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Feasibility of energy saving renovation measures in urban buildings The impact of energy prices and the acceptable pay back time criterion

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Abstract

The energy renovation of existing buildings is an important tool for the reduction of energy consumption in the building sector, the improvement of prevailing indoor thermal comfort conditions and also for the improvement of environmental conditions in urban areas. At the same time, it is a technical, economic and social problem, due to the way in which many cities have been built and the restrictions imposed by economic constrains that tantalise most countries in South-Eastern Europe, and also Greece. It applies particularly in Northern Greece, with its cold and prolonged heating season, where a series of studies was carried out since 1994 to approach the problem and develop viable proposals. Public and mixed-use buildings form a significant part of the building stock and are therefore a primary candidate for energy saving measures, especially as they also play the role of a 'pilot-demonstrator' for the private owned buildings. However, due to the low energy prices that prevailed over the last 10 years, and as energy saving measurements are capital intensive investments, little was done in that direction. The recent sharp increase in oil prices proved that this was a short-sighted policy. In the following paper are presented the results of a study that aimed to determine the potential of energy saving renovation measures, in a representative sample of buildings under realistic conditions, to evaluate the feasibility of these measures, and also the way in which this feasibility is being analysed, under the rapidly changing economic conditions. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Urban buildings; Energy renovation; Insulation; Heating system; Feasibility and economic criteria

1. Introduction: the climatic and energy features of the sample

The building sector in Northern Greece absorbs 31% of the final energy demand ranking second after the transport sector, in contradiction to the national energy balance, where industry consumes more than the building sector. This deviation is attributed to the climate, which is partly Mediterranean and partly continental, influenced by the rough Balkan winter. The city of Thessaloniki, which is located by the sea and features 1.05 million inhabitants out of the total 2.1 millions of the region, has climatic characteristics comparable to those of Toulon in France. There are, however, cities located in the mountainous inland like Florina, that justify the term continental climate. Data for these cities are presented in Table 1 [1].

2. Main features of the existing building's stock

A series of studies carried out over the last decade have shown that the improvement of the energy behaviour of existing buildings is a key factor for the rationalisation of the energy consumption in the building sector. This applies to Greece, as well as to many other European countries, where the dominant majority of the buildings are only insufficiently or not at all thermally insulated. This results in an average annual specific consumption, for space heating only, of 130–180 kWh/m^2, instead of the 80–110 kWh/m^2 that would be necessary if the buildings had been properly insulated, i.e. according to the valid legislation [2–4]. Compared to the regulations prevailing in other European countries, like Germany where values of 70 kWh/m^2 are the standard since the mid-nineties, this is a disappointing performance [5]. Still, due to the low energy prices between 1991 and 2000, this poor performance remained largely unnoticed. Interest shifted from the reduction of heating to the reduction of cooling loads, mainly by means of altering the electricity

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Table 1
Climatic data of Thessaloniki and Florina in Northern Greece compared to those of Toulon

	Degree–days ($DD_{ref\ 18\ °C}$)	Average temperature (°C)	Average minimum temperature (°C)	Design minimum temperature (°C)	Solar radiation (kWh/m^2)	Hours of sunshine (H)
Thessaloniki	1725	15.6	4.2	−2	1404	2555
Florina	2542	13.2	−3.4	−11	1230	1905
Toulon	1790	15.1	4.5	−2	1490	2710

pricing policy. The main issue over the last decade was that of cooling and air-conditioning in the summer, which lead to significant problems as the occurring peak-load demand increased by more than 55% over the last 10 years [6]. However, the real 'threat' appeared as late as in the fall of 2000: As retail oil-prices almost doubled within a year and electricity retail prices increased by an average of only 12%, the buildings' tenants, have started to use air-conditioning units, mostly of the split-type heat pumps, also for space heating. This might make sense from an economic point of view for the tenants, but presents a serious problem both for the national economy and the environment, due to the low efficiency, and the limited installed capacities, of the lignite-fired power plants operational in Greece. It also gives reasons to doubt whether it will be possible to reduce the CO_2 emissions, as foreseen by international agreements. From the aspect of rational energy use it is a completely false approach, as it focuses only on the search for a cheaper energy form, instead on the effort to reduce energy consumption in combination with providing cheaper energy. Finally, from the long term economic perspective, it is also a narrow minded policy, because it inevitably leads to higher running cost of the buildings by trying to avoid the initial investment needed to reduce energy consumption.

Within the series of research projects carried out with the participation the Aristotle University Thessaloniki, the possibilities of implementing energy saving measures in more than 90 buildings in Northern Greece were examined in the period 1994–2000. Out of these buildings a sample of 42 residential, public and mixed use buildings has been formed as representative, covering a wide range of ages and construction arts, from the end of the 19th century up to the early 1990s. The buildings include residences and/or public services, private enterprises, educational institutes, banks and a hospital. The distribution of the buildings' ages and uses is depicted in Fig. 1 and is, in terms of the buildings useful surface, fairly representative of the entire buildings' stock, as it was registered by the 1991 general national census, that presents the most recent data available.

2.1. Energy behaviour of the buildings

The energy audits carried out confirmed the significance of space heating in the buildings' energy balances. The energy consumption of the buildings included in the sample are presented in Fig. 2.

According to the date of construction three different groups can be determined: buildings dating from the end of the 19th century until 1940. This class consists of two major sub-groups: there are the rather few in numbers large buildings with an important 'monumental' architectural value, usually housing public services and authorities, offices, museums etc. where the options for intervention on the buildings' shells are rather limited. These buildings have been renovated over the years; contemporary heating systems have been installed and in some case also air conditioning systems. Their average annual space heating consumption of 183.5 kWh/m^2 can be regarded as acceptable, given their age and particularities. Then, there are the residential and mixed-use buildings, met mainly in the smaller cities, the villages and the rural areas, which are significant in number, but small in size. These are the buildings where space heating is covered mainly by means of wood-fired stoves, which results in low energy consump-

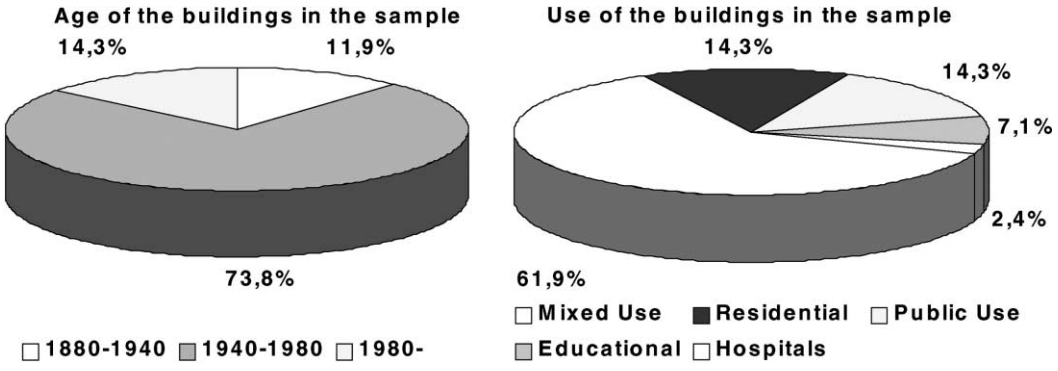

Fig. 1. Distribution of the buildings' age and use as included in the sample.

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