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Factors affecting electricity demand in Athens, Greece and London, UK: A comparative assessment

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ABSTRACT

This paper presents a comparison of the characteristics of the electricity demand for London, UK and Athens, Greece and explores its relationship with both climate and non-climate related factors. Year-to-year trends for both cities are identified, associated mainly with economic, social and demographic factors. In addition, several other effects such as weekly and holiday effects, unrelated to weather conditions are detected and are examined in comparison for the two cities. Gross National Product (GNP) per capita has been employed to aid de-trend the data in order to isolate the weather/climate influence on electricity demand. Temperature has been found to play the most important role in controlling the electricity load demand, especially for Athens. For both cities electricity demand peaks in winter but for Athens a second significant peak is apparent in the summer, not present in London. Thermal comfort levels for both cities have also been identified and compared. The optimum ambient temperature for low levels of electricity demand is found to be 20 °C for Athens and 16 °C for London. Using the approach of cooling and heating degree-days, it was identified that the sensitivity of the system electricity-demand/air-temperature is greater during the cold period of the year for both cities.

1. Introduction

Several economic activities are affected by weather fluctuations. One of the most sensitive is the electricity market, since power demand is closely linked to air temperature. The sensitivity of energy demand to weather stems from the fact that that produced electricity must be instantly consumed.

Various studies have investigated the influence of ambient air temperature, most times represented by heating and cooling degree-days, on electrical energy consumption [1–10]. However, temperature is not the only variable considered in the literature. Other primitive independent variables, such as relative humidity, clearness index, cloudiness, rainfall, solar radiation and wind speed [11–15], and derived variables including latent enthalpy-days, temperature–humidity index, Steadman's indoor apparent temperature, cooling radiation-days and clothing insulation units '*clo*' [8,16–18] have also been used by other researchers for the development of statistical models for energy consumption. In many cases modeling of electric energy consumption is multivariate, consisting in a mix between climate and other important economic factors. The main constituents of these economic factors are energy prices, income, Gross National Product (GNP), import and export values and energy demand index [17,19–25]. Population and production in total manufacturing, together with temperature, have also been used by Bessec and Fouquau [26] for modeling monthly electricity consumption to a panel of 15 member states of the European Union over the last two decades.

Lai et al. [27] tried to model the electricity consumption in the Asian gaming and tourism center of Macao SAR. As Macao is a very small city and tourists spend plenty of their time in an indoor environment, such as casinos, restaurants and hotel rooms, they proposed a model equation of monthly electricity consumption incorporating (except monthly mean air temperature and population) two more commercial-related determinants, the number of tourists per month and the hotel room occupancy. Also, in order to avoid abnormal data appearing in February (28 or 29 days) and other months (30 or 31 days) they proposed the number of days per month as a third determinant.

Co-integration techniques for establishing long- and short-term energy demand relationships with climate factors have also been performed [12,25]. Moral-Carcedo and Vicéns-Otero [28] in their analysis of the effects of temperature on the electricity demand in Spain, proposed a logistic smooth threshold regression model with the temperature as a threshold variable. This allows the relationship

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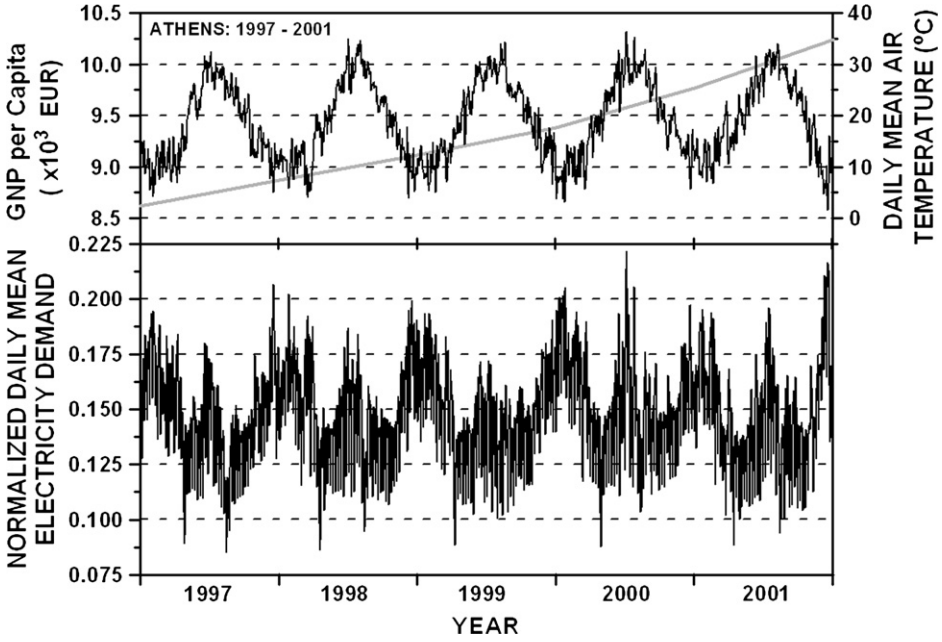

Fig. 1. Mean daily air temperature and electricity demand, normalized using the GNP per capita (gray line), for Athens, Greece, for the period 1997–2001.

between electricity consumption and temperature to depend on the level of the threshold variable i.e. the temperature. The same technique was used in the analysis by Bessec and Fouquau [26].

Daily electricity demand in countries throughout the world shows a clear seasonal pattern. Average daily electricity demand in most EU-15 countries, historically shows a single peak during winter months [29]. Only Spain, Portugal, Italy and Greece show an additional peak during summer months [5,29,30]. Demand patterns with only summer peaks may be found outside of Europe, e.g. as observed in Bangkok [31] and Hong Kong [1]. The seasonal pattern results from the fluctuating influx of solar radiation and the varying economic activity throughout the year in the Northern hemisphere [3].

Time series analysis of daily electricity demand data reviles a "U" shape relation between outdoor temperature and electricity demand [3,5,10,11,15,25,26,28,32,33]. This non-linearity refers to the fact that both increases and decreases of temperature, linked to exceeding certain "threshold" temperatures, increase the demand for electricity. According to Henley and Peirson [2], this response is caused by the differences between the ambient or outdoor temperature and the comfort or indoor temperature. When the differential between outdoor and indoor temperatures increases, the starting-up of the corresponding heating or cooling equipment immediately raises the demand for electricity. Naturally, the curve of the response of demand to temperatures depends especially on the climate characteristics of the geographical area to which the

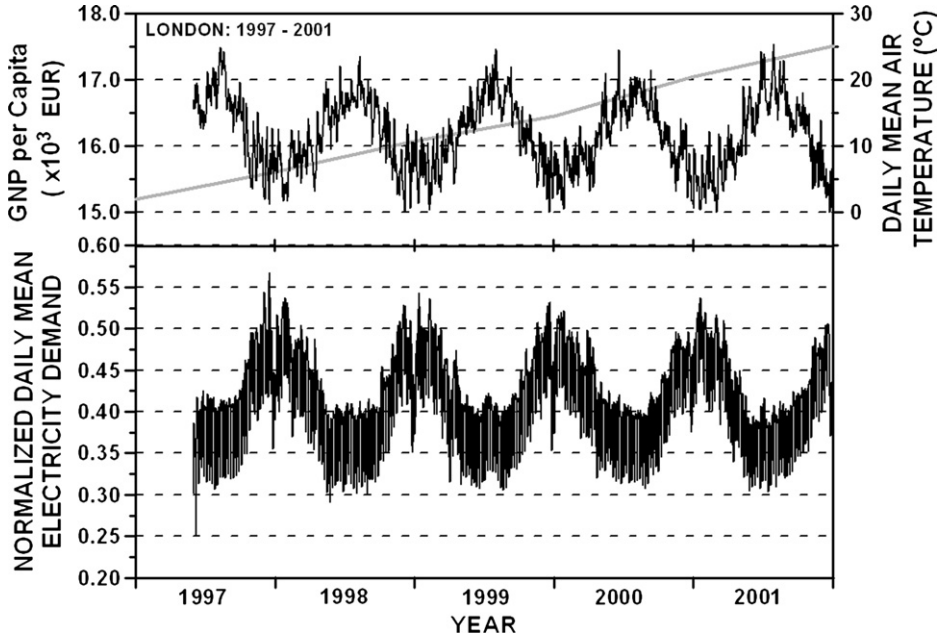

Fig. 2. Mean daily air temperature and electricity demand, normalized using the GNP per capita (gray line), for London, UK, for the period 1997–2001.