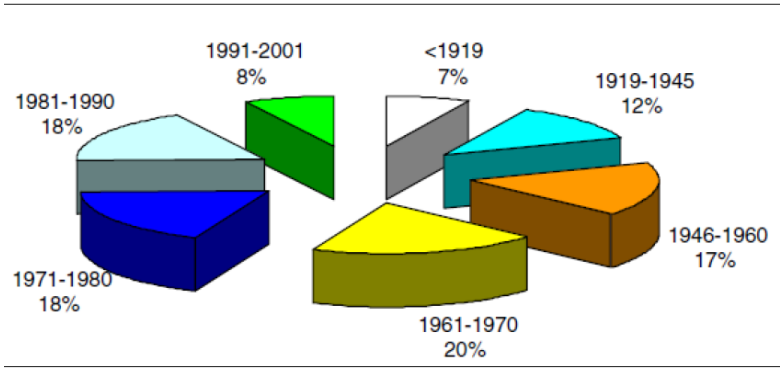

Figure 1. Age distribution of the Greek housing stock

Although the scheme is now well underway, it is still important to examine the condition of the housing stock in order to determine the exact size of the problem that the sector is facing and plan for the future. Furthermore, the cases of dwellings which have undergone upgrades should be analysed in order to evaluate the effectiveness of the whole scheme and to determine whether it performs as expected. Conclusively, an examination of how the upgrades have affected the lives of the users is undertaken.

2. Aims

The aims of this research are: a) To investigate the characteristics of the existing housing stock of Greece in terms of date and type of construction, size of households and to also look at its current energy performance based on case studies of dwellings for which an EPC has been produced; b) To examine a number of the above-mentioned cases of dwellings, which were energy upgraded in Naousa, Greece in order to analyse the energy improvements they demonstrated, as well as to explore the importance of the different technologies that were applied to them; c) To monitor the thermal conditions of three of the upgraded houses during the summer period and examine whether the changes managed to provide a comfortable environment to the users; d) To investigate the behaviour of inhabitants of Naousa within their homes in terms of their thermal environment for better understanding the needs of the local population and for future reference.

3. Methodology

The first part of the research involved the gathering of data concerning the characteristics of the housing stock of Greece both in terms of energy performance and in terms of age, type, etc. Access to a total of 400 Energy Performance Certificates in electronic form was acquired from two private assessing companies.

Secondly a total of thirteen case studies of dwellings that underwent energy upgrade refurbishments were examined to draw conclusions in respect of their improvement.

In order to investigate how the energy upgrades affected the thermal comfort of the users, the thermal monitoring of three of the aforementioned dwellings was performed. The monitoring was performed with the use of thermal data loggers which were installed in each room of the monitored case for a period of one month from 01/07/2013 to 31/07/2013. The owners of the above-monitored dwellings were also given questionnaires which investigated their level of satisfaction with the result of the upgrades. The final part of the research, analysed the answers of an occupancy survey from the inhabitants of the city of Naousa.

4. Results

Initially 400 dwellings from Thessaloniki and Naoussa were examined, for which an EPC was issued by two assessment companies per request of the owners. Both cities are situated in the same climate zone. Among the cases, the predominant energy class of the nine class scale of energy efficiency was G, the lowest possible, with 26% of the dwellings ranking as such. More than 98% of the examined dwellings belong in class C, D, E, F or G and are therefore characterized as energy inefficient. In agreement with Dascalaki et al. (2013) findings, the older dwellings (built prior to 1980) which have no thermal insulation have the worst energy performance with most of them ranking in class G. When looking at newer buildings, the energy performance improves progressively, with buildings built after 2000 ranking mainly in class C.

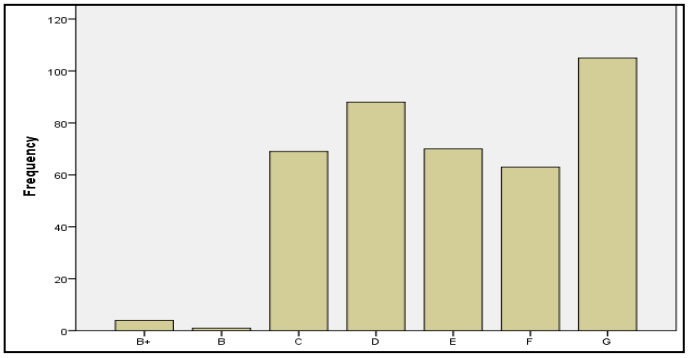

Figure 2. Energy rankings of examined cases

An interesting finding from comparing the results from this sample and the results of Dascalaki et al. is that both buildings that belong to the oldest age group and the ones that belong to the youngest, perform better than the average of dwellings in Climate Zone C. Of the 5 dwellings in class B or better, none was built after 2010. The dwellings that were built after 2010 ranked mostly in class C when according to legislation they should rank B or better. The overall average consumption is 295 kWh/m^2 while the average consumption of the three age groups (pre-1980, 1980-2000, after 2000) were 325, 269 and 245 kWh/m^2, respectively.

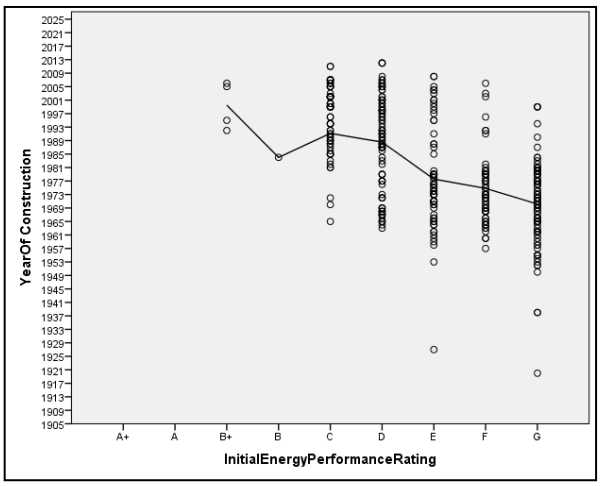

Figure 3. Energy performance and age relation trend

Thirteen of the aforementioned four hundred cases, which were subjected to energy upgrades, were looked into more detail. All the dwellings were built before 1987 and their mean age of construction was 1972. 72.7% of all the cases initially ranked in energy class G and the average initial primary energy consumption was 440 kWh/m^2. After the upgrade, the mean primary energy consumption became 257 kWh/m^2, which is an improvement of 40%. The predominant class is now C. The dwelling with the initial lowest consumption (163 kWh/m^2) was built in 1976 while the one with the largest (991 kWh/m^2) in 1987.

The solutions applied at the upgrades can be defined in three categories: a) Change of windows/installation of shading systems, b) Installation of insulation and c) new mechanical systems (boilers, solar thermal panels), each of which has several sub-categories. Among the examined cases, the most common solutions were the change of windows and balcony doors (22.9%), followed by the installation of external blinds (20.8%) and the installation of external insulation (16.7%). It was found that: a) the amount of investment plays a significant role in the overall improvement, but it does not guarantee an improvement in ranking, and b) the solution with the biggest impact in the improvement of the building's performance is the one performed first and each subsequent one has a lesser and lesser contribution. After the fourth or fifth intervention the improvement is minimal. A further examination of the relation between individual costs of solutions and subsequent overall improvement did not provide any concrete results for interventions coming from category 1 and 3 but it was found that there is probably a connection between the investment on insulation and the eventual improvement.

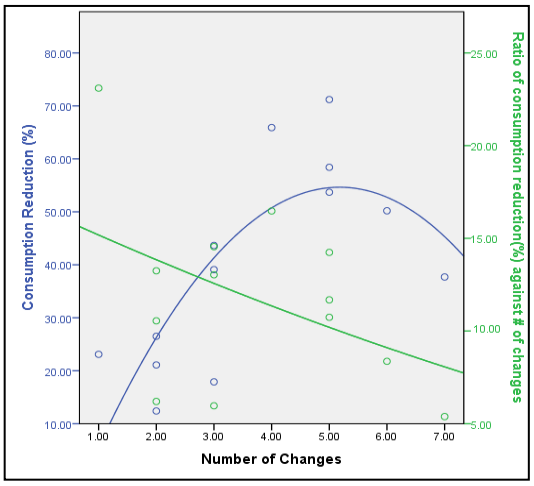

Figure 4. Relation of number of interventions with overall improvement

The occupants' evaluation regarding the upgrade of their homes was overall very positive. All the users replied that they were paying much or much less for their heating and cooling bills, that the problems they use to have, had been dealt with either completely or almost completely and that they felt that their investment paid off completely. In terms of thermal comfort, they replied that they never or almost never feel too cold during winter or too hot during summer and that they have no problems with drafts or with humidity levels. These responses present the whole upgrade as a success at least in the perspective of the occupants. However, it would be interesting to acquire real energy consumption before and after the upgrade to evaluate how much improvement was achieved.

The results of the monitoring of the thermal environment of three of the above energy upgrade cases were further examined. The monitoring took place during the summer of 2013. The mean temperature of the examined month was 25.6°C with the highest monitored external temperature, reaching 32°C. Overall, in all three cases the monitored temperatures of each dwelling's rooms were found to be within the acceptable limits set by EN 15251 (2007) for naturally ventilated dwellings and none of the dwellings faced any problems with either overheating or humidity levels. This along with the personal responses of the dwellings' users which were positive indicates the good performance of the upgrade interventions. In the instance of case study 1, where it was possible to examine the living habits of the occupants in two different occasions and because they were energy preserving conscious, it was found that in general, they had adapted their habits according to the thermal environment and as a result avoided performing activities that would result in unsettling their thermal comfort. This could be seen by the stability of the measured temperatures throughout the examined month. In the one occasion when the temperatures showed an extreme change, occurred when the occupant switched on an electrical application which produced a lot of heat, i.e. tumble dryer.

The sample of the occupancy survey was balanced with almost an equal number of men and women as well as quite diverse in terms of age, ranging from 24 to 69. The majority of the participants live with at least two more people, usually adults. On average the users stay indoors close to 8 hours during weekdays and eleven hours during Sundays, with women spending on average two hours more. The majority (60%) of the users replied that they never felt cold during winter while in the summer period 62.9% replied that they might feel too hot. This indicates that strategies adopted at the design of the local houses mainly addressed the problems of cold weather. More than half (57%) of the participants replied that they sometimes have high bills and the second most common answer being Often (17.1%). Close to 75% replied that they never or only sometimes have drafts in their homes, while 85.7% answered that they never encounter problems with humidity. When asked specifically about their heating and cooling bills, 71.5% thought that what they paid for heating was normal and 77.1% believed that their cooling bills were low or very low.

In terms of their behaviour within their homes in winter, the participants replied that they are usually dressed with a normal level of clothing (66%) or lightly (28.6%). When they feel that they are getting cold, they are more inclined to put more clothes on most of the time (close to 75%) rather than immediately turning the heat on (29% doing so often or very often). Finally, nearly 100% open their windows every day during winter for ventilation, with 45.7% doing so for less than half an hour but with also quite a few (17.1%) leaving them open for more than an hour, thus resulting in great heat losses.

Concerning the summer period, 66% (23) of the respondents own an A/C unit. Of these 23 persons, 34% would turn their A/C unit on often or very often immediately after feeling hot, while the remaining 64% would only do that sometimes. More than 90% however replied that they would open windows in order to create a draft, often, very often or sometimes.

The analysis of the above findings showed that overall the surveyed occupants of Naoussa enjoy comfortable environments in their dwellings consider that the bills they pay are rational. The respondents were found to influence their environments to a great extent through their behaviour both in negative (heat losses during winter by

opening windows) and positive ways (opting for natural cooling and ventilation during summer instead of using A/C). These findings are in agreement with previous research (Gill, 2011; Williamson, 2010; Stevenson and Rijal, 2010) which dictated that the users' behaviour affect their environment as well as the final consumption of a dwelling.

Conclusions

It has been established that the housing stock of the two examined cities is energy consuming and that there is an urgent need to proceed with its energy upgrade, if Greece wants to meet its commitments to the EU by 2020. The first actions that have been taken so far in the form of the subsidized schemes, appear to at least in theory, perform well and result in great energy reductions. Actual monitoring of these dwellings is needed, however, in order to draw concrete conclusions. The users' reaction to the upgrades and to the thermal environment has been unanimously positive, and a very good sign. Nevertheless, no feedback is collected systematically and therefore there is lack of data from a greater number of cases. Finally, the occupancy survey of the people of Naousa revealed how different habits of the users affect their thermal environment in agreement to previous findings from other researches.

References

Balaras C.A., Athina G. Gaglia, Elena Georgopoulou, Sevastianos Mirasgedis, Yiannis Sarafidis and Dimitris P. Lalas (2007). "European residential buildings and empirical assessment of the Hellenic building stock, energy consumption, emissions and potential energy savings." Building and Environment

Dascalaki E.G., Kontoyiannidis S., Balaras C.A., Droutsa K.G., Energy certification of Hellenic buildings: First findings, 2013, Energy and Buildings 65 (2013) 429–437

European Parliament (EP), Directive 2010/31/EUof the European Parliament and of the Council of 19 May 2010 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (Text with EEA relevance).<http://eur-ex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:EN:PDF> (accessed August 2013)

Gill Z.M., Tierney M.J., Pegg I.M., Allan, N., 2011. Measured energy and water performance of an aspiring low energy/carbon affordable housing site in the UK, Energy and Buildings, 43(1), pp. 117-125

Greek Ministry of Energy and Climatic change, Κανονισμός Ενεργειακής Απόδοσης Κτιρίων, 2009

http://exoikonomisi.ypeka.gr, (accessed June, 2013)

http://www.epbd-ca.eu/about, (accessed August 2013)

Stevenson F. and Rijal H.B., 2010, Developing occupancy feedback from a prototype to improve housing production, Building Research and Information, (38) 5, pp.549-563.

Williamson, T.J., Soebarto, V., and Radford, A.D. ,2010, The thermal performance of five award-winning houses: regulated, measured and perceived, Building Research & Information 38(5), pp 509–529