Specification of the socioeconomic dimensions of energy demand and consumption in Greece using Geographical Information Systems

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Abstract

In a period of intense economic crisis, one of the main problems, faced by the Greek society is the sufficient cover of energy needs. Due to the austerity measures, tax raises have led to a great increase in fuel prices. This factor, combined with income reduction, has led many households to lower energy consumption, even at very low levels that do not ensure comfort conditions in the residences. In many cases unsafe fuels are used for heating purposes and this leads to negative environmental impacts and health problems, even deaths due to poisonous gases emissions. Therefore, the Greek society is exposed to the problem of energy poverty and policy interventions are necessary, in order to avoid the serious social consequences of this situation.

For the time being, the Greek Government has applied some basic measures, which could help towards energy poverty alleviation. Households can purchase heating oil at lower prices through a subsidy policy that has been implemented since 2011. Moreover, energy efficiency interventions are promoted by giving financial motives to house - owners. The influence of these measures on alleviating energy poverty is not sufficient though. This can be attributed to inadequacies in designing such policies.

This paper aims at clarifying the "energy landscape" in Greece, which is an important prerequisite for designing effectively energy policy measures. Energy demand and consumption, as well as the corresponding cost of Greek residences have been estimated by combining meteorological data and technical data of residences. Thereby, the dimensions of energy poverty can be estimated. In order to better locate the inadequacies of energy policy measures and to suggest improvements, a spatial dimension is particularly necessary. Hence, Geographical Information Systems have been utilized, in order to understand the spatial patterns of energy demand, consumption and costs in Greece.

Energy costs seem to be particularly increased in mountainous Greece, due to the harsh climate and the, usually, old building stock found in these areas. Such findings could help towards redesigning subsidy policy e.g. for heating oil, in order to help local societies overcome high energy costs. For instance, in the mountainous town of Vitina in Peloponnese, a typical household is subsidized only for half of the actual heating oil consumption. Utilizing the findings of the present paper, such inadequacies in energy planning can be determined and this can lead to better solutions for overcoming energy poverty and improving development perspectives.

Keywords

degree-days, energy demand and consumption, energy costs, energy poverty, energy policy, Greece

Introduction

The energy sector is of great importance for economic and social development and has a serious environmental dimension (Pimentel & Pimentel, 2008; Coello, 2011). Under the impact of economic crisis, sufficient coverage of energy needs becomes a major issue and energy policies need reconsideration. Several methodologies have been developed to optimize energy systems and design energy policies. Most of them include a computational core of multicriteria optimization models, based on energy demand, available energy sources and their economic and environmental dimensions. However, apart from using energy optimization techniques, mapping the data related to energy matters through geographical systems can be a useful tool for energy planning and policy, since spatial patterns of such magnitudes and figures could help policy makers and other stakeholders towards to a better understanding of the current situation and hence, to better plan the energy strategies.

In this paper, findings from energy studies, regarding energy loads and energy costs, for the case of Greece, have been illustrated on maps, using Geographical Information Systems (GIS). The work illustrates effectively and highlights the areas of Greece that are afflicted by increased energy load and cost. The findings are useful for evaluating current energy policies and setting priorities for promoting measures against challenges, like energy poverty.

Methodology

In order to quantify the energy demand and consumption, the energy cost and to create relevant maps, including these data for Greece, the work of Katsoulakos (2013) and Panagiotopoulos (2014) has been utilized. More specifically, the methodology includes the following steps:

a) Calculation of heating and cooling degree days in Greece: Linear models, developed by Katsoulakos (2013), as well as Katsoulakos & Kaliampakos (2014) are used to calculate degree – days for the whole of Greek territory.

b) Calculation of energy demand: A database containing the data related to the quality and age of the building stock, the number of buildings and the number of households at municipal district level created by Panagiotopoulos (2014) is utilized. So, by combining the findings of step (a) with the database, thermal and cooling needs of every municipal district in Greece are calculated.

c) Estimation of energy consumption: By taking into account the statistical data about the energy production systems used in Greek households (Giakoumi & Iatridis, 2009), the findings of step (b) and the data related to electricity consumption (e.g. Giakoumi, 2010; www.dei.gr), the thermal and the electrical energy consumption, as well as the consumption for hot water production, in every municipal district of Greece are estimated.

d) Creation of maps: The results of the previous steps are imprinted in maps, using Geographical Information Systems (GIS). The analysis, as mentioned before, is made at municipal district level.

The findings of the methodological steps also lead to some useful estimations about energy poverty in Greece, as well as to better understand the spatial dimensions of energy related matters.

Results and Discussion

As far as degree days are concerned, in Figure 1, the results for heating degree – days (base temperature 16°C) are presented. In accordance with previous research (Matzarakis & Balafoutis, 2004), in Northern Greece and in mountainous areas, heating degree – days are increased. The peak of heating degree-days is found across the northern borderline, as well as in the region of Western Macedonia, in the mountainous areas of the region of Epirus, in the mountainous areas of central Greece and in some areas of mountainous Peloponnese. In the majority of islands and coastal areas, heating degree-days are relatively low. The effect of altitude on degree-days was not strongly highlighted in previous works. However, it seems to be the most significant factor affecting degree-days in the latitudinal range of Greece and the number of heating degree-days is increased in mountainous areas, even in southern Greece. In order to better understand the role of altitude, it is proved that it affects degree-days 3.5 times more than latitude, in Greece (Katsoulakos, 2013). Cooling degree-days follow, somehow, a reverse pattern. They are increased in areas with lower altitudes and they reduce in northern territories.

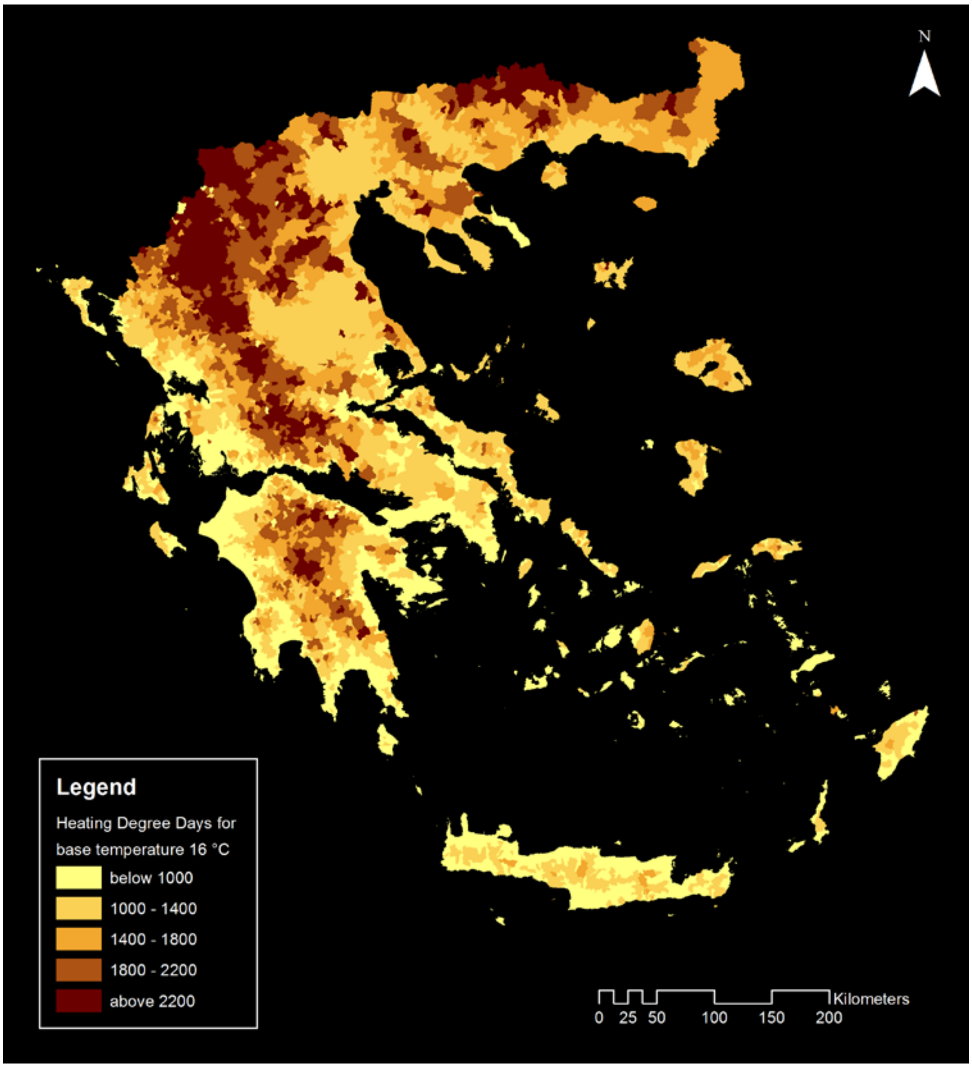

Figure 1. Heating degree – days (°C*days) for base temperature 16°C in Greece.

Following the results related to degree-days, heating energy demand is increased in northern territories and mountainous areas. At an altitude of 800m, the thermal energy needs of a residence with adequate features are almost two times greater than at sea – level. Figure 2 contains the annual thermal energy consumption in the households of Greece. Cooling needs are being met by electricity and since they are increased in lowlands and coastal areas, higher electricity needs are observed in these areas. The ratio between thermal and electrical load in a house at sea – level is 1.2:1. At the altitude of 1,000m this ratio becomes 4:1. In Figure 3, the total energy consumption for the whole of Greece is imprinted, estimated by taking into account the average energy system mix used in the country. Because of the significantly increased heating needs in mountainous areas, total energy consumption in these areas is also high.

The findings presented in Figure 2 prove that the current policy, regarding heating oil subsidy for households has been designed poorly. More analytically, as it is shown in the map (Fig. 2), in the area of Athens, the annual heating energy consumption lies below 10 MWh/household. In the, mostly mountainous, area of Fokis (marked with the yellow arrow in Figure 2) the annual heat consumption in the highest settlements is between 23 and 30 MWh/household. This means that residences in Fokis consume two or three times more thermal energy than in Athens. However, under the current subsidy policy, Athens and Fokis are classified in the same climate zone and the subsidized oil quantities are the same for the two areas. This, obviously, is a serious flaw of the present policy. The initial mistake in classifying Greek territories in climate categories leads to subsidizing significantly lower quantities of oil than those actually needed. For instance, in mountainous Peloponnese, in the town of Vitina, only half of the average, required oil quantity is subsidized (Katsoulakos, 2013).

High energy consumption in mountainous areas and northern Greece leads to serious financial burden for the households in these territories. At an altitude of 1,000m a residence using diesel oil heater for heating and hot water production and heat pumps for cooling needs to spend two times more money to cover, sufficiently, its energy needs. In Figure 4, the energy costs of Greek households are illustrated. As far as energy prices are concerned, the following assumptions were made, diesel oil: 1.2 €/lit, firewood: 120 €/tn, natural gas: 1.02 €/m^3, electricity: 0.13 €/kWh.

High energy cost renders mountainous areas more vulnerable to energy poverty. Energy poverty, according to the European Economic and Social Committee (EESC), occurs where a household finds it difficult or impossible to ensure adequate heating in the dwelling at an affordable price and having access to other energy-related services, such as lighting, transport or electricity for use of the Internet or other devices at a reasonable price (EESC, 2011). It is usually assumed that a household spending more than 10% of its annual income to cover energy needs is considered energy poor. In this context, it is proved that, under the circumstances of the ongoing energy crisis in Greece, more than 85% of the households lying at altitudes over 800m are energy poor (Katsoulakos & Kaliampakos, 2014). The irrationally designed subsidy policy for heating oil cannot alleviate this problem.

Apart from the economic dimension, high energy consumption is also related to a greater environmental footprint. Improvement in building energy efficiency can reduce both the environmental impact and the cost of energy consumption. According to the maps shown in the figures provided (Fig. 1, 2 and 3), it is reasonable to give special consideration to areas with high energy demand, as far as energy saving promotion is concerned. However, current policies (such as the programme “Energy saving at home” adopted by the Greek Government) promotes energy saving based only on technical and financial criteria. Giving some extra motives to the inhabitants of northern and mountainous Greece could be particularly effective and should be considered by policy makers.

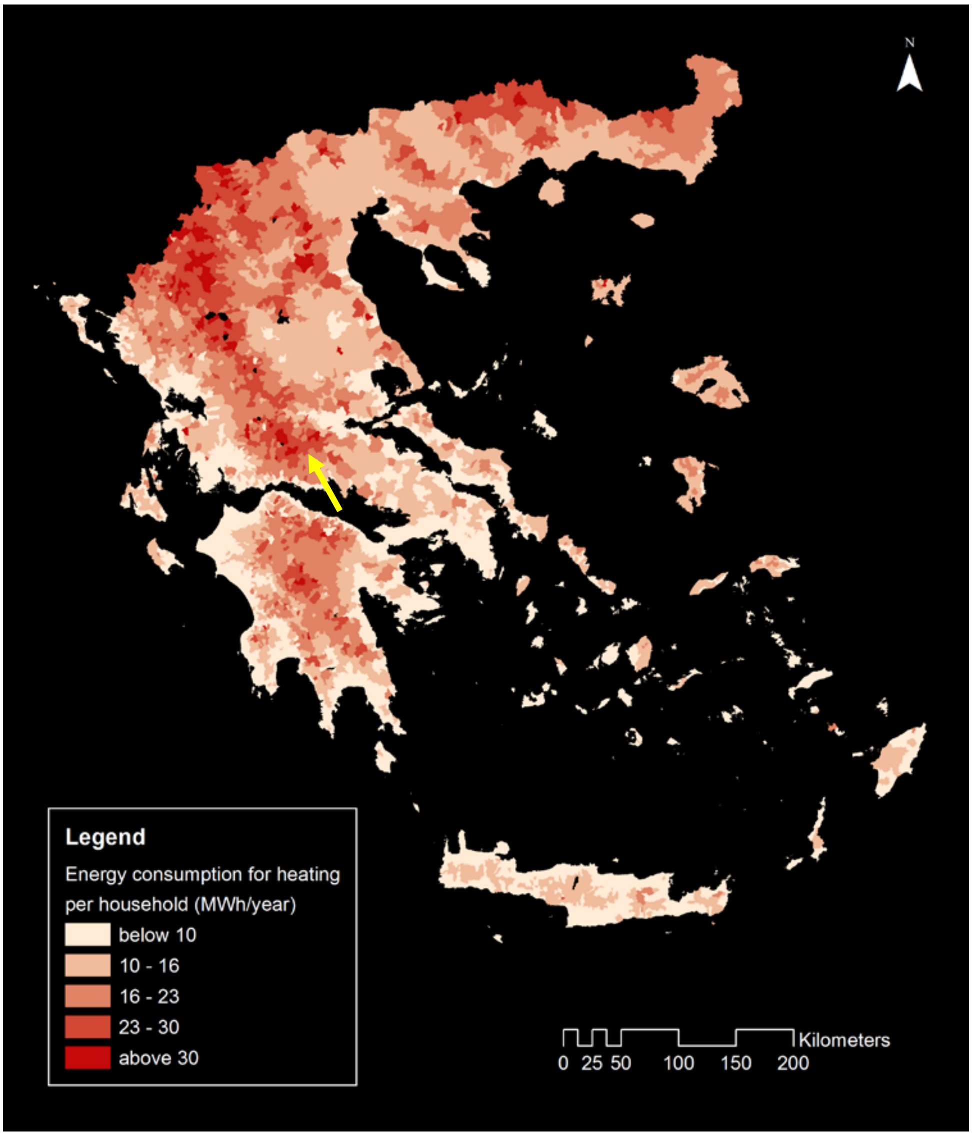

Figure 2. Annual thermal energy consumption in MWh/ household, in Greece.

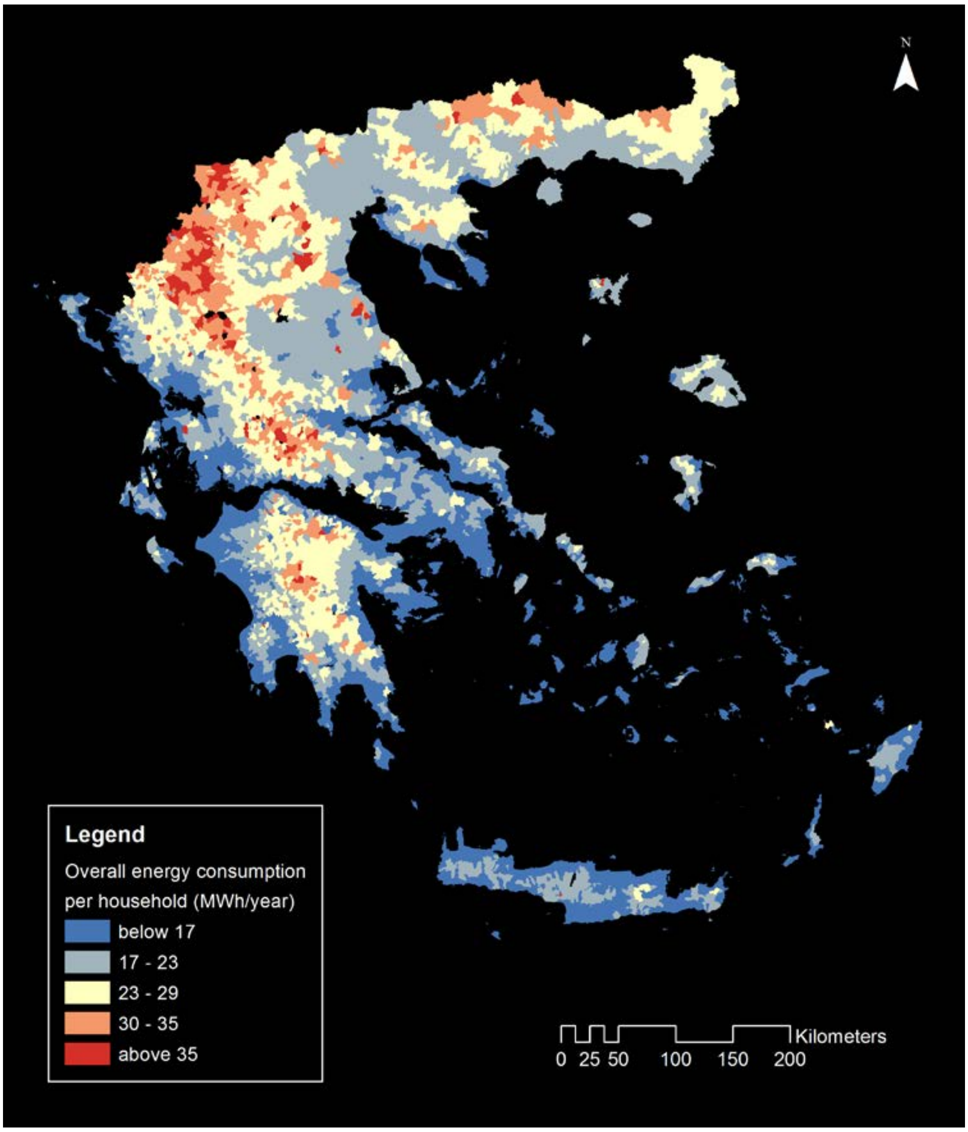

Figure 3. Total annual energy consumption in MWh/household, in Greece.

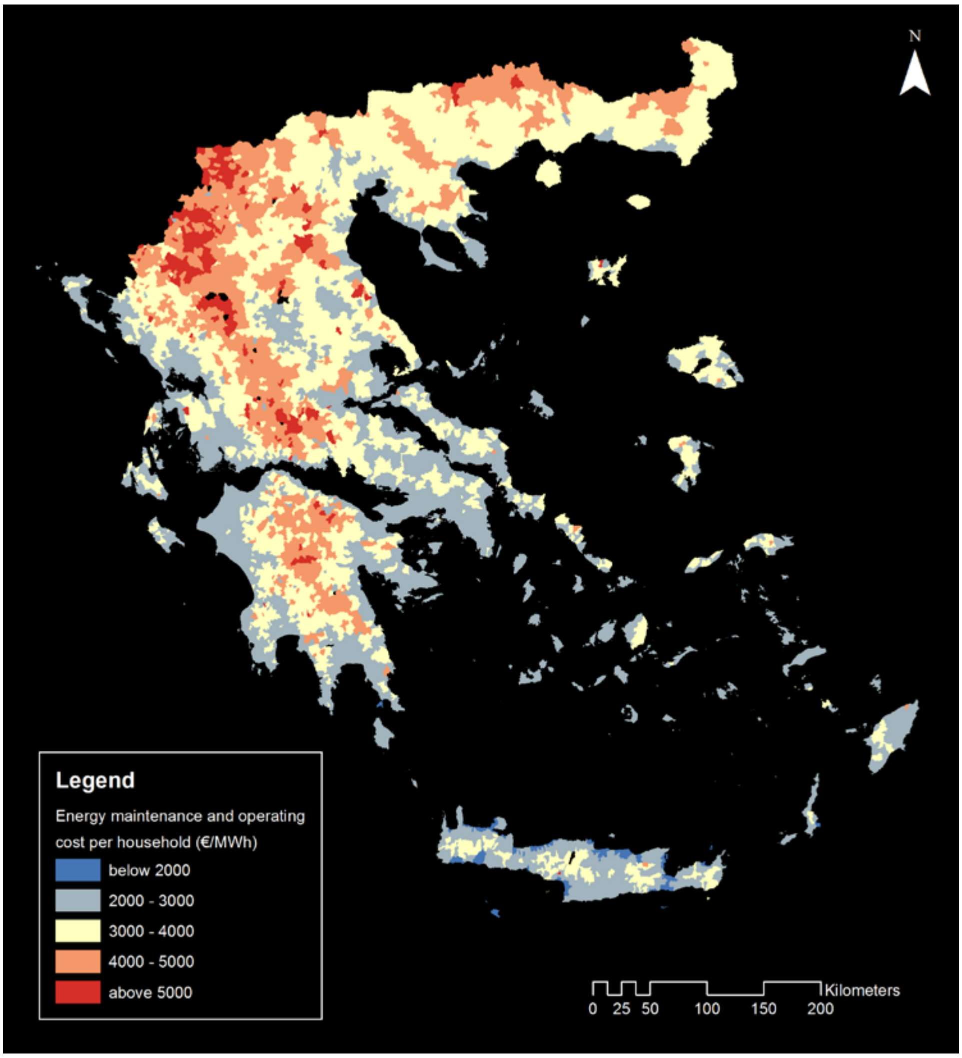

Figure 4. Total annual energy costs per household in Greece.

Conclusions

The findings presented in this paper and the conclusions extracted from them are summarized below:

- Altitude is the most decisive, influential factor, as far as degree-days are concerned, in Greece. Latitude is also an important factor but with far less impact on degree-days. Therefore, mountainous areas and northern Greece present the highest thermal energy demand.

- The total energy consumption is also higher in mountainous Greece and northern territories and this leads to particularly high energy costs. As it can be seen in the corresponding maps, the northern borderline of the country, as well as its mountainous core (from Epirus to Peloponnese) are the areas, which present high energy loads. Therefore, energy poverty, which affects the whole of country (and intensifies due to the economic crisis), is more severe in mountainous areas.

- The increased energy needs of certain areas in Greece have not been taken into account in the current policy, regarding subsidies in heating oil. Hence, it includes irrational assumptions and cannot alleviate effectively the problem of energy poverty.

Moreover, no special financial motives are given to the inhabitants of these areas for applying energy efficiency interventions at their residences.

Taking into account the abovementioned points, re-designing the current subsidy policy for heating oil is necessary, in order to alleviate effectively energy poverty. Moreover, by studying the maps presented in this paper, it is clear that mountainous Greece has a particular energy identity, described mostly by high energy load and cost. The physical and social features of mountain geography can make life harder in high – altitude settlements (Parish, 2002). The obstacles set by geography are enhanced by other issues, like high energy cost. Hence, ensuring sufficient energy supply at an affordable price is a prerequisite for the revival and the sustainable development of mountainous areas and should be set as an urgent policy priority.

Apart from these findings and assumptions, combining energy analyses at municipal level and GIS can be a useful tool for gaining an overall view for energy policy priorities, something proved by Panagiotopoulos (2014), as well.

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