On the Relation Between the Energy and Social Characteristics of the Residential Sector.

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Abstract

Social, financial, energy and technical data from about 1110 households have been collected during 2004 in the major Athens area. The sample has been divided in seven income groups and a detailed analysis has been performed. Important conclusions have been drawn regarding the quality of households, the operational conditions and the energy spent per income group. Low income people are more likely to be living in old buildings with poor envelope conditions. The cost per person and unit area is much higher for the low income group for both heating and electricity. Fuel poverty is quite high, especially when the actual oil prices are considered.

1. Introduction

Energy consumption of households is strongly related to the family income. Earlier research has shown that the higher the income, the higher the energy consumption of the household. The specific relation between the household income and the energy consumption of homes varies from country to country as a function of their economic and technical characteristics.

Important research has been carried out regarding energy expenditure in low income households. Fuel poverty is defined by the UK government as the number of households who need to spend in excess of 10% of income on energy services in order to achieve a specified heating standard. When expenditure exceeds 20 per cent of the income, the family is defined as suffering ‘severe energy poverty’. Statistical data around Europe has shown that fuel poverty reaches high levels in the South of Europe and according to moderate calculations accounts for about 12 % of the households in Italy, 30 % in Greece, 26 % in Spain and 44 % in Portugal. In parallel, fuel poverty in England alone totals between 2.8 million and 3.9 million households. Ireland, estimations show that 17.6 % of the households are energy poor, around 226000 houses. About 27 % of the fuel poor houses, around 4.7 % of the total housing stock, are suffering from chronic fuel poverty. Also, 12.7 % of the households suffer from intermittent levels of fuel poverty, i.e. occupants are occasionally unable to heat their homes.

Fuel poverty has important effects, mainly on human health. There is increasing evidence that lack of heating and poor indoor environmental conditions in low income households cause serious health problems and increase mortality. Low outdoor

temperatures during the winter season are associated with an annual average of 40,000 excess winter deaths in the UK. This country, together with Ireland, presents the highest rates of excess deaths in Northern Europe during winter, (16). Some research has attributed this excess mortality to poor standards of energy efficiency and resultant cold housing in these countries.

The residential sector in Greece accounts for about 24.5 % of the total final consumption in the country and presents a high increasing trend. In the period 1990-2002, the energy consumption of the residential sector increased by 54 %, while the total energy consumption increased by 35 % in the same period. In parallel, the energy consumption for space heating, electrical appliances and lighting increased by 65% since 1990, while space heating accounts for almost 72 % of the total energy consumption, (3.43 Mtoe). Given that the number of residential buildings has considerably increased during the same period, it is calculated that the unit consumption per dwelling has increased by 33 %, with an annual growth rate of 2.6%, and has risen from 0.98 toe/dwelling in 1990 to almost 1.32 toe/dwelling in 2002. The corresponding increase for space heating per unit, has been 30 % while the corresponding consumption of appliances and lighting has almost doubled, and has risen from 0.37 Mtoe in 1990 to 0.80 Mtoe in 2002, presenting an annual increase rate close to 6.6 %.

The structure of residential energy demand has been studied by many researchers. Most of the studies focus mainly on the analysis of the macroeconomic factors and the forecast for the future energy consumption.

The present study aims to analyse the main characteristics of the residential sector in Athens, Greece, and investigate the inter-relations between the energy consumption, income of households and the technical and social structure of the housing sector. Data from about 1110 households have been collected during 2004 in the greater Athens area and analysed. The methodology followed as well as the main results of the study, are discussed in the following section.

2. Data Collection and Organisation of the Study

Information and data have been collected through interviews with the members of the selected families and corresponding inspections of each building. The information collected has been organized into five main groups, (Table 1):

Group 1. General Information, involving data about the location of the building, its floor area, the number of occupants, the year of construction, the type of residence, the number of storeys, and some other information about the neighboring buildings.

Group 2. Information on the annual income of each family.

Group 3. Information on the operational schedules of the building. In particular, on the set point temperature, the heated and non heated part of the building, and on the mean daily hours of heating.

Group 4. Information on the energy consumption and the type of fuels used; in particular, on the energy consumption for heating and electricity uses, the type of fuel used for heating, the heating system, the number and type of air conditioners installed in the house and, finally, information on the maintenance of the heating system. Electricity consumption has been

obtained directly from the bi-monthly electricity bills, while oil consumption for the apartment buildings has been obtained from the monthly invoices issued for each apartment by the managers of the buildings. Finally, for the detached buildings, the oil purchase invoices have been checked.

Group 5. Information on the quality of the envelope and in particular: on the type of glazing and the existence and type of insulation.

All information is considered as fully confidential. A database has been created and the necessary quality control has been performed, while all extreme values have been excluded. At the end, data from 945 buildings have been used. Based on the distribution of the annual income, seven income classes have been defined, (Figure 1), and specific analysis has been performed for each income class in a comparative way. Income classes have been defined using intelligent clustering analysis. Clustering is a mathematical technique to classify numerical data. It is based on the identification of sub-groups on a data set, called 'clusters', where all objects are described by similar characteristics. Every cluster contains a number of member objects represented by given locations in the space and a center defined as the point in the cluster space where the sum of the specific distances of every member object belonging in the cluster is minimized. Clustering techniques have been extensively used to create natural groupings of data in energy sciences. Fuzzy clustering is a quite new, 'intelligent' technique that considers that each individual element in the data set belongs to a cluster to some degree that is defined by a membership function.

3. Results of the Study

Social, financial, energy and technical data from about 1110 households have been collected during 2004 in the greater Athens area. The sample has been divided into seven income groups and a detailed analysis has been performed..

The main conclusions are :

a) There is an almost a linear relation between income and occupied space per household. The mean occupied area for the richest income group is about 115 % higher that the corresponding area for the poorest group.

b) The mean occupied surface per person is close to 37 m^2. The number of inhabitants per household increases as a function of income. The median value of the occupied area per person does not present important differences between the various income groups and only for the richest group the occupied surface per person is much higher.

c) As it concerns the distribution of the age of the households per income group, it is found that the higher the income the lower the age of the buildings. The mean age of households of the lower income group is 29 years while for the richest group is 19 years

d) As it concerns the type of households per income group, it found that as the income increases the number of households living in apartments decreases. Almost 64 % of the families in the lower income group live in apartments, while the corresponding number for the richest group is 48 %. In parallel, low income families live mostly in the lower part of multistory

buildings while high income households live mainly in the higher part of the buildings. Also, the analysis has shown that high income households prefer to live in smaller size multistory buildings, while low income families live mainly in buildings with a much higher number of apartments per floor.

e) There is a very clear relation between the income level and the percentage of non insulated dwellings. The higher the income the higher the percentage of insulated buildings. Only 28 % of people of the poorest group lives in insulated buildings, while the corresponding figure for the richest group is close to 70 %. In parallel, the higher the income the higher the percentage of buildings with double glazing. For the poorest group the percentage of double glazed buildings is 24 % while for the richest group the corresponding figure is 67 %. Insulated buildings with double glazing are quite rare for the lower income groups, (8 %), while the corresponding percentage increases to 60 % for the high income group.

f) The mean daily duration of heating is close to 7.5 hours per day. The heating period increases considerably, up to 8.5 h per day, in the richest groups. The average set point temperature for the heating period is close to 18.4 C. The difference in the set point temperature between the poorest and the richest groups is about 1 C

g) A very high increase of the installed a/c per household is observed as a function of income. The mean value for the lower income group is close to 0.6 air conditioners/household, while the corresponding value for the upper income class is close to 2.15. However, the density of installed air conditioners per square meter is much higher for the lower income people that for all other groups. Although middle and high income people use more air conditioning, the relative cost of comfort during the summer period is much higher for the lower income people

h) The distribution of the energy consumption for heating presents a U type shape with high consumption at the two limits. High energy consumption per square meter is observed for both the low and high income groups. As it concerns the mean heating energy consumption per person and area it is found that the lower the income the higher the cost of heating per person and unit of surface. The cost per person and m2 for the lower income group is to about 127 % higher that the corresponding cost of heating for the richest group.

i) As it concerns the heating energy consumption per type of dwelling it is found that the energy consumption of detached houses is to about 50 % higher that that of apartments.

j) There is a considerable decreasing trend of the heating energy consumption as a function of age of the buildings. The calculated decreasing trend of the heating consumption is close to 0.8 kWh/m2/year.

k) For detached houses, the combined impact of insulation and double glazing decreases the mean heating energy consumption of the building stock to about 40 kWh/m2/y compared to a single glazed non insulated dwelling. For apartments,

the corresponding reduction is much lower, 8 kWh/m2/y.

l) There is almost a linear relation between the annual expenses for electricity and the family income. High income families pay almost 160 % higher annual cost than the low income ones. As it concerns the annual electricity cost per unit of area and person it is found that the lower the income the higher the cost of electricity per person and unit of area. Low income people pays almost 67 % higher electricity cost per person and square meter than high income people.

m) The use of air conditioning increases considerably the annual electricity expenses especially in the low income groups. As a mean value, the use of air conditioning increases the annual expenses to about 100 Euros per household, or 0,6 Euros/m2, or 12.5 Euros per person. The increase is much higher for the low income groups, where the relative increase of the cost because of the air conditioning use is close to 195 Euros/household, or 1.2 Euros/m2, or 87 Euros/person.

n) The mean income fraction spent for heating and electricity is close to 2.4 and 3.1 % respectively, (2004 values). Annual heating expenditures represent almost 6.2 % of the total income of the poorest people. The corresponding figure for the upper income group is close to 0.6 %.

o) Almost, 1.63 % of the households suffer from fuel poverty and 0,35 % from severe fuel poverty, (2004 values). Fuel poverty in low income groups, is close to 16 %. Severe fuel poverty, in the low income group, is calculated close to 4 %, (Figure 15d).

p) As it concerns energy poverty, the average percentage of the households spending more than 10 % of their income for energy is close to 11.3 %, while 2 % spends more than 20 %, (2004 values). Almost 40 % of the low income group spends more than 10 % of their income for energy, (energy poor), while almost one fifth of the poor households spends more than 20 % of their income for energy, (severe energy poor).

q) Considering 2006 fuel prices and increase of GDP, the mean income fraction spent for heating has increased from 2.4 % to 4.5 %, while the average percentage spent for energy has increased from 5.5 % to 7.4 %. For the low income group, the average income fraction spent for heating has been increased from 6.2 % to 11.6 %. In parallel, the total expenses for energy of the same group have been increased from 12.1 % to 17.6 %.

r) New fuel prices have increased the average percentage of households suffering from fuel poverty from 1.6 % to 8.4 %. For the lower income group, fuel poverty has been increased from 16 % to 36 %. Average severe fuel poverty has been increased from 0.35 % to 1.5 %. The percentage of severe poor in the lower income group has been increased from 4 to 12 %.

s) The average percentage of households suffering from energy poverty, has risen from 11.3 % to 21.1 %. Energy poverty in the low income groups has increased from 40 to 60 %. The mean percentage of severe energy poor, has also increased from 2 to 3.7 %. Severe energy poverty in low income groups has risen from 20 % to 32 %.

The whole analysis permits to conclude that energy consumption spent for heating and electricity purposes is quite high and there is a very potential for energy conservation. Energy consumption per person and square meter both for heating and electricity, is much higher in the low income groups mainly because of the poor quality of the building envelope. Fuel and energy poverty reach quite high levels in the low income groups and there is a dramatic raise because of the recent increase of the fuel prices.

Energy policies addressing the residential sector should set as a priority the improvement of the envelope quality of dwellings where low income people is living. Further increase of the fuel prices will aggravate seriously the economic situation of these households and may create a serious social problem. It is calculated that a further increase of oil prices by 10 dollars per barrel brings 2.5 % of the population under fuel poverty. The creation of a special fund to finance energy retrofitting of low income households appears to be a necessity.

1.

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Tables

Type of Information		
:Group 1 : General	Location of the building	
	Surface of the Building	
	Year of Construction	
	Type of Residence	Single Storey
		Two/Three storey
		Maisonette
		Apartment
		Other
	Number of Storey	
	Number of inhabitants per household	
	Number of other buildings or apartments in contact with	
	Existence of a Pilotis	
Group 2 : Income		
	Monthly Income of the family	
Group 3 : Energy System and Operational Conditions	Set Point Temperature (C)	
	Percentage of Spaces non Heated	
	Mean daily hours of Heating	
	Type of Heating System	
Group 4 : Energy Consumption	Monthly Energy Consumption for Heating Fuel	
	Monthly Electricity Consumption	
	Type of fuel used for Heating	
	Frequency of the heating system maintenance, (years)	
	Number and power of A/C systems	
Group 5 : Quality of the Envelope	Type of Glazing (single, double, other)	
	Type of Insulation	

Table 1. Specific Information and Data collected through the Questionnaire