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Energy, economic and environmental performance of heating systems in Greek buildings

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Abstract

The introduction of natural gas in the Greek energy market broadened the options in the field of space heating. Residents in five major Greek cities can choose from a variety of different fuels and systems for heating their houses or working spaces; 12 more cities will be connected to the gas network within the next 5 years. Considering that space heating is the major energy consuming activity in the Greek building sector and that the environmental constrains imposed by the Kyoto protocol will be met only with difficulty, if at all, a strategy concerning the developments in space heating seems to be necessary. This however presupposes an elaborate analysis of the overall performance of the alternative systems, taking into consideration the particular conditions of the Greek energy system and the 'established' way of designing residential and mixed-use buildings. The present paper aims to present the empirical comparative results related to the three most popular heating systems operated in Greek multi-apartment and mixed-use buildings, which use three different fuels, respectively: a central oil-fired boiler, a unitary gas-fired boiler and unitary heat pumps.

Keywords: Heating systems; Residential buildings; Energy consumption; Environmental performance

1. Introduction

Local and regional parameters are of importance both to the structural features of buildings and to their HVAC systems. These 'native' features of a building stock are regarded as typical and have resulted from an evolutionary process, directly shaped by conditions such as: the local climate (mainly air temperature, solar radiation, wind direction and speed, rain, snow, etc.), geological and other environmental features (e.g. seismic activity), the availability and the cost of building components and materials, the availability and the skills of qualified personnel, the social and cultural background, the subjective operational requirements on behalf of the users (individuality versus community spirit) and, of course, the regulatory and legal framework [1,2]. A further parameter is the availability and cost of energy sources, with regard to the availability and the purchase cost of heating and cooling equipment. Thus, Greek urban buildings demonstrate, when compared to other Mediterranean countries certain particularities with respect to the use of heating systems. In most Greek cities the weather conditions during winter can be characterized as rather mild, and this is reflected both in the duration of the heating period and the mean and absolute minima of air temperature [3]. Most Greek urban buildings built prior to the 1970s did not have a central heating installation, although unitary systems are being retrofitted since the late 1980s [4]. Retail household prices of electricity are despite a series of increases since 2003, rather moderate compared to most European countries [5]. Natural gas was introduced to retail consumers in 2001. The above factors, amongst others, should be taken into consideration towards a more effective policy, since the discussion of the implementation of the European Directive 2002/91/EC on the energy performance of buildings in Greece has started in the year 2003 and is still, in February 2007, going on.

2. Heating systems in Greek buildings

The most popular heating system in Greek buildings is a central oil-fired boiler, distributing the heat produced to hydronic radiators. These central, high temperature systems use in order to deliver the heat either a two-pipe (a supply and a

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return pipe) scheme or a single pipe one. The former was used in older constructions, as a rule until the early 1980s, while the latter is widely used today, in combination with time-meters, volumetric flow rate or heat-meters installed in every apartment. Supply and return temperature controllers help to optimize the circulation, by means of a three-way mixing valve, which is mandatory for all buildings of more than three floors. Frequently a compensating thermostat is also used, to enable the system to respond to ambient temperature variations. In the apartments the temperature is regulated by means of a room thermostat, usually installed in the living room [6]. Such systems are nowadays retrofitted in old buildings. The older buildings, mainly those built in the 1950s and 1960s, do not have a central heating installation and are heated either by unitary oil-fired stoves or electrically driven devices (radiators, stoves). Since the 1990s air to air heat pumps, of the split unit or room air-conditioner type, have become increasingly fashionable, as their purchase cost dropped dramatically. Since the introduction of natural gas in the late 1990s it has been observed that single family gas-fired boilers have been retrofitted in the balconies of many apartments in Greek major cities' multi-storeyed buildings.

In relation to either the heat production source or the distribution systems there are a few cases of differentiation to be noted. In two medium sized cities in northwestern Greece, Kozani and Ptolemaida, there are district heating installations fed with thermal energy from nearby located, lignite-fired power generation plants. Despite the excellent potential, both in terms of radiation intensity and sunshine duration, and the fact that Greece is a leading force in Europe in the production of solar thermal systems, those are used exclusively for domestic hot water production, apart from some pilot projects [7]. Similarly, the use of biomass and geothermal energy in the building sector is practically non-existent, with the exception of the use of wood in rural, mountainous areas.

With respect to the heat distribution systems, the market is dominated by hydronic radiators, while floor systems have a small, but distinct, presence in expensive, single family houses. Fan coil units are pretty common in office buildings, but not in residential ones. Air heating is very rare in Greek buildings, mainly because of their very heavy construction due to seismic reasons, which results in high thermal inertia of the building's shell.

3. Description of the typical Greek building

This section briefly describes the typical multifamily residential building in Greece. The reason why a brief description has been opted for relates to the scope of the present paper which focuses on the heating systems' comparison, by means of building and HVAC simulation with the EnergyPlus programme [8]. Interested readers can, however, find a detailed discussion of this topic in related literature [1,9,10].

3.1. Physical description of the building

The typical multifamily building has three floors, built on top of/above a pilotis or an enclosed parking lot, and is not attached to any other building (Fig. 1). Its main façade is considered to be south oriented. There are two basement rooms that contain the boiler room and other utilities. Each apartment has a front and a rear balcony in the form of projections (overhangs) of 2 m width. The surface of each floor is 240 m^2 which is divided into two almost identical apartments (114 m^2 each), the remaining floor area being occupied by the staircase. Every apartment features a living room, a kitchen, a bathroom/WC and two bedrooms. Each room constitutes a different thermal zone for the thermal simulation.

3.2. Thermal description of the building

The building was simulated for two levels of thermal insulation corresponding to two constructional time periods:

- before the introduction of the Greek thermal insulation regulation (TIR) in 1979, building (MF 1) with no thermal insulation, and
- after 1979, building (MF 2) insulated with 5 cm of extruded polystyrene on all its construction elements, in order to comply with the TIR for the least favorable climatic zone, namely zone C [11].

It is noted that Thessaloniki lies in climatic zone C, Athens in zone B, and the southern mainland together with the islands add up to zone A, which is the warmest one.

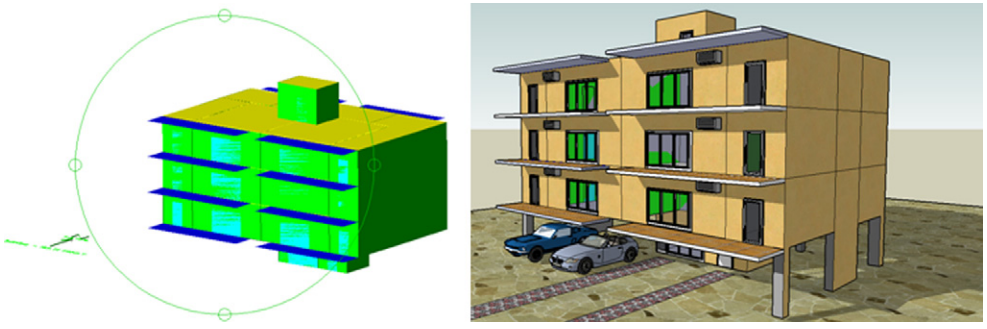

Fig. 1. The typical Greek multifamily building.