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Public awareness and willingness to adopt ground source heat pumps for domestic heating and cooling

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ABSTRACT

Nowadays, residential heating and cooling are responsible for a significant part of the total global energy consumption. In order to create environmentally friendly buildings, the application of renewable energy technologies is recommended. Such a technology is GSHP[1] systems. This study examined the level of consumers' awareness on this technology, their perception on considering installing such a system, as well as the factors influencing the above issues. According to a logistic regression analysis, knowledge concerning the use of a GSHP system for residential use is positively related to the existence in the residence of a person with an occupation or interests associated to environment, technology or engineering, as well as the awareness about RES[2] issues and higher educational level. Also, considering installing a GSHP system is positively related to the existence in the residence of a person with an occupation or interests associated to environment, technology or engineering, awareness on RES and alternative technologies, as well as younger age groups, higher income groups, university and technical vocational education graduates.

Contents

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[1] Ground source heat pump.
[2] Renewable energy sources.

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1. Introduction

The energy consumption of households is constantly rising due to the increased demand for amenities and the more time spent indoors [1]. Buildings consume about 40% of global energy consumption, while the percentage of the residential sector approaches 25% of total consumption [2,3]. In Greece, 29% of total energy is consumed by households [3]. A big part of residential energy is used for space heating, cooling, air conditioning as well as hot water production. The distribution of residential energy consumption between different categories may vary depending on the climate zone. It may vary from 40% for heating, 20% for hot water, 8% for air conditioning [4] to 57% for heating and 25% for hot water [5]. Generally, in developed countries the average for heating, cooling and air conditioning accounts for 50% of the residential energy consumption, which corresponds to approximately 20% of the total energy consumed [1].

The reduction of energy used for heating and cooling can provide a solution against increased energy consumption of the residential sector. A sustainable option is the use of innovative technologies based on RES, forming an efficient and effective solution for energy reduction [2,5–12].

GSHP systems are technologies that can contribute in a sustainable manner to the reduction of energy consumption of buildings and their independence from fossil fuels by covering their heating, cooling and hot water needs. GSHP are very efficient compared to conventional systems, while their operating principle is based on the fact that unlike air, earth has a constant temperature during the whole year. During winter the system transfers thermal energy from the ground to the building to heat it, while during summer it cools the building by discarding thermal energy to the ground. Moreover, it can provide hot water without extra energy consumption. Although GSHP systems usually have a higher installation cost than conventional systems, their operation and maintenance costs are significantly lower. So, the payback period of the installation can be very low, combining financial benefits with environmental protection through reduced GHG emissions [13–17].

Diffusion of GSHP systems is still in an early stage, since the space heating and cooling sectors are mainly occupied by conventional technologies. However, the technology has great development potential as, among other advantages, it can be installed in any area since its application is irrelevant of the underground temperature. The regions in which the technology is more developed are North America and some European countries (Germany, Switzerland, Austria, France, and Scandinavian countries), while development also occurs in some other countries like Japan and Turkey [13–15]. Regarding to the EU market, in 2012 98,807 GSHP units were sold, thus exceeding the number of 990,000 total installed units. On the contrary, due to the financial crisis and the decline of the construction activity there was a decrease in sold units compared to 2011 by 8.9% [18]. Diffusion of this technology in Greece is rather low, with available data showing that in 2013 there were 800 GSHP systems installed in Greece, with estimations giving a total number up to 1,000 units [19]. After all, public awareness on renewable energy technologies in Greece has been found to be incomplete [20,21].

The present study attempts to answer the questions of how informed the public in Greece is about the GSHP renewable energy technology, and how willing it is to adopt it. Specifically, the aim of this study is to identify the factors that affect whether the consumer knows the technology, as well as the factors that will lead him to consider installing the technology in his residence.

2. Factors influencing residential heating system selection

The initial work examining the factors that have an influence on the selection of residential heating systems involved the U.S., and used Census data in order to examine the possible influence on the selection process of demographic and socioeconomic characteristics and factors such as the installation and operation cost of the system [22–25]. During last years, from 2000 until now, the number of studies conducted on the specific issue has increased. These studies emphasize not only on the socioeconomic, spatial and residential characteristics, but also on how consumer's behavior, preferences and attitudes can affect the selection process. Additionally, the majority of these studies focus on specific types of heating systems based on renewable energy technologies. Countries that have been mostly studied this way are mainly the Scandinavian: Norway [26–34], Sweden [35–42] and Finland [43–46], as well as Germany [47–55] and the UK [56–60]. Table 1 presents the identified studies that involve residential heating selection factors, based on the country that is being examined. The ranking (ascending to descending) is based on the total number of studies found for each country.

A clear classification of the work can be made regarding the data and the variables that are being examined. Studies can be divided between those using real preferences using Census data, or data from questionnaires regarding real decisions, and those which take into account stated preferences regarding hypothetical decisions using data obtained from the appropriate questionnaires [52]. Regarding the work using stated preferences on hypothetical decisions, usually the willingness to pay (WTP) for specific technologies is examined through choice experiments [46,49,51,59,60,66,70,72].

Work regarding real preferences or decisions can be categorized based on the type of variables used to examine the heating system selection process. There are studies [22–25,48,61–65,68,69,76,77] that use only socioeconomic, spatial and residence characteristics, as well as some characteristics related to the heating system, such as price of fuels [22,62,76], investment cost [22–24,61,63,68], operating cost [22–25,61,63] and physical work involved in using a system [68] in order to examine the selection process. On the other hand, there are studies that take into account not only the aforementioned factors, but also examine the influence of consumers' behavior, lifestyles, attitudes, intentions, norms and preferences for specific heating systems characteristics on the selection process [26–45,47,50,52–58,67,71,73–75,78].

Many of the studies that also examine behavioral and preference factors use theories on innovation and technology diffusion and consumer behavior in order to construct a theoretical basis and explain the context in which consumers make their choices regarding residential heating systems [26,28–31,35,38,39,42–45,52,53,55,72,78]. Theories that are more commonly used are Diffusion of Innovations (DoI) Model from Rogers [79] and Theory of Planned Behavior (TPB) from Ajzen [80]. According to Rogers [79], the factors that can have a positive effect to the diffusion of an innovative technology can be particularized to five: “relative advantage, compatibility, complexity, trialability and observability”. On the

Table 1
Categorization of studies based on country examined.

Norway	[26–34,61–63]
Germany	[47–55,64,65]
Sweden	[35–42]
USA	[22–25,66,67]
Finland	[43–46,68,69]
UK	[56–60]
Canada	[70,71]
Ireland	[72,73]
New Zealand	[74,75]
Italy	[76]
Slovenia	[77]
Switzerland	[78]