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A feasibility evaluation tool for sustainable cities – A case study for Greece

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ABSTRACT

Designing measures for the reduction of energy consumption in urban areas is a complex venture indeed. In terms of urban sustainability, such measures affect energy efficiency as well as environmental, economic and social aspects. Numerous publications dealt with such methodological approaches in the past, whilst the subject of sustainable urban areas and cities is constantly gaining interest. Furthermore, energy performance depends on building density, occupancy and consumer profile, climatic conditions, not least construction quality, factors linked, directly or not, to socio-economic aspects. Greek cities are known for their density, their polymorphic structure and their complexity. Thus, planning energy conservation measures is a difficult task, demanding a precise methodological approach, which will embody most of these aspects to a great extent. This paper proposes a methodology on how to manage Greek cities in terms of their energy efficiency, emphasizing on the residential stock.

1. Introduction

The latest international developments in the field of energy supply, along with the major issue of the environment protection, set new priorities and yardsticks concerning the energy policies implemented globally. The fact that the sovereign models for the energy consumption are mainly based on the oil consumption, in combination with the reduction of the fossil oil production, could lead in time to a new form of energy crisis. In Europe 27 the final energy consumption is constantly rising, whilst the total production of primary energy is dropping (Fig. 1).

The relation between these factors can also be described by the "energy dependency factor". Energy dependency shows the extent to which an economy relies upon imports in order to meet its energy needs, whilst the indicator is calculated as net imports divided by the sum of gross inland energy consumption plus bunkers (Fig. 2). Fig. 2 describes the respective tendency in EU-27 and various Member States, indicating an upward trend. Moreover, Greece is one of the most energy depended countries in EU-27 with an average dependency of 69.9% and a rather constant performance over the past 3 years.

Meanwhile, buildings in Europe account for one third of the total energy related CO_2 emissions (Eurostat, 2010c) and consequently the European building sector consumes approximately 40% of the world's total primary energy (Eurostat, 2008). This situation describes a rising trend; from 2007 to 2008 the CO_2 emissions from Households and Services rose by 8.2% (EEA, 2010), whilst during the period 1990–2005 the per capita household energy consumption increased in the majority of the Member States (EU-27) by 11.6%. During this period only five Member States managed to decrease their per capita energy consumption (EEA, 2008).

Furthermore, it is characteristic that, according to EEA (2006), by 2020 approximately 80% of Europeans will be living in urban areas, whilst in some countries the quote will reach 90% or more. Besides the energy aspect, one should therefore consider the quality of living standards prevailing in the cities.

In this context many studies have been carried out in order to estimate sustainability standards of cities both in developed and developing countries. Compact cities, megacities, as well as city sectors and areas have been a popular subject of thorough analysis (Haughton, 1997; Roy, 2009). Apart from high density in the urban environment, the urban sprawl phenomenon is also characterizing European cities: their compact nature as well as their random growth and expansion often lead to urban sprawl (EEA, 2006), with apparent impact on increased energy consumption.

Moreover, as Madlener and Sunak (2011) state in their work, cities are responsible for almost 75% of the global resource consumption, whilst this does not necessarily ensure proper living conditions. They also underline the great impact of urbanization on sustainability as well as on energy consumption by demonstrating the main factors influencing energy behavior of cities, and especially for private households.

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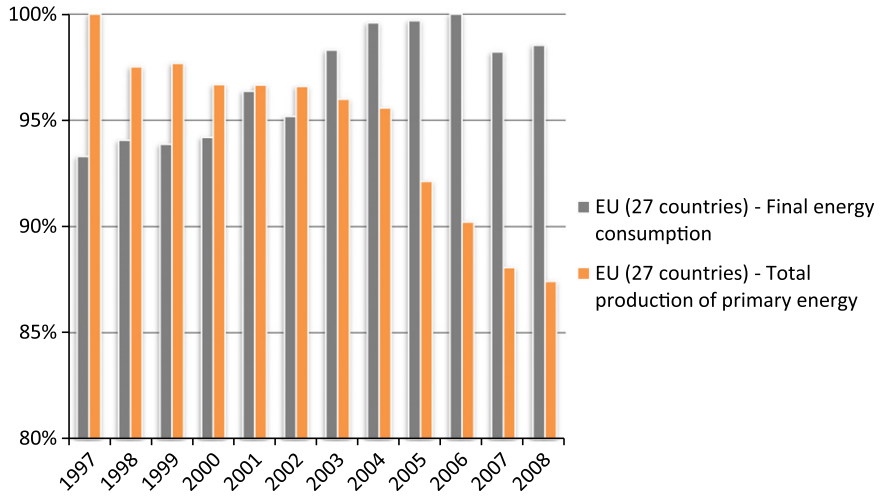

Fig. 1. Total production of primary energy and final energy consumption in EU 27 since 1997.
Source: Eurostat (2010a).

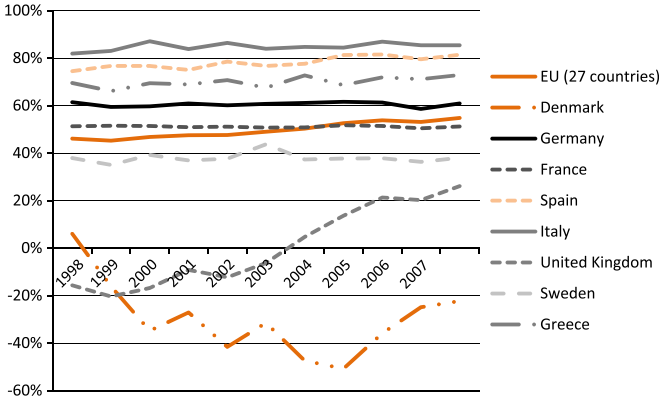

Fig. 2. Energy dependency in % in EU-27 and various Member States.
Source: Eurostat (2010b).

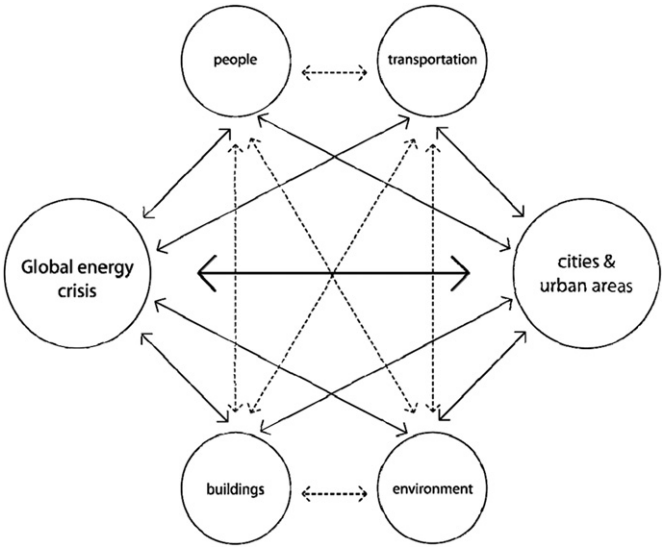

Fig. 3. Connection between the influencing variables.

The methodology presented in this paper is based on the sequence of events and the interactive relationship between the need to control the global environmental and energy development as well as the sustainability and energy performance of urban areas and cities. In the following figure the link between the parameters, which affect energy efficiency policies concerning the urban environment is depicted (Fig. 3). These factors are both influencing and simultaneously being influenced by the anthropogenic activity, the local infrastructure, the buildings and of course the environment. In this framework, the proposed methodology is mainly based on the idea, that any energy conservation policy should not only concern the buildings as units, but also the future impact of such measures on cities and urban areas, as well as on economic, environmental and energy aspects, in this case of the Greek reality. Hence, the focus is on buildings and their relation to the urban energy behavior.

2. Cities

2.1. A brief overview

In order to assess the relationship between the building unit and the urban areas, the relevant terminology needs to be clarified. According to Neuman, cities are historic centers of government, industry, commerce, residence, and culture (Neuman, 2000). Big cities, city sectors and megacities (Madlener and Sunak 2011), compact cities (Holden and Norland, 2005), urban blocks (Sonne, 2009), historic cities (Strange, 1997; Strange, 1996) and urban regions (Arribas-Bel et al., 2010), as well as Mediterranean cities (Munoz, 2003; Cheshire, 1995), not only are definitions found in the literature, but they also refer to specific typologies of the built environment. Each typology comprises of numerous variables, often with no apparent relation to each other. However, there is a common characteristic that describes cities; they remind us of a complex organism. The hallmark concerns their aging process, thus, as a part of a city grows older, others are still developing. This phenomenon is affecting a series of parameters, with an apparent chain reaction, among which their energy behavior and the respective environmental impact. So how do we deal with an organism that does not age in a homogeneous way and needs retrofitting in terms of its energy behavior? The scope of this paper is to give the respective answer(s), especially as regards Greek cities and their energy performance.

2.2. Sustainable cities

The subject of sustainable cities and urban environment has become popular since the early 1990s (Roy, 2009). Hence, respective