Heating demands differences between central and surrounding areas in the coastal town of Patras

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ABSTRACT

Heating demands of buildings are in general influenced by various factors, such as the type of use (offices, residences, etc.), shape, placement, building materials, meteorological conditions etc.

In this work, the heating demands of spaces, which are located in central and surrounding areas of the city of Patras, are examined. For this purpose, a set of 10 data loggers, have been placed, in chosen characteristic locations, to monitor ambient air temperature variations. The collected data serve to calculate the heating degree hours and results are obtained and presented.

1. INTRODUCTION

The continuously increased worldwide urbanization has created a series of problems, the most serious been the traffic difficulties, the climatic quality and the increased energy consumption. Ambient air temperatures in dense urban areas are higher than those of the surrounding rural country, a phenomenon known as “heat island”. It is clear that urban areas without a high climatic quality use more energy for air conditioning in summer and even more electricity for lighting. Moreover, discomfort and inconvenience to the urban population due to high temperatures, wind tunnel effects in streets and unusual wind turbulence due to wrongly designed high rise buildings is very common (Bitan, 1992). Statistical data (Stanners and Bourdeau, 1995) show that the amount of energy consumed by cities for heating and cooling of offices and residential buildings in western and southern Europe has increased significantly in the last two decades. An increase of the urban population by 1% increases the energy consumption by 2.2%, (Santamouris, 2001) i.e. the rate of change in energy use is twice the rate of change in urbanization.

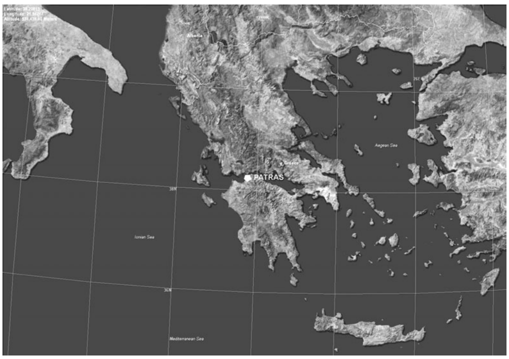

Figure 1: Patras location.

Despite all these annoying disadvantages, urbanization presents some advantages. One of them is the reduced heating demand of the urban buildings, during heating periods. One reason is the dense building and consequently the smaller heat loss area per m^3 of enclosed volume, reduced infrared radiation exchange and less infiltration. Another reason is the “heat island” phenomenon, less intense than in summer conditions, but still able to create higher urban temperatures.

Many works have carried out to investigate the impact of the urban climate on the energy consumption of urban buildings. A number of big, medium and small cities have been studied, each one having its own characteristics. In Greece, the case of Athens has been extensively examined (Santamouris et al., 2001; Martilli et al., 2003). It would be very useful to examine the case of a medium size city, especially of an extended coastal city, in order to investigate possible particularities and/or similarities. For this reason, an effort has begun, the last few months, to establish a measuring network for the study of the climate impacts in the city of Patras. This paper constitutes a preliminary work of this project, based on a very small set of collected data. A number of 10 automatic temperature-measuring stations have been installed in the major Patras area. Collected data, for a period of about 50 days, were analyzed and led to the calculation of heating degree-hours (HDHs) for each selected location.

2. DESCRIPTION OF THE URBAN REGION AND MEASURING NETWORK

The city of Patras is located in Southwest Greece (38° 15′ N, 21° 45′ E) and is the capital of this region. It has a population of about 200.000 and expands across the sea and a few hills. It has a mild and moderate Mediterranean climate, with elevated precipitation.

Patras is not an industrial town. Its industrial zone is located much far away from the town and isolated by mountains. The center of the town is characterized by high automobile traffic.

In order to have a good figure of the climate impacts, a set of 10 temperature measuring stations have been installed in the major Patras area, while another 7 stations will be functional soon. The measurement points were selected with the following criteria:

I To get information about the boundary conditions around the town.
II To study densely built areas with heavy traffic.
III To study densely built areas with less traffic.
IV To study medium density built areas.

A detailed map showing the relative position of the stations is given in Figure 2.

As shown in Figure 2, four stations (No 3, 4, 5, 10) have been placed in densely built areas (urban) with heavy traffic; four stations (No 6, 7, 8, 9) have been placed in densely built areas (urban) with less traffic; one station (No 2) is placed in a medium density built area (suburban) and one station (No 1) is placed in a rural area (standing outside the map). All the stations have been placed at the level of the first floor of buildings, taking care to be shaded and not affected by IR radiation. The instrumentation used was selected to satisfy several criteria like acceptable cost, satisfactory performance according to the international meteorological standards, low maintenance, internal power supply and high data storage capacity. In order to protect the instruments from solar radiation and rain, white wooden boxes with lateral slots were constructed. All sensors were calibrated between them and against high precision thermometers.

Measurements have been taken on a minute basis and stored every 1 hour, for a winter period of about 50 days, from 9/12/2004 to 27/1/2005.

3. TEMPERATURE AND HEATING DEGREE-HOURS DISTRIBUTION

The collected data have been treated and temperature variations are extracted. Three representative distributions are presented in Figure 3. The chosen locations represent measurements points of an urban area with heavy traffic (station No 10), a suburban area (station No 2) and a rural area (station No 1).

It must be mentioned that the colder days of this winter occurred outside the collection period and they are not included in the diagram.

The same temperature distributions are presented in Figure 4, focused on a one-day period.

The calculation of the heating degree-hours (HDHs), is performed for two different base temperatures. As it is shown in a recent work (Matzarakis and Balafoutis, 2004), the base temperature for the calculation of heating degree-days over Greece is considered as T_{base}=14 °C, which corresponds realistically to the requirements of the Greek territory and confirms the answers on a questionnaire that was filled in by householders in the most populated Greek cities. So on, the HDHs are calculated for the classical base temperature of 18 °C (T_{base}=18 °C) and for the base of 14 °C (T_{base}=14 °C). In Figure 2, the 5 digits number next to each station represents the HDHs for T_{base}=18 °C. More analytically, the individual results are summarized into Table 1 and

Figure 2: Relative position of the measuring stations.

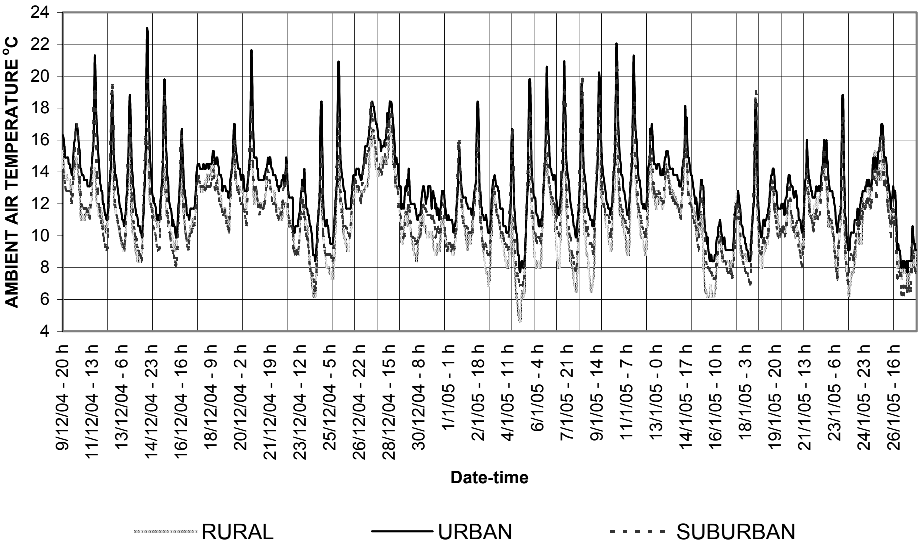

Figure 3: Temperature distributions for three representative areas.

presented in Figures 5, 6.

4. RESULTS AND DISCUSSION

From the comparison of the above calculated HDHs, the ratios of urban vs. rural and urban vs. suburban areas are extracted. As it occurs for T_{base}=18 °C, the mean value of HDHs of urban areas is equal to ***0,777*** of the value of HDHs of rural area and ***0,831*** of the value of HDHs of suburban area. In other words, the urban HDHs are ***22,3%*** less than the rural HDHs and ***16,9%***

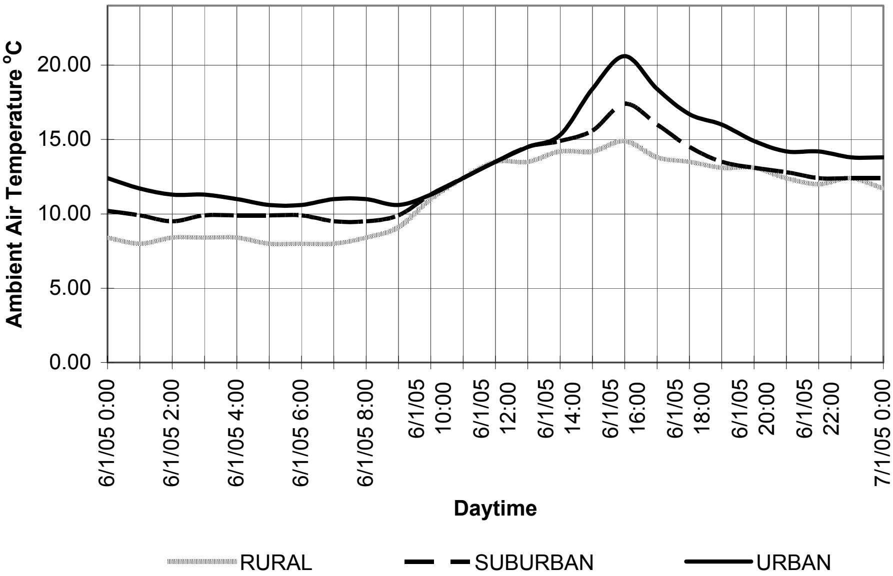

Figure 4: Temperature distributions for three representative areas.

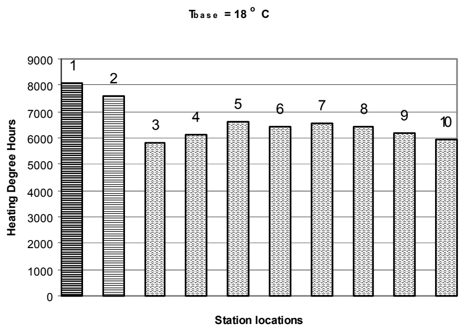

Figure 5: HDHs for T_{base} = 18 °C.

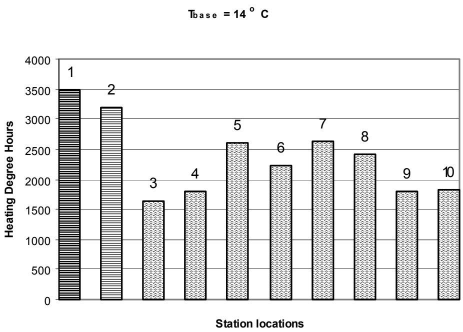

Figure 6: HDHs for T_{base} = 14 °C.

less than suburban HDHs.

For T_{base}=14°C the situation is more impressive, leading in values of:

HDHs(urban)/HDHs(rural)=0,609;
HDHs(urban)/HDHs(suburban)= 0,663.

Otherwise, HDHs (urban) are ***39,1%*** less than HDHs(rural) and ***33,7%*** less than HDHs(suburban). That means, for spaces with the same values of overall heating loss coefficient multiplied with overall heat loss area (UA) and same infiltration, the correspondent heating demands have the same proportionalities as for HDHs.

In general urban structures appear smaller heat loss area per m^3 of enclosed volume, reduced infrared radiation exchange and less infiltration, which lead to furthermore reduced heating demands.

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Table 1: Heating Degree-Hours.

Station No.	Location	HDHs T_{base}=18 °C	HDHs T_{base}=14 °C
1	Rural area	8085,4	3481,2
2	Suburban area	7564,7	3197,2
3	Urban area	5817,4	1625,3
4		6125,6	1809,9
5		6619,7	2610,9
6		6453,8	2240,4
7		6532,8	2621,7
8		6436,1	2408,2
9		6198,2	1806,3
10		5952,7	1824,8
Mean value, Urban areas		6285,82	2118,44

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