Investigation of energy performance and climate change adaptation strategies of hotels in Greece.

A thesis submitted for the degree of Doctor of Philosophy

by

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ABSTRACT

There is evidence that hotels are the highest energy use buildings of the tertiary sector in Europe and internationally because of their operational characteristics and the large number of users. Therefore, there is potential for significant energy savings. This study investigated the energy performance of the hotel sector in Greece and proposes a methodology for their energy classification and climate change mitigation strategies for an optimum building envelope design for a typical hotel building operated all year or seasonally. This was achieved by collecting operational energy data for 90 Greek hotels and analyzing them using the k-means algorithm. Then a typical hotel building was modelled using TRNSYS and climate change weather files to assess the impact on its energy demand and to propose climate change mitigation strategies. The assessment was performed via hourly simulations with real climatic data for the past and generated future data for the years 2020, 2050 and 2080.

The analysis of the energy data (based on utilities supply) of 90 hotels shows average consumption approx 290 kWh/m^2/year for hotels with annual operation and 200 kWh/m^2/year for hotels with seasonal operation. Furthermore, the hotels were classified in well separated clusters in terms of their electricity and oil consumption. The classification showed that each cluster has high average energy consumption compared to other buildings in Greece.

Cooling energy demand of the typical building increased by 33% and heating energy demand decreased by 22% in 2010 compared to 1970. Cooling load is expected to rise by 15% in year 2020, 34% in year 2050 and 63% in year 2080 compared to year 1970. Heating load is expected to decrease by 14% in year 2020, 29% in year 2050 and 46% in year 2080.

It was found that different strategies can be applied to all year and seasonally operated buildings for the most energy efficient performance. These include:

a. For all year operated buildings: insulation, double low e glazing, intelligently controlled night and day ventilation, ceiling fans and shading. The building of year 2050 would need more shading and the building of year 2080 would need additional shading and cool materials.
b. For seasonally operated buildings: Intelligently controlled night and day ventilation, cool materials, ceiling fans, shading and double low e glazing. Only the building of year 2080 would need insulation.

This study makes a contribution to understanding the impact of the climate change on the energy demand of hotel buildings and proposes mitigation strategies that focus on the building envelope in different periods and climatic zones of Greece.

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LIST OF SYMBOLS

A	Surface area (m^2)
Acooling	Cooled area (m^2)
Aheating	Heated area (m^2)
C_v	Ventilation conductance (W/K)
D_d	Daily degree days (℃ day)
f_r	Thermal response factor
N	Room air change rate (ach)
Qcooling	Annual energy for space cooling (kWh/m^2)
qcooling	Normalised energy consumption for cooling (kWh/m^2)
Qheating	Annual energy for space heating (kWh/m^2)
qheating	Normalised energy consumption for heating (kWh/m^2)
RH	Relative Humidity (%)
U	Building fabric U-value (W/m^2K)
Ufr	Frame U-value (W/m^2K)
Ugl	Glazing U-value (W/m^2K)
Uopen	Opening (glazing and frame) U-value (W/m^2K)
Uroof	Roof U-value (W/m^2K)
Uwalls	External walls U-value (W/m^2K)
Uground	Ground floor U-value (W/m^2K)
Upartition	Partition to non-heated enclosed spaces U-value (W/m^2K)
V	Volume (m^3)
x_o	Existing hourly climatic data
$(x_o)_m$	Climatic variable x_o over month m
Y	Thermal admittance (W/m^2K)
Δx_m	Absolute change in monthly-mean climatic variable for month m
θ_b	Base temperature (℃)
$\theta_{o,j}$	Outdoor temperature in hour j (℃)
λ	Thermal conductivity (W/mK)
ρ	Density of building fabric (kg/m^3)

LIST OF ABBREVIATIONS

BMS	Building Management System
CCWorldWeather Generator	Climate Change World Weather File Generator
CDD	Cooling Degree Days
CFCs	Chlorofluorocarbons
CH_4	Methane
CIBSE	Chartered Institution of Building Services Engineers
CO_2	Carbon dioxide
CRES	Centre of Renewable Energy Sources and Savings
dhw	Domestic hot water
DSY	Design Summer Year
EER	Energy Efficiency Ratio
EPBD	Energy Performance of Buildings Directive
EPI	Energy Performance Index
EPW	Energy Plus Weather
GDP	Gross Domestic Product
GHG	Greenhouse gas
HadCM3	Hadley Centre Coupled Model, version 3
HCFCs	Hydrochlorofluorocarbons
HDD	Heating Degree Days
HVAC	Heating, ventilation and air conditioning
IPCC	Intergovernmental Panel on Climate Change
Low – e	Low - emissivity
LPG	Liquefied Petroleum Gas
MATLAB	Matrix Laboratory
N_2O	Nitrous oxide
PFCs	Perfluorinated Compounds
SF6	Sulfur Hexafluoride
TMY	Typical Meteorological Year
TRNSYS	Transient System Simulation program
TRY	Test Reference Year
WMO/OMM	World Meteorological Organisation/Organisation Meteorologique Mondiale
WWTC	World Travel & Tourism Council
TOTEE	Technical Chamber of Greece

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Furthermore I am thankful to the hotel owners for the provision of information on the energy and environmental performance of 90 hotels and especially the hotel owners, Vassilis Diamantopoulos and Miltos Ilias of the demonstration hotel 'Long Beach'.

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CHAPTER 1

Introduction

1 Introduction

Hotels are the highest energy consuming buildings of the tertiary (non residential) building sector because of their operational characteristics and the large number of users. Data indicates that they are the highest of the building stock after shopping malls and hospitals (Karagiorgas, 2007, Santamouris et al., 1996). In Europe, the estimated total energy consumption of hotels is 39 TWh, most of which is attributed to electricity (Bohdanowicz and Martinac, 2007; ÅF-Energikonsult AB, 2001). This accounts approximately to 0.7–1% of the final energy consumption of buildings in Europe (EUROSTAT, 2012).

Tourism is one of the main sectors of the Greek economy that motivates regional and national development and offers a number of jobs to young people. The importance of tourism to the worlds' and country's economy is reflected in the Gross Domestic Product (GDP) of any country in the world. According to the World Travel & Tourism Council, in the case of Greece, the direct contribution of Travel & Tourism to GDP was 6.5% of total GDP in 2012 and is forecast to rise by 0.6% in 2013 and by 3.2% pa from 2013-2023. The tourism' total contribution to employment (including jobs indirectly supported by the industry) was 18.3% (689000 jobs) in 2012 (WWTC, 2013). This involves economic activities of hotels, travel agents, airlines, and other passenger transportation services (excluding commuter services) in Greece. But it also includes the activities of the restaurant and leisure industries directly supported by tourists.

According to the literature the reported average energy consumption for the European hotels (based on utilities supply data) for the 1990s varies between 239 and 300 kWh/m^2/yr (Bohdanowicz and Martinac, 2007). In absolute values average hotel energy consumption is 215 kWh/m^2/yr in Italy, 273 kWh/m^2/yr in Greece, 278 kWh/m^2/yr in Spain, 420 kWh/m^2/yr in France (Karagiorgas et al 2007, Santamouris et al 1996) whereas in the UK current energy benchmarks quote 540 kWh/m^2/yr (CIBSE Guide F, 2004) .

There is great difficulty on specifying the energy consumption of the hotel buildings. This is because their energy consumption can vary widely from hotel to hotel depending on location, size, operation, guest facilities and also because there is not a homogenous methodology on gathering information on the building energy and environmental performance**.**

A research on 90 Greek hotels proves the hoteliers' lack of knowledge on the energy performance of their premises. Additionally to this, a high percentage of the hotel building stock is unprepared to tackle the climate change in means of un-insulated building envelope and the use of old and rather energy consuming building systems. A big percentage of the hotel stock, around 40%, was built before 1979 when the Greek national Thermal Insulation code (ΦΕΚ 362/04.07.1979) was put into force, being the first significant energy conservation measure applied in Greece.

The Thermal Insulation Regulation of Buildings was not updated until 2010, when the EPBD (Energy Performance of Buildings) Directive 2002/91/EC was incorporated into the national legislation with the Law 3661/2008 and officially applied in July 2010 with the publication of the new Energy Regulation (ΦΕΚ Β ' 407, 2010) and the respective Technical Guidelines. The EPBD regulation puts the foundation for the energy rehabilitation of buildings in means of building envelope and systems and requires the issue of an energy certificate that rates the energy performance (class) of the building. Despite of the existence and application of the EPBD regulation, in Greece there are not official benchmarks for buildings, apart from various studies that were conducted during the last 20 years aiming at the collection of energy data and the classification of different type of buildings. Classification helps to organize a large set of data so that future reference in this data can be made more effectively. The classification aims at distinguishing and grouping objects with similar characteristics. In the case of buildings, it groups the buildings according to their energy performance and highlights the best and worst case studies. In this research, an attempt is made to classify 90 Greek hotels according to their operational energy consumption. The classification aims to define energy benchmarks and to define the typical building that will serve as 'reference' for the study of climate change mitigation techniques for an optimum building envelope design.

The future climate change is defined by an increase in the Greenhouse Gas emissions (GHG) and in turn in the global mean temperatures (IPCC, 2011; European Environment Agency, 2004). Many studies have concentrated on the impact of the climate change on the building energy use. It is proved that, in the Mediterranean countries, the increase of the air temperature results in an increasing trend of the cooling energy demand and a decreasing trend of the heating energy demand of buildings. Taking into account that cooling relies mainly on electricity this signifies a tremendous increase of the electricity demand in the near future.

Many studies focus on simulations using projected future files in order to predict the impact of the climate change on the building energy use, (Oxizidis et al., 2008; Eames et al., 2012, Guan, 2009; Guan, 2012; Jentsch et al., 2008). Additionally, in the literature four methods appear for the preparation of future weather data, these include: the extrapolating statistic method, the morphing procedure based on the imposed offset method, the stochastic weather model and global climate models. According to the literature, the comparison and analysis of these four methods conclude that the morphing method is the most reliable one for building simulations (Belcher et al., 2005; Guan, 2009).

The thesis is structured in 2 main parts. In the first part, it presents information on the energy and environmental performance of 90 Greek hotels that are located in climatic zones A, B and C of Greece. This is performed via questionnaires prepared for the purposes of this research and on-site visits. Then, based on the collected data an attempt is made to propose a classification method and to define typical and best performance hotel buildings.

In the second part of the thesis, the impact of the climate change is computed by modelling a typical hotel building as this is derived by the classification. The typical building is a real building and is located in climatic zone B of Greece. Then climate change mitigation strategies are defined for an optimum building envelope design. The effectiveness of these strategies is also assessed for climatic zones A and C of Greece.

Objectives

The three main objectives of the study are:

- to propose a classification method for the hotel buildings that can be applied also to other type of buildings,
- to propose climate change mitigation strategies for a typical hotel building and define the most energy efficient techniques for an optimum building envelope design for present year, and years 2020, 2050 and 2080 and
- to assess the effectiveness of the optimum building envelope in the 3 climatic zones of Greece (A, B and C).

The study shows that the building design can be treated differently according to the mode of operation. Therefore, an optimum building design is defined for (a). 'all year' operated building and (b). 'seasonally' operated building.

More specific objectives are:

1. Collect energy and environmental performance of 90 hotels all around Greece using a questionnaire prepared for this scope and carrying out on site visits
2. Derive energy benchmarks to enable classification of hotels in Greece based on operational energy use on electricity and oil, using the k-means algorithm controlled with the silhouette plot. The classification aims at the creation of 'reference' values so that techniques might be sought for reducing the energy consumption.
3. Separate the hotels in well separated clusters and the definition of 'typical' and 'best practice' buildings in each cluster.
4. Model the energy performance of a 'typical' hotel building that is located in climatic zone B of Greece.
5. Assess the impact of the climate change on the energy demand of the typical building for the period 1970 – 2010 using real climatic data.
6. Assess the impact of the climate change on the energy demand of the typical building for future periods, using generated climatic data.
7. Define climate change mitigation strategies for the reference hotel building for the present year, and years 2020, 2050 and 2080 using generated future climatic data.
8. Define the most energy efficient techniques for 'all year' and 'seasonally' operated 'optimum' buildings
9. Investigate the effectiveness of the most energy efficient techniques in climatic zones A and C of Greece.

Original contribution to the body of knowledge

As mentioned, currently there are not official benchmarks in Greece although the EPBD legislation requires the energy certification of buildings. The classification of the hotel buildings resulted in well separated clusters based on operational energy consumption, and defined best practice and typical hotel buildings. The proposed methodology can be used for any type of building.

Although literature presents significant work on the impact of the climate change on the building energy demand using simulations with future climatic files, no extended work was detected for the area of Greece. Furthermore, the methodology used for the identification of the most energy efficient techniques for an optimum building envelope design can be applied for any other type of buildings.

The following publications have resulted from this work:

- Farrou I., Kolokotroni M., Santamouris M. (2012) 'A method for energy classification of hotels: A case study of Greece', Energy and Buildings 55, pp .553-562.
- Farrou I., Kolokotroni M., Santamouris M. (2013), Building Envelope Design for climate change mitigation: a case-study of hotels in Greece, 34th AIVC-3rd TightVent-2nd Cool Roofs'- 1st Venticool conference; held in Athens on 25-26th September 2013, paper submitted in August 2013.

The papers are presented in Appendix 7 and Appendix 8.

Structure of the thesis

Chapter 1 introduces the work, its objectives and briefly outlines original contribution to knowledge.

Chapter 2 makes a review of the literature on the hotel sector. It focuses on the energy performance of the hotel sector in Greece; however reference is made to other countries of Europe as well as of other parts of the world in order to have an holistic view of the hotel sector and understand the operation of the hotel units, the main energy sources, the fuel intakes and the energy breakdown.

Chapter 3 presents the characteristics of the Greek hotel building stock and statistical information on the Greek tourism. It also outlines the current legislation that supports the categories and the construction framework of the hotel buildings.

Chapter 4 reports the environmental and energy performance of 90 hotels all around Greece as this derives via questionnaires and on-site visits. Information is gathered on the building construction, construction date, building systems, fuel used, environmental policy of the hotels and this information is statistically analysed. Additionally the normalized average energy consumption of the hotels in terms of electricity and oil is calculated.

Chapter 5 considers a classification method to group the energy data of the 90 hotels and to set typical values in order to compare the sample between them and with the rest of the building sector. The classification gives an idea of quantitative parameters and is an attempt of defining typical and best practice values. The k-means algorithm is used for the classification controlled with the 'silhouette' plot within the MATLAB environment.

Chapter 6 introduces the use of the simulation modelling and describes the demonstration – typical hotel building that is selected in order to assess the impact of the climate change on the hotel sector and to propose an 'optimum' building envelope design. The chapter presents the energy consumption of the hotel for the years 2007 – 2010. The energy consumption is simulated using the software TRNSYS; the model is calibrated and the correlation of the simulation results with the real data shows that the simulations are representing the real case satisfactorily.

Chapter 7 gives an overview on the climate change and its consequences on several aspects of the environment. Especially it discusses the climate change impact on the energy profile of buildings. This chapter also presents existent emission scenarios for Greece and the simulation weather files created for climatic zone B. The generation of future files uses the CCWorldWeather Generator tool (Southampton University, 2010) developed by Southampton University. The procedure followed is based on the 'morphing method'.

Chapter 8 investigates a number of mitigation strategies for the demonstration hotel in order to tackle climate change impact. Following the methodology that is described in CIBSE TM36 (CIBSE TM36, 2005), five principles are analysed. The majority of these focus on the building envelope and are: 'blow away' (intelligently controlled night and day ventilation), 'switch off'; (shading), 'reflect' (cool materials) 'reflect and switch off' (glazing), 'switch off & absorb' (insulation) and 'convection' (ceiling fans). For each of the above principles, different scenarios are simulated in order to define the most energy efficient techniques for an optimum building design, for the current situation and for future years (2020, 2050 and 2080).

Chapter 9 defines the 'optimum' building for climatic zone B and for the present year, year 2020, 2050 and 2080. The optimum building incorporates the most energy efficient techniques as these originate from the simulations in chapter 8. Two modes of optimum buildings are defined: an 'all year' optimum building and a 'seasonally' operated building.

Chapter 10 investigates the effectiveness of the ‘optimum’ buildings in climatic zones A and C of Greece.

Chapter 11 summarizes the main findings of the study and presents the main conclusion.

Chapter 2

Greek Hotels _ Literature Review

2 Greek hotels _ Literature Review

2.1. Introduction

This chapter focuses on the relevant literature background concerning the hotel sector. An attempt is made to answer questions like 'What is the energy flows of a hotel unit', 'Which parameters have an impact on the energy consumption of hotels' and 'what information is available on the energy consumption of hotels'.

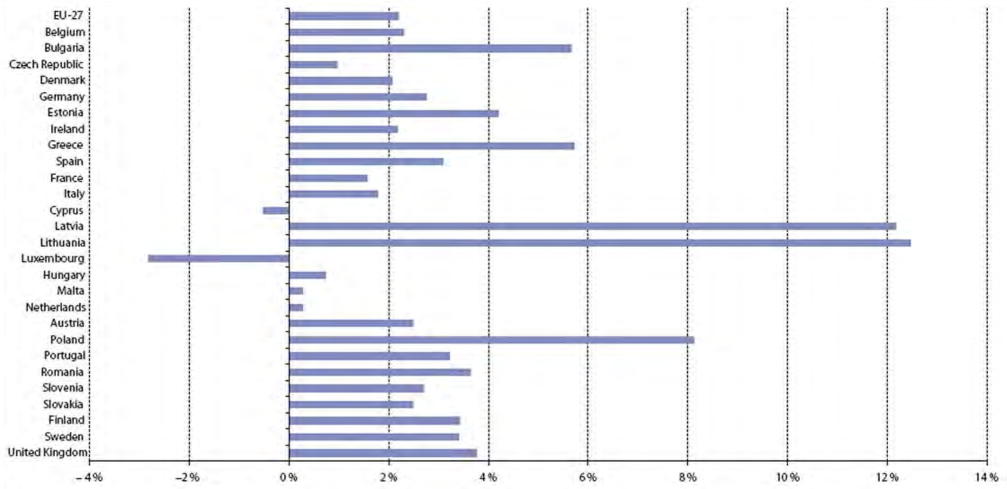
The research focuses on the hotel sector in Greece; however a reference is made on other countries of Europe as well as of other parts of the world in order to understand the operation of the hotel units, the main energy sources, the fuel intakes and the energy breakdown. Regarding the Greek hotel sector, several research studies are reported in the literature. This chapter presents the main outcomes of two EU projects and one national project that outline the energy profile of the Greek hotels. The results of these projects seem particularly interesting and useful for the purposes of this research. The above mentioned research projects are the following:

- The National energy project 'VALOREN' Programme, performed in 1990.
- The CHOSE EU project: Energy Savings by Combined Heat Cooling and Power Plants in Hotel Sector. This was a SAVE II programme, with contract no XVII/4.1031/Z/98-036, funded by the Commission of the European Communities Directorate General for Energy. The final report of the project was prepared in 2001.
- The HOTRES project: Technical support to the tourism industry with renewable energy technologies, phase 1: hotel sector. This was an ALTENER 2 programme, with contract no 4.1030/Z/00-113 and duration from 31/03/ 2001 to 30/03/ 2003.

2.2. Tourism in the Mediterranean countries

Tourism is one of the main economic activities of the countries in the Mediterranean area. These countries attract a rather big percentage of approximately 30% of the world tourist population that is around 220 million of tourists (Lagoudi and Spanos, 2004), a number that is expected to rise significantly in the future.

Today five of the top ten preferred tourist destinations are in Europe and a large increase of tourists is expected. Statistics from the EU countries (EUROSTAT, 2011; Figure 1) show that for the period 2004-2008, the main 5 beneficiaries of the increase in the EU tourism are Latvia, Lithuania (occupying the first position), Poland, Bulgaria and Greece.



(¹) Malta, only hotels; Sweden and United Kingdom, estimated for 2008.

Source: Eurostat (tour_occ_n).

Figure 1 Night spent in hotels and campsites, in the 27 countries of EU, average annual change rate for the period 2004-2008 (EUROSTAT, 2011)

Figure 2 Greek tourism and GDP (WWTC, World Travel & Tourism Council, 2013)

Tourism has a major impact on the world economy, by supporting a large number of jobs, by exporting the local purchases of goods and selling a number of national facilities and services. The importance of tourism to the worlds' and country's economy is reflected in the Gross Domestic Product (GDP) of any country in the world. In the case of Greece, the direct contribution of Travel & Tourism to GDP was 6.5% of total GDP in 2012 and is forecast to rise by 0.6% in 2013 and by 3.2% pa from 2013-2023, (Figure 2). The tourism' total contribution to employment (including jobs indirectly supported by the industry) was 18.3% (689000 jobs) in 2012 (WWTC, 2013). This involves economic activities of hotels, travel agents, airlines, and other passenger transportation services (excluding commuter services) in Greece. It also includes the activities of the restaurant and leisure industries directly supported by tourists.

2.3. Architectural structure of hotels

A hotel unit can be distinguished in three areas with different energy needs that should be handled accordingly, (Bohdanowicz et al., 2001; IMPIVA 1994):

-The stay room areas i.e. the rooms including the bathrooms and showers facilities. The energy loads of the zones vary according to the number of users and their behaviour. Also these areas do not have simultaneous occupancy during the day. Probably this is the area that is most influenced by the user’s behaviour.

-The common areas including the reception area, lobby, bars, restaurants, swimming pools etc. Usually these spaces are characterized by high thermal losses due to interaction with the external environment and high internal gains due to large variation of users. In terms of building elements, these areas may also consist of large glazing surfaces in order to have visual and operational interaction with the external environment. Also in these areas a large amount of energy is attributed to artificial and/or decorative lighting that is operating most of the day.

-The service areas including kitchens, offices, store rooms and laundry. These spaces are energy intensive with stable internal gains and require advanced air handling units to cope with high ventilation, cooling and heating loads. In terms of architecture, these areas are treated as ‘closed’ envelopes as exchange with the external environment is not required.

The building orientation is considered mainly in the design of the rooms and the common areas. The rooms may consist of the areas with the highest proportion glazed area/room area where the available view is also taken into consideration. Solar protection is important for the thermal comfort of the users.

The common areas should also be orientated according to their use especially if they are linked to external activities i.e. external lounge to swimming pools, bars etc, in order to provide external areas with optimum thermal, acoustic and visual levels and be protected by high solar gains and exposed winds. Usually these areas should be distinguished in multiple thermal zones and be equipped with building systems that can be adapted to the large variation of users.

The service areas are usually designed in the less privileged areas of the site, i.e. facing north or in basements. As already mentioned, these areas provide stable internal loads due to the facilities they offer.

As an entity the building envelope of a hotel unit should satisfy the following parameters:

- Thermal levels (with a well-insulated building envelope)
- Acoustics levels (providing the desired acoustic levels especially in the rooms). This can be achieved by designing the hotel unit far from noisy areas or/and eliminating external and internal sources of noise.
- Lighting levels (making optimal use of daylight)
- Availability of views (this is of great importance especially in the holiday hotels)
- Indoor air quality (providing adequate amount of air and designing naturally ventilated spaces in order to refresh the income air and remove indoor pollutants)
- Minimised energy consumption. This can be achieved with the combination of a properly designed building envelope (orientation, thermal insulation, solar protection) and optimal building systems for each use. Also building services should operate only when they need to. An energy management system is important for the energy plan of a hotel that may lead to energy savings up to 30% (Kasinis 2006).

2.4. Energy use in the hotel sector

Hotels are the most energy consuming buildings of the tertiary sector because of their operational characteristics and the large number of users. Their energy consumption can vary widely depending on their location, their size and the services they offer. Additionally the behaviour of their occupants affects their energy performance; usually the hotel residents are not conscious and are demanding regarding their accommodation and the provided facilities. Moreover, they are paying a fixed price independently to their energy use something that strengthens the feeling that energy is ‘free of charge’, (Santamouris et al., 1996).

A broader overview on the hotel industry shows that there are 300 000 hotels worldwide, accounting for more than 11 million rooms, of which 70% are located in Europe and North America (Bohdanowicz et al., 2001). It seems that the hotel sector presents the highest energy consumption of the building stock after the sales and the food services, health cares and certain types of buildings, (Bohdanowicz and Martinac, 2007; Santamouris et al., 1996). The energy consumption in the hotel sector is highly diversified and very difficult to refer in detail. The total energy consumption of hotels is recorded regularly or is available through the energy bills. However the monitoring of the subsystems and the energy breakdown is rarely met as it is regarded as a procedure complex and expensive. Additionally, collective and comparable data on the energy use of hotels worldwide is not available.

From the literature it can be concluded that electricity is the primary source of energy in the hotel sector whereas the portion of oil and gas are much smaller. Thus the amount of electricity used is a good indicator of the performance of the hotel unit.

An attempt of classification of the EU hotel sector according to the energy consumption is proposed in the EU research ‘Rational Use of Energy in the Hotel Sector’, Thermie Programme action B -103 (IMPIVA, 1994) as shown in Table 1. The hotels are distinguished in three types of hotels, large, medium and small, according to the number of rooms. The energy performance of each type of hotel is characterized as good, fair, poor and very poor for electricity, fuel and domestic hot water (dhw).

Table 1 Classification of hotels according to their size and the facilities they offer (IMPIVA, 1994)

Efficiency rating	**Good**	**Fair**	**Poor**	**Very Poor**
A) large hotels (more than 150 rooms) with air conditioning, laundry & indoor swimming pool				
Electricity (kWh/m^2/year)	<165	165-200	200-250	>250
Fuel (kWh/m^2/year)	<200	200-240	240-300	>300
Total (kWh/m^2/year)	<365	365-440	440-550	>550
Water (kWh/m^2/year)	<220	230-280	280-320	>320
B) Medium-sized hotels (50-150 rooms) without laundry, with heating & air conditioning in some areas				
Electricity (kWh/m^2/year)	<70	70-90	90-120	>120
Fuel (kWh/m^2/year)	<190	190-230	230-260	>260
Total (kWh/m^2/year)	<260	260-320	320-380	>380
Water (kWh/m^2/year)	<160	160-185	185-220	>220
C) Small hotels (4-50 rooms) without laundry, with heating & air conditioning in some areas				
Electricity (kWh/m^2/year)	<60	60-80	80-100	>100
Fuel (kWh/m^2/year)	<180	180-210	210-240	>240
Total (kWh/m^2/year)	<240	240-290	290-340	>340
Water (kWh/m^2/year)	<120	120-140	140-160	>160

Various researches report the energy consumption of hotels in different parts of the world in terms of Energy Performance Index (defined as the site energy consumption per unit of gross floor area): in 1995 the averaged annual Energy Performance Index for hotel buildings in the United States was 401 kWh/m^2, 40.9% for electricity and 51.9% for gas. Domestic hot water heating, space heating and lighting accounted for 40.4%, 18.2% and 17.8% respectively. A survey that was conducted for 19 hotels in Ottawa in 1991 showed different results: the annual averaged energy intensity was 688.7 kWh/m^2 with electricity accounting for 28.9%, gas 26.4% and steam 44.7% respectively. In the case of the UK, a survey dated on 1988 reported annual energy consumption 715 kWh/m^2 with gas accounting for 74% of the total energy consumption (Deng and Burnett, 2000). Additionally, in the UK current energy benchmarks quote 540 kWh/m^2 of which 400 kWh/m^2 are attributed to fossil fuel and 140 kWh/m^2 to electricity for typical hotels and 340 kWh/m^2 of which 280 kWh/m^2 are attributed to fossil fuel and 80 kWh/m^2 to electricity for best practice holiday hotels (CIBSE Guide F, 2004). A study on hotels of Singapore (1993) show average energy use intensity of 468 kWh/m^2. A later survey conducted in 2005-2006 on 29 hotels of Singapore showed average annual electricity consumption 361 kWh/m^2, fossil fuel energy 66 kWh/m^2, and total energy intensity 427 kWh/m^2, (Priyadarsini et al., 2009).

Past studies on hotels of Hong Kong reported average electrical energy consumption of 257.8 kWh/m^2 and 366 kWh/m^2, (Deng and Burnett, 2000). Another research on hotels of Hong Kong was conducted in 1995 and data was collected from 16 hotels. The averaged

Energy Use Index was calculated to 564 kWh/m^2.The majority of hotels in Hong Kong consume 3 types of fuel: electricity, gas and diesel but consumption is dominated by electricity. The survey showed that 73% of total energy consumed is electricity, (Deng and Burnett, 2000).

The same audit showed that a clear correlation between the electrical energy consumption of the hotels with the class of the hotels, the year of construction and the hotel occupancy cannot be fixed, for example the energy consumption of a four star hotel was higher than that of a five star hotel (Figure 4). On the other hand, the parameter that has an impact on the electricity used is the external temperature (Figure 3) because Hong Kong is an area with a long hot and humid summer; all hotels are air-conditioned and energy is mainly used for space mechanical cooling and dehumidification. Another research on a Greek hotel located in an island of climatic zone A of Greece showed that although the occupancy was decreased during the month of July, the electricity consumption was elevated compared to the other months and this was attributed to the increased use of air-conditioning because of high external temperature in summer (Dorizas et al., 2008).

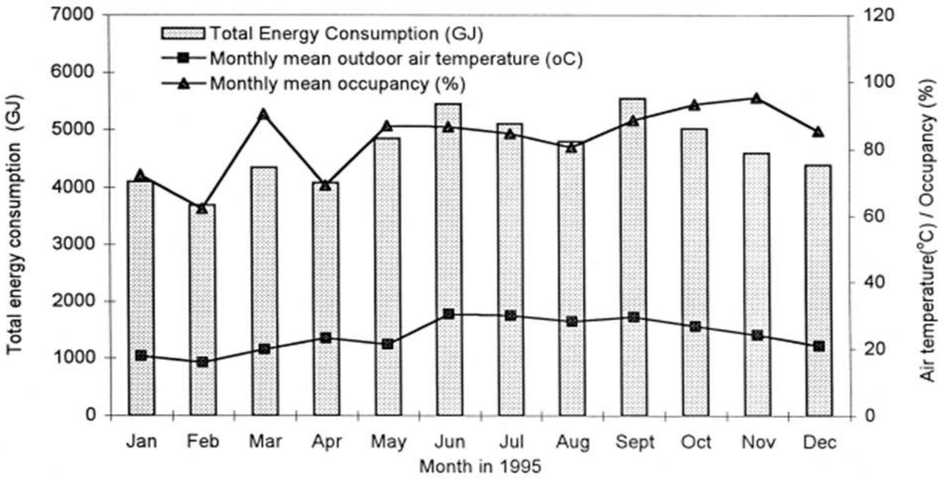


Figure 3 Correlation between the energy consumption, mean outdoor temperature and mean occupancy level for an example hotel in 1995 (Deng and Burnett, 2000)

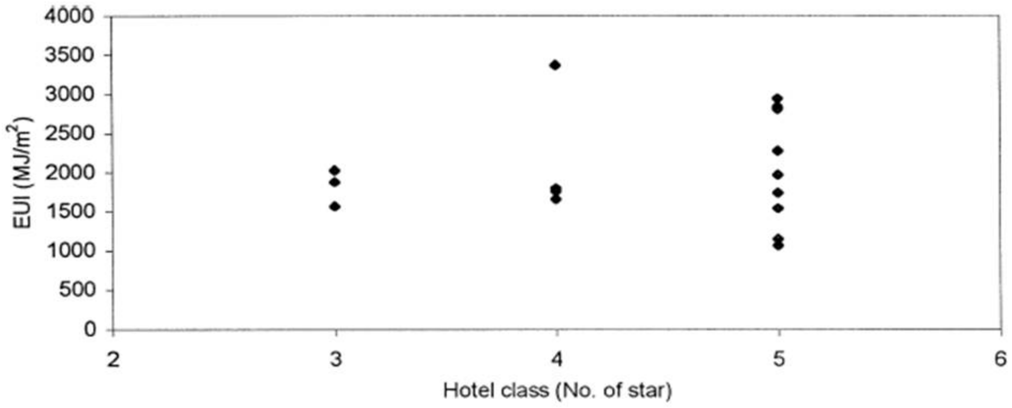


Figure 4 Correlation between energy consumption and hotel class (Deng and Burnett, 2000)

Another research on the collection and analysis of 184 hotels, Hilton International and Scandic hotels in Europe (Bohdanowicz and Martinac, 2007) showed the existence of correlation between the energy consumption of the hotels and the floor area. Usually hotels of larger areas present larger energy loads (Figure 5).

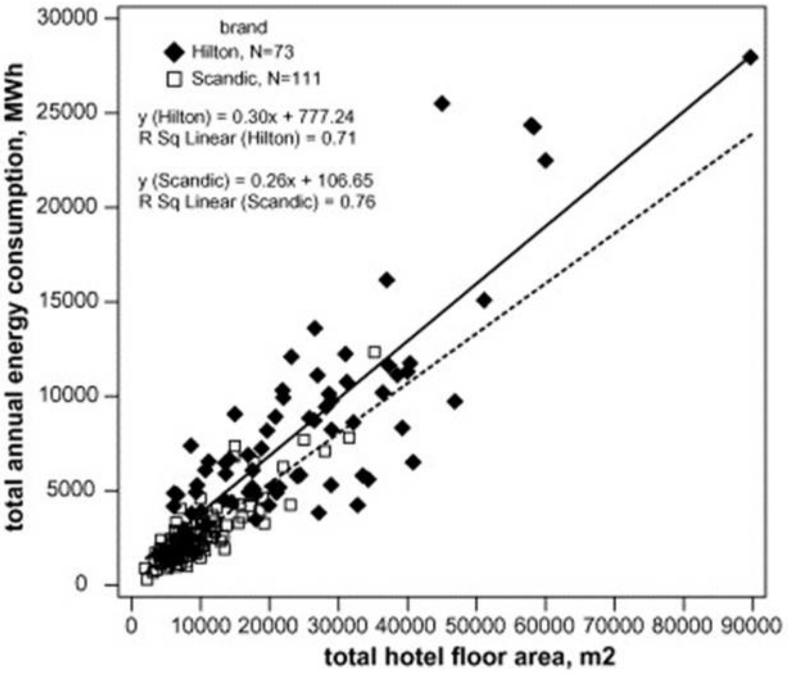


Figure 5 Energy consumption of hotels versus floor area (Bohdanowicz and Martinac, 2007)

The research of hotels in the area of Singapore also shows the existence of correlation between the energy consumption of hotels and the external temperature and the class of the hotel (Figure 6). Moreover, relative humidity and global solar radiation did not have any significant correlation with the energy consumption, (Priyadarsini et al., 2009).

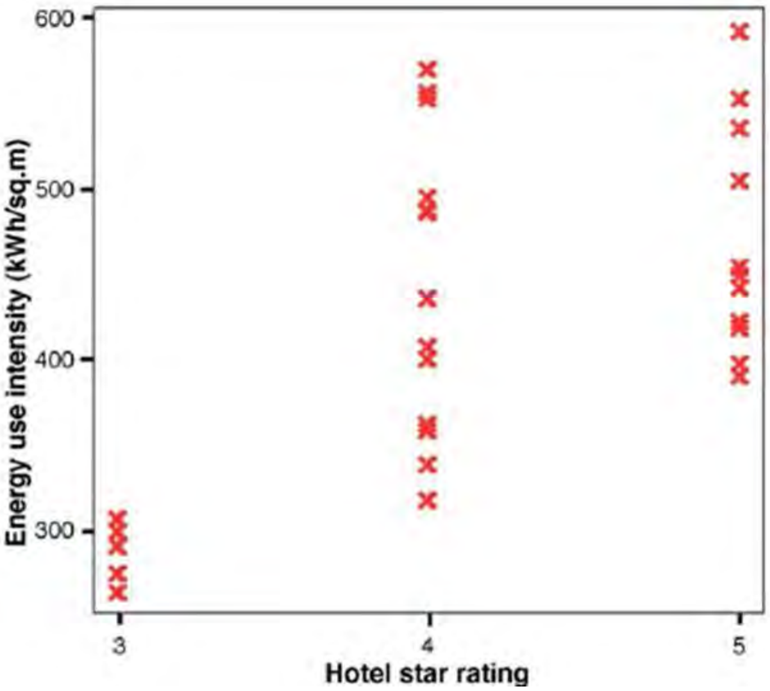


Figure 6 Correlation between energy consumption and hotel class for hotels in Singapore (Priyadarsini et a.,l 2009)

- **Hotel sector in Europe**

Concerning the hotel sector in Europe, the estimated total energy consumption is 39TWh. Out of that 50% is electricity consumption (ÅF-Energikonsult AB, 2001; Lagoudi and Spanos, 2004).

In absolute values the energy consumption for the hotel sector is calculated to 215 kWh/m^2 in Italy, 273 kWh/m^2 in Greece, 278 kWh/m^2 in Spain and 420 kWh/m^2 in France (Santamouris et al., 1996, Naukkarinen, 2007).

A summary of the energy performance of the hotels reported in the literature is shown in Table 2.

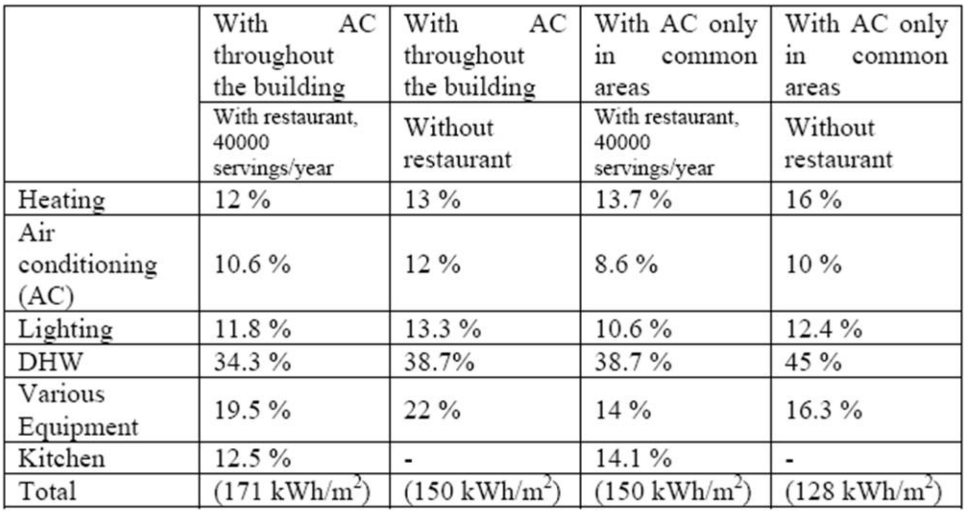
Table 2 Average energy consumption for hotel buildings all around the world

Energy consumption of Hotel Buildings all around the world		
Country	Average energy use, kWh/m^2/year	Source
Canada – Ottawa (1991)	688.7	Deng and Burnett, 2000, Bohdanowicz et al., 2001
Japan (1991)	745	Bohdanowicz et al., 2007
Europe (1990s)	238.9-300	
Hong Kong (1995-1997)	148.4-988 average 564	Priyadarsini et al., 2009, Deng and Burnett, 2000
Singapore	427	Priyadarsini et al., 2009
US (1999)	313.9	Bohdanowicz et al., 2007
UK (1988)	200-1000 average 495	
UK (London 1988)	715	Deng and Burnett ,2000
New Zealand (1999)	158.6	Bohdanowicz et al., 2007
Sweden (1999, 2001, 2003-2004)	100-200	
	198-379	
	282-300	
Cyprus (2001)	103-370 average 272.6	
Greece (2001)	72-519 average 289.9	
	273	Santamouris et al., 1996
Italy (2001)	249-436 average 364.4	Bohdanowicz et al., 2007
	215	Karagiorgas et al., 2007, Santamouris et al., 1996
Portugal (2001)	99-444.6 average 296.4	Bohdanowicz et al., 2007
France	420	Karagiorgas et al., 2007 Santamouris et al., 1996
Spain	278	
Europe (1990s)	55.5 kWh/guest-night	Bohdanowicz et al., 2007
New Zealand (1999)	9.7-105.6 kWh /guest-night	
Zanzibar (2000)	61.4-254.4 kWh /guest-night	
Cyprus (2001)	24.2 kWh /guest-night	
Majorca (2001)	14.2 kWh /guest-night	

From the literature it is concluded that space air-conditioning is the first energy consuming sector in a hotel unit. Domestic hot water is the second most energy consuming sector and lighting is third in the rank that may be higher depending on the presence of decorative lighting. Table 3 shows the energy breakdown of a typical 3 star hotel in Southern Europe, for a fully air conditioned and partially air-conditioned hotel, with and without a restaurant. As it is shown, domestic hot water is mostly influenced by the class of the hotel and consumes larger portion (45%) of the total energy consumption of the building in the case of the partially air-conditioned hotel without a restaurant. The heating sector consumes larger portion of the total building energy in a partially a/c hotel without restaurant (16%) compared to a fully a/c hotel with restaurant (12%). On the other hand a fully a/c hotel without restaurant presents higher proportion of cooling energy consumption of the total energy (12%) compared to a partially a/c hotel with a restaurant (8.6%). The lighting sector is the one that is less influenced by the areas that are conditioned and the restaurant facilities.

Additionally the total area of the air conditioned spaces has little impact on the energy attributed to the kitchen use. As it should be expected, the total energy consumption of the fully air-conditioned hotel with a restaurant is higher by 43 kWh/m^2 annually than the energy consumed by a partially air conditioned hotel without a restaurant.

Table 3 Energy breakdown for a typical 3-star hotel located in Southern Europe (Bohdanowicz et al., 2001)



	With AC throughout the building	With AC throughout the building	With AC only in common areas	With AC only in common areas
	With restaurant, 40000 servings/year	Without restaurant	With restaurant, 40000 servings/year	Without restaurant
Heating	12 %	13 %	13.7 %	16 %
Air conditioning (AC)	10.6 %	12 %	8.6 %	10 %
Lighting	11.8 %	13.3 %	10.6 %	12.4 %
DHW	34.3 %	38.7%	38.7 %	45 %
Various Equipment	19.5 %	22 %	14 %	16.3 %
Kitchen	12.5 %	-	14.1 %	-
Total	(171 kWh/m^2)	(150 kWh/m^2)	(150 kWh/m^2)	(128 kWh/m^2)

❖ Hotel sector in Greece

Concerning the hotel sector in Greece, annual final energy demand is estimated at 4.2 TWh (Santamouris et al., 1996), representing 28% of total energy demand in tertiary (non-residential) building sector, the fuel breakdown is 18% for oil and 82% for electricity (Ali et al., 2008; Zografakis et al., 2011). Within another research project, energy data was collected of 32 hotels in Crete showing that the mean annual electricity cost per room is 234.52 euros, the mean annual electricity cost per bed is 112.17 euros, the mean annual electricity cost per stay was 4.33 euros and the mean annual electricity cost per room square meter was 8.12 euros (Zografakis et al., 2011).

2.5. Energy consumption of the Greek hotel sector

Most information on the energy consumption of the hotel sector in Greece derives from the National project VALOREN and the EU projects with acronyms CHOSE and HOTRES. The main results that are useful for this research are presented below for each project.

2.5.1. National energy project 'VALOREN' Programme

Data on the energy performance of Greek hotels was collected during an extensive energy audit of buildings that was carried out in Greece within the frames of the National energy project 'VALOREN' Programme partly financed by the Ministry of Industry, Research, Technology and Commerce, the Hellenic Productivity Center and the European Commission, Directorate General for Energy. Energy audits were performed in different types of buildings, including hotels, office, commercial and school buildings. The research was performed in 1990. The collection of data was performed using standard protocols and the collected information concerned the architectural aspects of the buildings, their building services, lighting installations and water systems. Data was collected for 158 hotels in Greece, of which 140 are located in Athens, and the rest all over in Greece. According to the analysis, the total annual energy consumption of hotels in Greece is 4.3 TWh with average 273 kWh/m^2/annually. The annual energy consumption in hotels is second to hospitals (406.8 kWh/m^2), whereas 187 kWh/m^2 is attributed to office buildings, 152 kWh/m^2 to commercial buildings and 92 kWh/m^2 to school buildings, (Figure 7).

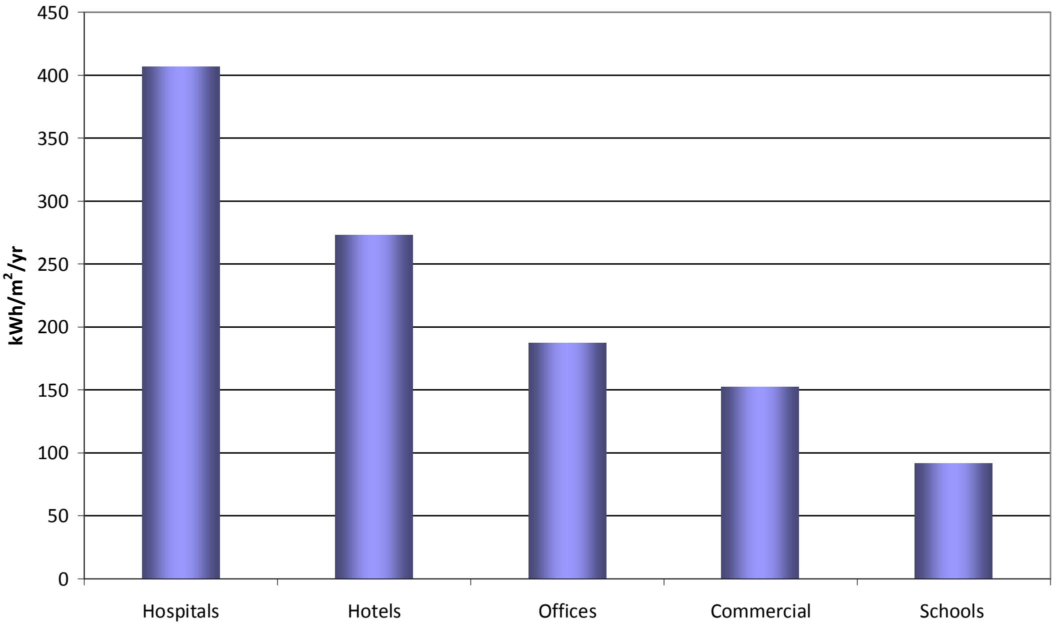


Figure 7 Average annual energy consumption (kWh/m^2) in different types of buildings in Greece (Santamouris, 1996)

Within the frames of the VALOREN project, the annual energy consumption was recorded for thermal and electrical energy. The electrical energy consumption for each subsystem (lighting, air conditioning, appliances) was subtracted from the total number through a series of calculations, based on the power consumption and the hours of operation of the systems.

The analysis shows that heating is the main energy consuming sector and accounts for 198 kWh/m^2 that represents 72% of the total energy consumption. Artificial lighting accounts for 24 kWh/m^2 that is 9% of the total, cooling accounts for 11 kWh/m^2 that is 4% of the total and all other electrical appliances account for 40 kWh/m^2 – 14.6 % of the total (Table 4, Figure 8).

Table 4 Estimated energy use for the Greek hotels, (Jagemar and Olsson, 2008)

Estimate of total energy use						
	Avg floor area	Total energy use	Electricity/ equipment	Heating	Lighting	Cooling
	m²	kWh/m²/yr	kWh/m²/yr	kWh/m²/yr	kWh/m²/yr	kWh/m²/yr
Hotels	3,268	273	40	198	24	11

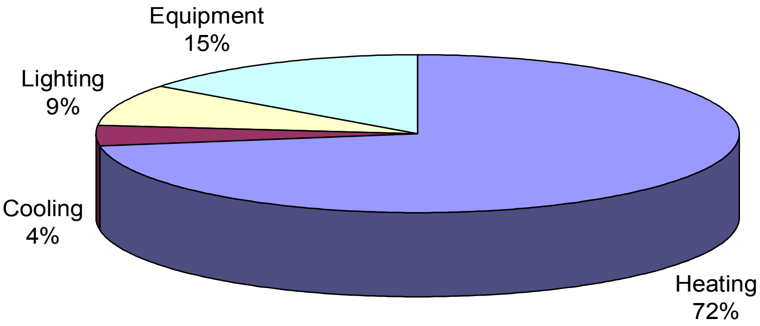


Figure 8 Breakdown of energy use in Greek hotels (Jagemar and Olsson, 2008)

Cooling accounts for a rather small percentage of the total since a lot of the Greek hotels are naturally ventilated and do not provide air conditioning. In Athens, the average annual total energy consumption in the audited air-conditioned hotels is 298 kWh/m^2, in hotels with split unit heat pumps is 218 kWh/m^2 and in naturally ventilated hotels is 168.7 kWh/m^2.

The same research presents the frequent distribution analysis on the building stock. It is estimated that 13% of the sample has average annual energy consumption below 100 kWh/m^2 while in 33% of the hotels the energy consumption ranges between 100 and 200 kWh/m^2.

For 45% of the hotels, the average annual electrical energy consumption is below 50 kWh/m^2 and for 37% it ranges between 50 and 100 kWh/m^2.

For the average annual thermal energy consumption, 69% of the hotels have a consumption less than 200 kWh/m^2, while for 31% it ranges between 200 and 400 kWh/m^2 (Santamouris et al., 1996).

2.5.2. EU project CHOSE

CHOSE project: ‘Energy Savings by Combined Heat Cooling and Power Plants (CHCP) in the Hotel Sector, Commission of the European Communities Directorate General for Energy, contract no XVII/4.1031/Z/98-036, (Alteren Inc, 2001; ÅF-Energikonsult AB, 2001).

The aim of the project was to investigate the technical and economic viability of combined heat, cooling and power plants, CHCP, in the hotel sector, as well as the energy saving potential through this technique. Through this action guidelines were developed to assess the suitability of CHCP installations in different types of hotels.

The research presents the following apportionment of the energy consumption in the hotel sector (Figure 9), also referred in the Thermie Programme Action 103-B :

- Heating and air conditioning account for approx 48% of the total energy
- Domestic hot water production, 13% of the total energy consumption
- Lighting, 7% of the total energy consumption
- Catering (kitchen facilities) , 25% the total energy consumption
- Other electrical appliances (equipment, elevators etc)

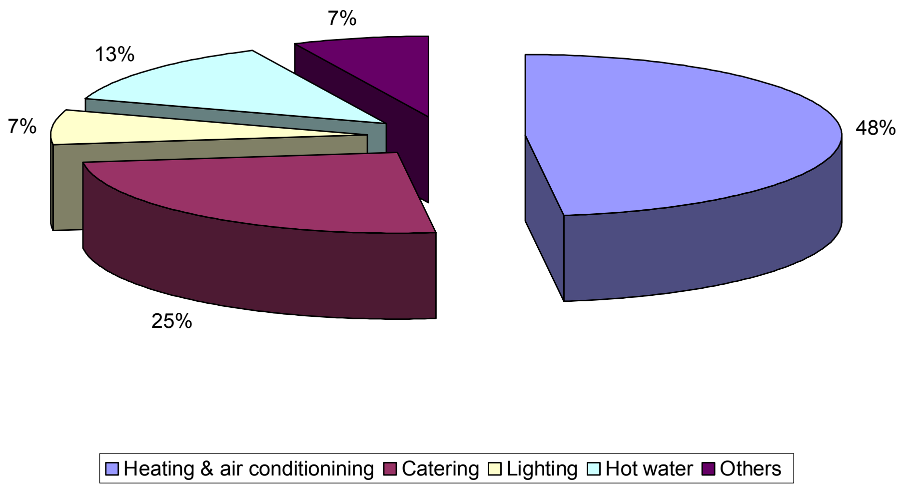


Figure 9 Breakdown of energy consumption in hotels (ÅF-Energikonsult, AB)

Heating and air conditioning

Space conditioning (heating and air conditioning) accounts for about half the energy consumption in hotels. However this can increase depending on various parameters like the performance and the operation of the cooling and heating systems, the weather conditions, the building construction (presence of thermal insulation).

Domestic hot water

The energy required for the production of hot water accounts approximately to 15% of the total energy consumption but this is higher regarding the facilities provided, the luxury of the hotel, the size of the kitchen, restaurant and laundry amenities.

For example, a five star hotel requires around 150 lt per guest per day while a three star hotel requires 90 lt per guest per day. The annual energy consumption to produce domestic hot water in a medium sized hotel with average annual occupation of 70% may reach 1500-2300 kWh /room.

Domestic hot water can be produced by electricity, natural gas, fuel oil or solar energy.

Lighting

The energy consumption for lighting is much dependent on the size of the hotel, the lighting installations, and can vary from 7% to 40% of the total electrical energy consumption.

Catering - kitchen

Kitchen use represents 25% of the total hotel energy usage and is attributed to appliances and cooking. Additionally, refrigeration of food is a significant load.

The average energy consumption in kitchens is 1.2 kWh per meal. The energy consumption for hot water (washing, cooking) is approximately 0.2-0.3 kWh per meal.

Additionally, ventilation in kitchens is very important and energy attributed to this can be great.

Others services – Swimming pools

Swimming pools are responsible for a large portion of energy use. It is estimated that swimming pools require from 45000 kWh to 75000 kWh per season.

Within the EU CHOSE project data was collected from 10 hotels in Greece, of which 6 hotels are located in Thessaloniki, 2 in Athens and 2 in Rhodes, (Table 5, **Error! Reference source not found.**). Five of these hotels use electricity and oil, four hotels use electricity, oil and liquefied petroleum gas (LPG) and one hotel electricity and LPG. The usage of electricity is split between space conditioning varying between 14% to 42%, lighting varying between 11% to 24%, kitchen facilities varying 10-18% and the rest attributed to other purposes (Table 5). The energy profile of the hotels is shown in **Error! Reference source not found.**.

Table 5 Electrical energy use for the 10 case studies hotel buildings within the EU CHOSE project (ÅF-Energikonsult, AB)

Breakdown of electricity used		
Hotels	Heating / cooling and hot water production	Electricity used
Hotel 1 (Thessaloniki)	Rooms and common areas fully a/c. Oil for heating and dhw LPG for laundry	29 % for air conditioning 21 % for lighting 50 % for other purposes
Hotel 2 (Thessaloniki)	Rooms and common areas fully a/c. Oil for heating	22 % for air-conditioning 23 % for lighting 55 % for other purposes
Hotel 3 (Thessaloniki)	Rooms and common areas fully a/c. Oil for heating and dhw	30 % for air conditioning 21 % for lighting 49 % for other purposes
Hotel 4 (Thessaloniki)	Rooms and common areas fully a/c. LPG for heating and DHW	40 % for air conditioning 18 % for lighting 42 % for other purposes
Hotel 5 (Thessaloniki)	Rooms and common areas fully a/c.Oil for heating	19 % for air conditioning 24 % for lighting 57 % for other purposes
Hotel 6 (Thessaloniki)	Rooms and common areas fully a/c. Oil for heating	22 % for air conditioning 23 % for lighting 55 % for other purposes
Hotel 7 (Athens)	Rooms and common areas fully a/c	42 % for air conditioning 25 % for the patisserie 24 % for lighting 9 % for other purposes
Hotel 8 (Athens)	Rooms and common areas fully a/c Oil for heating and dhw. LPG for kitchen & laundry purposes	14 % for air conditioning 86 % for lighting & all other purposes
Hotel 9 (Rhodes)	Solar collectors of total surface area 366m2 and oil as auxiliary system	36 % for air conditioning 23 % for lighting 18 % for the kitchen and refrigerators 23 % for other purposes (lifts, sewage treatment plant etc.)
Hotel 10 (Rhodes)	Oil for heating, LPG for dhw	42 % for air conditioning 11 % for lighting 10 % for the kitchen 37 % for other purposes(lifts, sewage treatment plant etc.)

Table 6 Energy consumption (kWh/m^2 and MWh/room) of ten selected hotels within the frames of the EU CHOSE project (ÅF-Energikonsult, AB)

			Energy consumption (MWh/year)			Specific consumption	
Hotels	Area (m2)	Rooms	Thermal	Electrical	Total	kWh/m^2	MWh/room
Hotel 1	24,930	284	5,814	4,820	10,634	427	37.4
Hotel 2	9,050	118	1,192	989	2,181	241	18.5
Hotel 3	7,435	131	1,102	1,116	2,218	298	16.9
Hotel 4	5,950	124	1,067	763	1,830	308	14.8
Hotel 5	5,250	133	765	338	1,268	210	8.3
Hotel 6	3,500	111	735	616	1,351	386	12.2
Hotel 7	13,720	182	1,558	3,099	4,657	339	25.6
Hotel 8	35,110	400	7,536	10,679	18,215	519	45.5
Hotel 9	18,240	242	538	769	1,307	72	5.4
Hotel 10	23,000	300	571	1,712	2,283	99	7.6

2.5.3. EU project HOTRES

HOTRES project: Technical support to the tourism industry with renewable energy technologies, (phase 1: hotel sector) an ALTENER 2 programme, with contract no 4.1030/Z/00-113, (Karagiorgas et al., 2006).

The aim of the Altener project 'HOTRES' was to promote the implementation of 5 renewable energy technologies (solar, thermal, solar passive, solar PV, biomass and geothermal) in the tourism industry and to assess the regional hotel markets of 5 European regions regarding their energy consumption profile (Madeira, Andalusia, Sicily, East Attica, Corsica/Alps Maritimes).

The market of the Solar thermal Sector in Greece was assessed for the period 1985 to 2001 and information was collected on the application of renewable energy systems in hotels of European countries. The collected data concerning Greece was provided by importers, manufacturers of thermal solar systems, members of the Greek Solar Industries Association, the association of solar systems manufacturers of Crete and manufacturers of Northern Greece. The study showed that over 100 hotels in Greece use thermal solar systems for domestic hot water production, swimming pool heating and solar air-conditioning. The total surface area of these systems is 28,820 m^2 and their size varies between 20m^2 (Tsangarakis Hotel in Crete) and 2,783 m^2 (Cretan Village in Crete). 41.40% of these systems are in Crete, approximately 2.1% in Northern Greece and the rest 56.5% across the rest of the country.

In the majority of the hotels the surfaces of the solar systems vary between 100-200m^2, followed by hotels with surfaces between 0-100 m^2 and 200-500 m^2. The average size of large solar systems in Greek hotels is 257 m^2. Only ten hotels are equipped with systems of over 500m^2. Table 7 shows ten Greek hotels with the largest solar energy systems.

Table 7 Greek hotels equipped with larger solar systems (Alteren, 2001)

Hotel name	Surface area (m^2)
Aldemar (Cretan Village, Royal Mare,Knossos Royal Village)	2,783
Rodos Palace	1,115
Greta Maris	660
Grand Hotel	600
Kontokali Hotel	600
Kerkyra	600
Lyttos Beach Club	593
Aeolos Beach	588
Corkyra Beach	577
Robinson Lyttos Club	579
Total	8,695
	30.17% of total

Table 8 shows some examples of hotels with renewable energy systems based on the analysis within the Altener project 'HOTRES'.

Table 8 Greek hotels with the use of renewable energy (Alteren, 2001)

Name of hotel	***Renewable energy technologies examined***						
Greece	**Place**	**Biomass**	**Geo-thermal**	**Solar PV**	**Solar SHW**	**Solar cooling**	**Green roof**
Porto Valitsa	Chalkidiki		46 kW		30m^2		
Metropolitan	Corfu			1.67kWp	600m^2		
Lutania Beach	Rhodos	525kW			600m^2	601m^2	601m^2
Casino Rhodos	Rhodos		30kW				
Colossos Beach	Rhodos		1751 kW		200m^2		
Kresten Palace	Rhodos		1050 kW		400m^2		
Marie Hotel	Rhodos			1.38kWp	60m^2		
Rethymnon Village	Crete					1700m^2	
Hostel	Legrena Attiki		210kW				
Elounta	Crete		210kW	6.4kWp			
Atrion	Crete	120.000 kcal/h					
El Greco	Crete						1000m^2

Figure 10 shows the fluctuation of the market development. Interest in investment is observed the first eight years examined, and then there is a gap of five years. From 1997 there is a significant rise the maximum value being that of the year 2000, a fact that can be attributed to the National Operational Program for Energy (O.P.E.) subsidies available during that period. Also the increase in investment between 1988-1990 could be attributed to the EU-supported VALUE financing scheme.

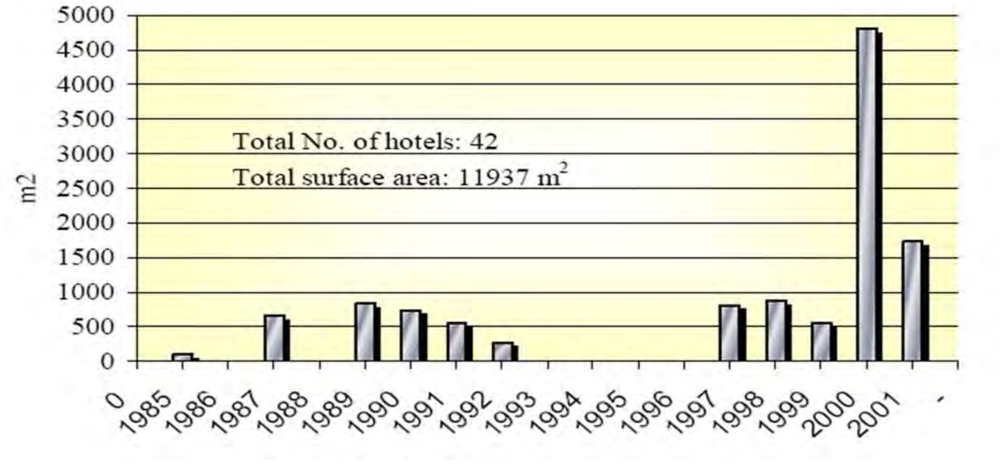


Figure 10 Market development of central thermal solar systems in the hotel industry of Greece (Alteren, 2001)

2.6. Energy flows in a hotel unit

Within the frames of another study on Greek hotels data is collected through fuel and electricity bills for 8 hotels of three geographical types: mountain, city and coastal, (Karagiorgas et al., 2007). Based on the results of this audit it was concluded that electricity is reported as the main fuel intake. LPG and oil for domestic hot water follow. Space heating is the most energy consuming sector. Other energy consuming sectors include ventilation and air conditioning, domestic hot water, laundry and catering facilities, internal and external lighting of common areas, electricity consumed while room staying including the light use, and energy consumed for lifts. For deluxe hotels leisure facilities like swimming pools consume a significant amount of energy.

The study presents in details the energy flows of one of the eight study cases, of the Greek mount type hotel of deluxe category, the hotel Montana in Evritania. The energy consumption of hotels is presented per night spent (kWh/ns) as a different approach to calculate the energy consumption in a hotel unit rather than the ones used in other researches as kWh/m^2/a or MJ/m^2/a.

For the specific mountain type hotel in Greece the following are observed:

-Total energy consumption is 94.14 kWh/ns for the year 2003

-Electricity is the main energy source and account for 28.27% of total

- LPG is second in use mainly for domestic hot water and accounts for 24.64 %

- Oil is used mainly for space heating purposes and accounts for 23.74%

- A lunch in a deluxe category hotel in Greece like ‘Montana’ absorbs 5.5 kWh/lunch

- A bath in a deluxe hotel in Greece absorbs 1.66 kWh/bath

For the same hotel the most energy is consumed during the room stay (35.57%). Leisure facilities follow accounting for 25.96%. Figure 11 shows the energy breakdown for hotel MONTANA diagrammatically.

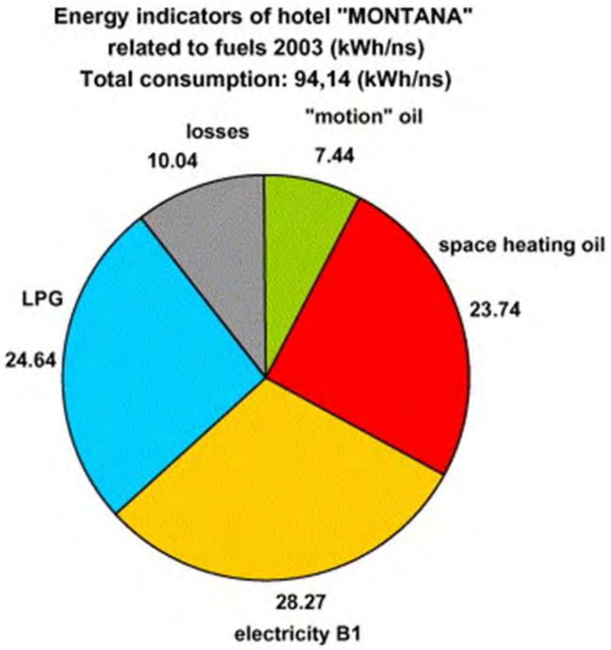


Figure 11 Energy breakdown for the hotel MONTANA, for year 2003 (Karagiorgas et al., 2007)

2.7. Chapter Conclusions

It can be concluded that the hotel buildings are rather complex systems that combine different zones and uses. Their operation is multidimensional, meaning that other spaces of the hotels operate throughout the day, other parts operate throughout the night and some spaces operate 24hours. In terms of architecture and functionality, the literature suggests the following three areas: the rooms, the common areas and the service areas, three zones with different approach concerning their architectural design and their energy profile.

In the literature it is reported that the hotels are one of the most energy consuming buildings of the tertiary sector after the sales, the healthcares and some types of office buildings. Although there is information on the total energy consumption of the hotel buildings through the fuel and energy bills, on the other hand there is no sufficient information on the energy breakdown as very few hotels monitor their sub-systems. Additionally, due to large differences between hotels, it is difficult to arrive at general consumption figures. Several researches report average energy consumption of the hotel sector in different countries, however it is not sure if these figures are the result of the same methodology and the calculation method, i.e. the normalization procedure that was followed. Also as it is shown, many indexes are used for the energy consumption, the one most frequently met is kWh/m^2/year. Some studies present the energy consumption in kWh/guest-night, kWh/month, kWh/bed and kWh/euros. This derives from the need to arrive at most accurate results regarding the energy consumption of hotels since these buildings constitute of different energy loads according to the various spaces and it is very difficult to have an overall view. Therefore the comparison of the energy consumption of hotels in different countries is probably not a correct procedure. It should be also noted that the sample of the different researches do not comprise the same number of hotel buildings and it is questionable if the sample is representative of the building stock.

From the literature research it is concluded that electricity is the main fuel used, and in most study cases this accounts for more than 50% of the total energy consumption. Gas, oil, lpg and natural gas follow and are used mainly for space and water heating.

In a hotel unit the main energy consuming sector is the space conditioning (heating / cooling and ventilation) and in some study cases this may account 75% of the total energy consumption. Energy for lighting is in a way fixed and may vary from 12-20% of the total energy, however in luxury hotels this may increase much more mainly because of the decorative lighting. Energy for domestic hot water is also stable and may account for 35-40% of the total energy demand depending mainly on the occupancy of the hotel.

Concerning the parameters that may have an impact on the energy consumption of the hotels there is a contradiction in the literature: some studies report that no real correlation can be found between the energy consumption of the hotel and its class, area and occupancy. But the external temperature is the one that influences most the energy consumption and also has an impact on the electricity use that is the fuel the most used. However, other researches show the existence of correlation between the energy consumption of the hotel and the class and area of the buildings.

The energy classification of the hotels is rather difficult as it depends on many parameters like the class of the hotel and the facilities it offers, the geographical location, the type of hotel, i.e. coastal, city, mountain, the operational period i.e. seasonal or annual operation, the building design in terms of area, construction and the building systems used.

In the literature research, the following methods of classification are reported concerning the hotel sector:

-Within the EU research 'Rational Use of Energy in the Hotel Sector 'Thermie' Programme Action 103-B, the EU hotels are classified in 3 groups according to the number of the rooms that they occupy; (large hotels >150 rooms, 50 <medium hotels <150, small hotels < 50 rooms) and in 4 groups according to their energy consumption in electricity, fuel and water (good, fair, poor and very poor performance).

-For the purposes of the national project VALOREN, the frequent distribution analysis is used as a classification method.

The findings of this chapter are summarized below:

- The hotels are one of the most energy consuming buildings of the tertiary sector therefore there is a huge potential for energy savings
- On various researches there is available data on the total energy consumption of the hotels in different countries around the world, however little information exists on the energy breakdown.
- Due to the complexity of the buildings there is no clear correlation what affects most the energy consumption of these buildings among various parameters like the external climate, the area, the size, and the buildings systems. However, most of the

researches around the world agree that the external temperature has the major impact on the electricity used.

- Electricity is the main fuel used in the hotel sector. Additionally the main energy consuming sector is the space conditioning (heating / cooling and ventilation). Domestic hot water follows and then lighting.
- There is no homogenous method to report the energy consumption of the hotels; different energy indexes are reported (kWh/m^2/year, kWh/guest-night, kWh/month, kWh/bed and kWh/euros) in the various researches of the literature.
- There is very limited information in the literature on the energy classification of the hotel buildings.
- Concerning the Greek hotel sector, from a sample of 158 hotels most of which located in the greater area of Athens, the average total energy consumption is 273 kWh/m^2/y. Heating is the main energy consuming sector. However, it should be noted that 98 hotels of the sample (approx 62%) are not air conditioned.
- Although the Greek hotels are highly energy intensive buildings, very few of these use renewable energy sources and solar energy technologies.

The next chapter presents the main characteristic of the hotel sector in Greece in means of construction, energy conservation measures and current legislation.

CHAPTER 3

Statistical Analysis of the Hotel Sector in Greece

3 Statistical Analysis of Hotel Sector in Greece

3.1. Introduction

This chapter is structured into 2 sections: The first section presents the main characteristics of the hotel sector in Greece. It also presents information on the existent legislation that supports the categories and the construction framework of the hotel buildings.

The general characteristics and the statistical information of the hotel sector derives from the National Statistical Agency of Greece (www.statistics.gr) and the Hellenic Chamber of Hotels (www.grhotels.gr).

3.2. Characteristics of Greek tourism

The 'hotel' sector covers all tourist accommodation facilities including, low budget, economy, business and luxury hotels, camping, bungalows, bed & breakfast facilities, rooms to let, hostels, motels, etc. The size, number of beds and occupancy may vary enormously, considering the seasonal occupation.

Tourism is very season depended. It is registered that 67% of the occupation is found between June and September while no less than 92% of the occupation is found between April and October (www.statistics.gr).

The analysis of the Greek tourism by geographical department for the period 2007 shows that 62% of tourism arrivals concentrated in four departments and specifically in Attiki (22.1%), in Crete (13.9%), South Aegean (13.3%) and central Macedonia (12.6%).

Regarding the accommodations, 80% of these occurred in 5 departments of Greece, in Crete (23.4%), South Aegea (22.5%), in Attiki (11.8%), in Ionion islands (11.5%) and central Macedonia (10.9%).

Additionally, compared to the year 2006, there is an increase in destinations in the mainland of Greece (Makedonia, Ipiros and Peloponese).

Statistics for the year 2007 show that a large percentage of tourists come from European countries (16.6% arrivals and 9.4% accommodation) like Italy, Germany and Great Britain. Also there is an increase in the arrivals from the United States, (www.statistics.gr).

3.3. Number of Greek hotels

Information on the number of the Greek hotels and the construction year of the building stock is provided by the National Statistical Agency of Greece (www.statistics.gr). Based on the latest stock registration, that was carried out in year 2000, hotels account for 22,830 buildings out of 3,990,970 buildings that is approx. 0.6% of the building stock. Additionally 31% of the registered hotels were constructed before 1981 when the thermal insulation code was put into force whereas 14% of the Greek hotels were constructed between 1981-1985, 17% between 1986-1990 and 17% between 1990-1995 (www.statistics.gr).

Additional information on the number and the quality/category (*stars) of the hotel is provided by the Hellenic Chamber of Hotels. Officially 9,036 hotel units are registered in the Hellenic chamber of Hotels (approximately 682,050 beds).

The number of hotels by geographical department and star (*) system is presented in Figure 12 and the number of hotels that are registered in the Hellenic Chamber of Hotels according to the star (*) system is presented in Figure 13 .

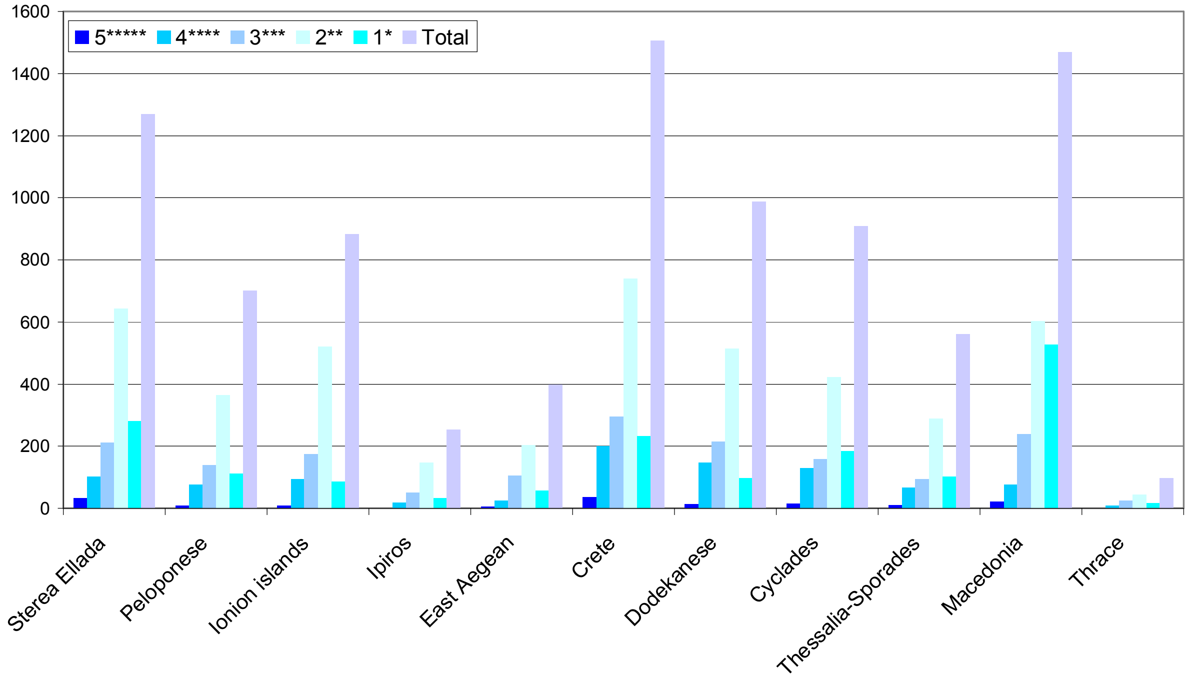


Figure 12 Greek hotels by geographical department (http://www.grhotels.gr)

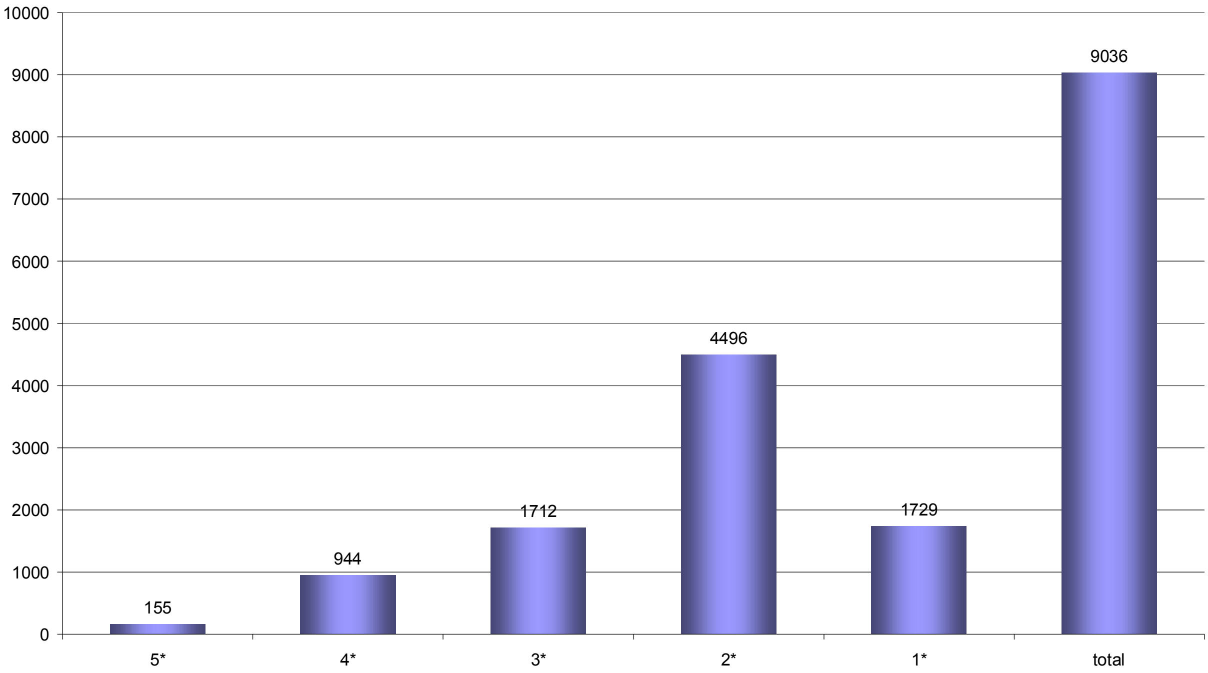


Figure 13 Number of hotels registered in the Hellenic Chamber of Hotels (http://www.grhotels.gr)

3.4. Construction characteristics

The available information on the construction and building materials derives from the National Statistical Agency of Greece and refers to all type of buildings (including hotels). Data concerning the hotel stock separately is not available. However, the analysis can also apply in the construction of the hotels.

For all type of buildings:

- For the decades 1920, 1930 and 1940 stone comprised the main construction material for more than 80% of the building stock
- From 1960 to 1970 concrete was used in more than 50% of the new buildings in conjunction with brickwork that was used in more than 30% of the new structures
- In the last decades the use of concrete was increased to more than 70% while the use of brickwork was reduced to 20% and the use of stone to 2%
- The use of wood is very limited in the total of the building construction
- The use of metal although very limited slightly increases throughout the years.

3.5. Energy conservation measures for the building stock

The Thermal Insulation Regulation of Buildings (ΦΕΚ 362/04.07, 1979) is the first significant energy conservation measure applied in Greece in 1979 and was updated in 1981. In practice it is the only measure concerning the thermal insulation that was ever applied in Greece. It was in force until the implementation of the EPBD (Energy Performance of Buildings) Directive 2002/91/EC that was incorporated into the national legislation with the Law 3661/2008 in 2008 but officially was implemented in July 2010 with the publication of the new Energy Regulation (ΦΕΚ Β ’ 407, 2010) and the respective Technical Guidelines being applied since January 2011 (Technical Chamber of Greece, 20701-1/ 2010; Technical Chamber of Greece, 20701-3/ 2010; Technical Chamber of Greece, 20701-4/ 2010; Technical Chamber of Greece, 20701-2/ 2010). The Regulation on ‘Rational Use of Energy and Energy Conservation’ (KYA 21475/4707/) was another attempt, drafted in 1998, but never implemented in practice (Theodoridou et al., In Press). This would replace the Thermal Insulation Regulation of 1979 and would require an energy study for all new built buildings along with their energy certification. However the relevant enactment was never published.

According to the national Thermal Insulation Regulation (1979) Greece was split into 3 climatic zones (A, B and C), as shown in Figure 14, and the building envelope of all structures should comply with the follows criteria:

- External Walls: Uwalls < 0.7 W/m^{2}K (for all climatic zones)
- Roofs and exposed horizontal surfaces i.e. Pilotis: Uroof < 0.5 W/m^{2}K (for all climatic zones)
- Ground floors:

Uground < 3.0 W/m^{2}K (climatic zone A)
Uground < 1.9 W/m^{2}K (climatic zone B)
Uground < 0.7 W/m^{2}K (climatic zone C),

- Partitions to non-heated enclosed spaces:

Upartition < 3.0 W/m^{2}K (climatic zone A)
Upartition < 1.9 W/m^{2}K (climatic zone B)
Upartition < 0.7 W/m^{2}K (climatic zone C)

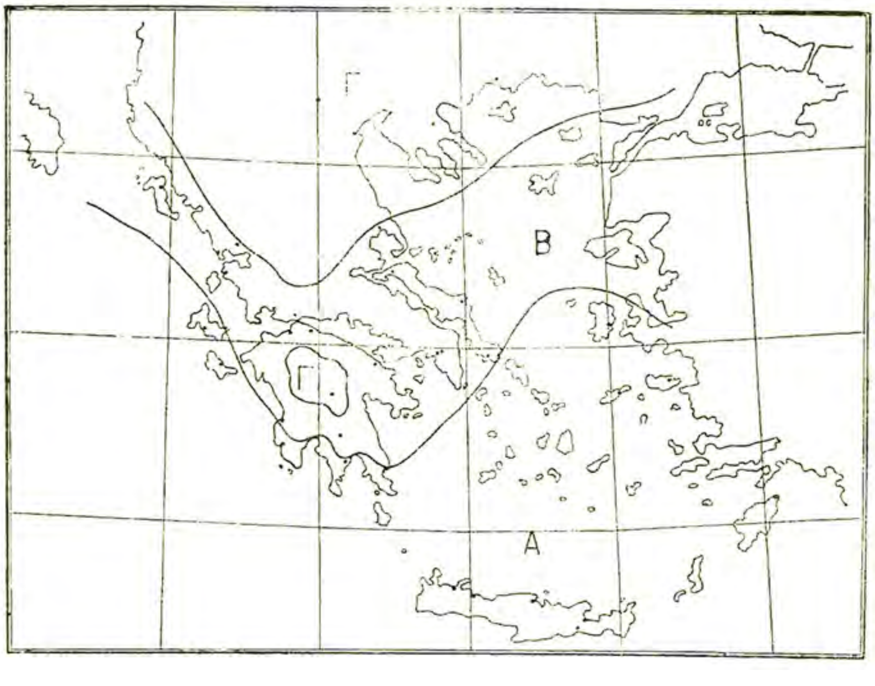


Figure 14 Map illustrating the climatic zones according to the Thermal Insulation Regulation dated in 1979 (ΦΕΚ 362/04.07, 1979)

Since January 2011 the new Energy legislation (ΦΕΚ Β ’ 407 2010) sets stricter limits regarding the thermal insulation of buildings.

According to the new legislation the U-values as shown in Table 9 should be applied:

Table 9 U-values according to the new legislation (Technical Chamber of Greece, 20701-1/ 2010)

Building element	U-value (W/m^2K) according to the Technical Chamber Of Greece (20701-/2010)			
	Climate zone			
	A	B	C	D
Roofs	0.50	0.45	0.40	0.35
External walls	0.60	0.50	0.45	0.40
Floors adjacent to external air-pilotis	0.50	0.45	0.40	0.30
Floors adjacent to ground floor	1.20	0.90	0.75	0.70
External walls adjacent to ground	1.50	1.00	0.80	0.70
Glazing	3.20	3.00	2.80	2.60

As shown in Figure 15 the new legislation splits Greece in four climatic zones instead of three. The climatic zone D applies for areas of northern Greece with altitude higher than 500m.

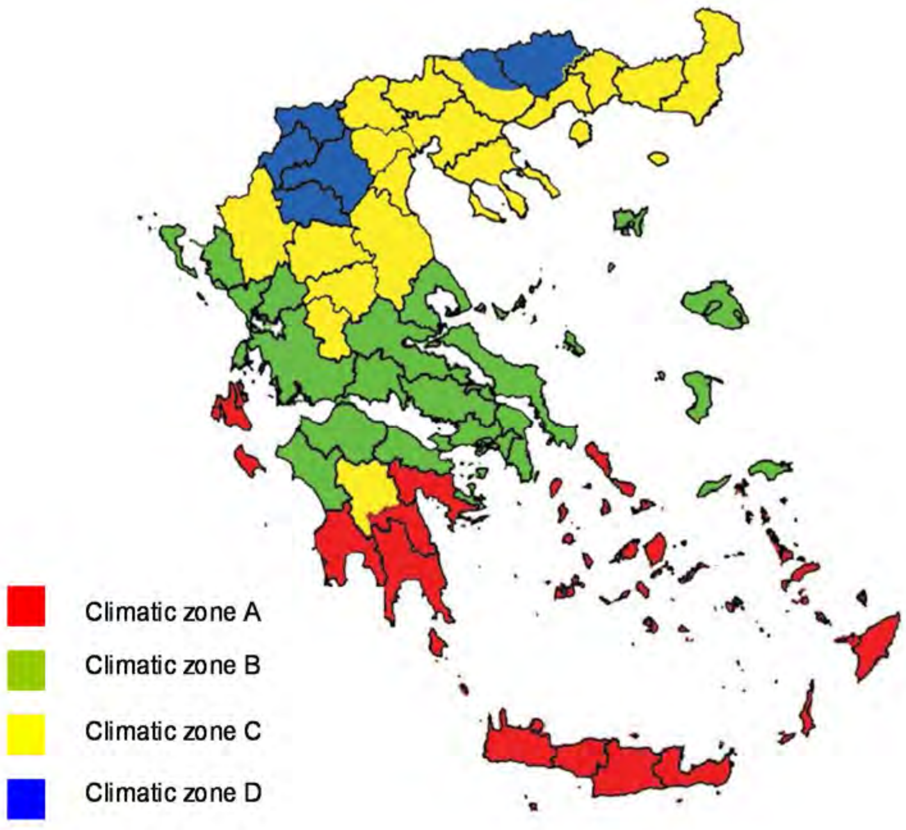


Figure 15 Climatic zones according to the new legislation (Technical Chamber of Greece, 20701-3/ 2010)

3.6. Legislation and classification of tourist accommodation according to the ‘star system’

The main legislation that covers the hotel sector in Greece is described with the following enactment:

- ΠΔ 43/2002 (ΦΕΚ Α’ 43/7.3, 2002): Classification of main tourist accommodation according to the ‘star system’ and technical specifications.

According to the enactment ΦΕΚ Α’ 43/7.3 (2002), the hotels of Greece come under the same classification system with the hotels of other European countries.
The hotels are distinguished in:

- ‘Classic’ hotels
- ‘Motels’
- Furnished apartments
- Hotels of mixed type

Additionally they are distinguished in ‘**urban**’ hotels in the case of hotels located in cities or within boundaries of building settlements and ‘**holiday – resort**’ hotels in the case of hotels located in open areas and outside building settlements. Usually the urban hotels operate throughout the year (12 months) whereas the resort hotels operate seasonally (5-6 months).

Concerning the hotel size, 3 categories are distinguished according to the number of beds:

- ‘Small’ hotels with number of beds less than 100 (beds<100)
- ‘Medium’ hotels with number of beds between 100 and 300 (100<beds<300)
- ‘Large’ hotels with number of beds greater than 300 (beds>300)

The present enactment predicts the operational and technical specifications of the hotels so that the users can recognize the provided services of the hotel. The buildings should comply with:

- Obligatory **technical** specifications concerning the hotel capacity, the characteristics of the building site and building specifications
- Obligatory **functional** specifications concerning the facilities provided by the hotels

- Obtained **points-marks** according to the facilities and the category of the hotel. Each hotel should obtain a minimum total of points that constitute the 'reference/base' of each category.

The classification of each hotel is authorized by the Greek Tourism Organisation (E.O.T.)
In more details, the classification of the hotels is as follows:

1. 'Classic' Hotels

Hotels that comprise common areas (reception, lobby, restaurant) and at least 10 rooms and service areas. These hotels are located in urban areas, cities or building settlements. They may consist of one building or more that are located in the same building site. These hotels may belong to 5 categories according to the 'star' system, from 1* to 5*****. Only refurbished hotels can be characterized as 1* hotels but not the new built ones.

2. Motels

Hotels that comprise common areas (reception, restaurant) at least 10 rooms and service areas. These hotels are located in open-air areas, outside cities, usually on highways with intense traffic that join urban or touristic areas. They may consist of one or more than one building that are located in the same site. These hotels are used by people who travel and commute by car and may be of 2 categories according to the 'star system', 4 star motels (****) and 3 star motels (***).

3. Furnished apartments

Hotels that comprise common areas (reception and lobby) and furnished apartments of one or two rooms with bathroom and kitchenette. These hotels are located in urban areas, cities or building settlements. They may consist of one building or more that belong in the same site. These hotels may belong to 5 categories according to stars, from 1* to 5*****. Only refurbished apartments can be characterized as 1* hotels and not new built ones.

4. 'Mixed' type (Classic hotels and furnished apartments)

These hotels comprise common areas, reception, lobby, restaurant, shops, service areas and rooms with bathrooms or /and rooms with bathroom and kitchenette. These hotels may not include less than **300 beds**. They are located in open air areas and obligatorily in more than one building that are designed in the same building site. These hotels may be of four (****) or five (*****) stars.

The classification of the hotels in terms of their size and number of stars is summarized in Table 10.

Table 10 Classification of hotels according to the Greek enactment (ΦΕΚ Α’ 43/7.3,2002)

		AREA I (URBAN hotels)				**AREA II** (RESORT hotels)			
	Functional characteristics	Small < 100 beds	Medium 100<beds<300		Large >300 beds	Small < 100 beds	Medium 100<beds<300		Large >300 beds
1	‘Classic’ hotels	*Stars	*Stars	Max number of beds			*Stars	Max number of beds	
		5*	5*		5*	5*	5*		5*
		4*	4*		4*	4*	4*		4*
		3*	3*			3*	3*	200	
		2*	2*	200		2*			
		1*							
2	Furnished apartments	5*	5*						
		4*	4*		5*	5*	5*		5*
		3*	3*		4*	4*	4*		4*
		2*	2*	200		3*	3*	200	
		1*				2*			
3	Mixed type								5*
									4*
4	Motels					4*	4*	300	
						3*	3*	200	

When a hotel is to be constructed, an environmental study is prepared in order to describe the suitability of the building site in terms of topography, pollution, noise levels and to ensure that the construction works will not damage the biodiversity of the greater area. However and although the legislation was edited in 2002 there is no reference in specific energy and environmental issues of the building hotels.

In terms of the building systems of the hotels, the design takes into consideration the Greek legislation and the international codes such as the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), and the German Institute for Standardisation -Deutsches Institut für Normung (DIN).

Concerning the internal environmental conditions the legislation requires (ΦΕΚ Α’ 43/7.3, 2002 p.681):

Heating period

- Rooms : internal temperatures of minimum 20°C

- Common areas: internal temperatures of minimum 18°C

Cooling period

- Rooms/common areas: maximum temperature of 26°C

For the four categories of hotels (classic, motel, furnished apartments and mixed type) the following are compulsory:

- Air-conditioning in all the common areas, rooms and apartments
- Heating for the hotels with operation more than 5 months
- Domestic hot water for 24 hours / day
- Adequate lighting for all internal and external spaces.

From the above it is obvious that there is no prediction of any measure that would save energy and that would favorite the internal environmental conditions in terms of natural ventilation, maximization of natural lighting, use of energy efficient building systems and/or renewable energy.

It is interesting to note that the maximization of credits and the update of hotels to a better category (* class) depends on many parameters irrelevant to the energy performance of the buildings. An example of parameters that influence the category of the hotels is given below:

The availability of parking area for the 25% of the rooms, the proximity to a bus stop, the internet connection in the rooms, the transfer of the luggage to the airport, the area of the room, provision of television and video in the rooms, the facilities in the bathrooms, the existence of a meeting room, the area of the restaurant, entertainment areas, gym, shops etc.

However the legislation gives credits for the follows special specifications (ΦΕΚ Α' 43/7.3, 2002 p. 729):

- Certification of energy management by acknowledged constitution like the Centre of Renewable Energy Sources and Savings (CRES)
- Certification of ecologic management by acknowledged constitution
- Certification of provided facilities through acknowledged international system (i.e. ISO)

For each of the above parameters the hotels are accredited with 200 credits.

3.7. Chapter Conclusions

Some general remarks on the hotel sector in Greece and the relevant legal framework are the following:

- According to the National Statistical Agency of Greece the hotel sector accounts for approx. 0.6% of the building stock.
- 31% of the registered hotels in the National Statistical Agency of Greece were constructed before 1981 when the thermal insulation code was put into force whereas 14% of the hotels were constructed between 1981-1985, 17% between 1986-1990 and 17% between 1990-1995.
- The Thermal Insulation Regulation of Buildings (ΦΕΚ 362/04.07,1979) was the main energy conservation measure that was into force until January 2011. Then it was replaced by the Energy legislation ΦΕΚ Β' 407 2010 (EPBD). Therefore all buildings that are constructed between 1979 and up to 2011 comply with the thermal insulation levels defined by this legislation.
- According to the Greek enactment ΦΕΚ Α' 43/7.3 the hotels are classified in 'classic hotels', 'motels', 'furnished apartments' and 'hotels of mixed type'. Additionally they are distinguished in 'urban' hotels in the case of hotels located in cities or within boundaries of building settlements and 'holiday – resort' hotels in the case of hotels located in open areas and outside building settlements. Usually the urban hotels operate throughout the year (12 months) whereas the resort hotels operate seasonally (5-6 months). The same enactment splits the hotels regarding the number of beds, in small hotels (number of beds < 100), medium hotels with number of beds between 100 and 300 and large hotels with number of beds > 300.
- Concerning the category of the hotels, the enactment ΦΕΚ Α' 43/7.3 proposes the 'star' system in a 5-scale, from 1 star to 5 star.

From above it is evident that the construction of all building stock in Greece, including the hotel sector, follows a legal framework rather old that was not updated until very recently. This resulted in constructions with inefficient thermal protection and inadequate indoor environmental conditions.

It is interesting to note that the main enactment ΦΕΚ Α' 43/7.3 that supports the Greek hotel sector proposes the use of the international codes ASHRAE, DIN, VDO, VDE for the design of the building systems. However, there is no prediction of any measure that would save energy and that would favorite the internal environmental conditions in terms of natural ventilation, maximization of natural lighting, use of energy efficient building systems and/or renewable energy.

For this reason and in order to understand better the current energy use in hotels in Greece the environmental and energy performance of 90 hotels from a number of different areas in Greece is presented in the next chapter 4. Material included in chapters 4 and 5 have resulted in a paper published in the Energy and Buildings Journal, (Appendix 7).

CHAPTER 4

Survey of 90 Hotels in Greece

4 Survey of 90 Hotels in Greece

4.1. Introduction

This chapter presents the environmental and energy performance of 90 hotels around Greece. The information on the hotels was collected using questionnaires and visits on site. Analytically, information was collected for hotels of climatic zones A, B and C of Greece. The data concerning the hotels of climatic zone C (around 40 hotels that is approx. 44% of the examined sample) was collected within a research conducted by the University of Thessaloniki in collaboration with the University of Ioannina, department of Environmental Management (Boemi, 2011). The data of the rest of the sample (50 hotels that are located in climatic zones A and B) was collected using a questionnaire prepared by the author for the purposes of this research. For most of these hotels the data was collected during visits on site. The information on the electrical and thermal energy consumption covers the year 2007 and is provided by the hoteliers, whereas the available bills are very few. The energy consumption of the hotels is normalized per area and climate and then the average thermal and electrical consumption is calculated.

It should be noted that the collection of the data was very difficult and many questionnaires were not answered. Additionally in many cases the data of the energy consumption was not available. Despite the difficulties, the energy consumption was collected from 90 hotels located in climatic zones A,B and C of Greece.

4.2. Methodology

Different data collection methods for the building environmental and energy performance are reported in the literature (Santamouris, Balaras, et al., 1994; Santamouris et al., 1996; Argiriou et al., 1994; Boemi, 2011). Standard reporting protocols, energy audits, specific questionnaires to perform surveys, questionnaires upload on website are some of the used methods. However, lack of energy data is noted in many case studies and remains a significant drawback (Nikolaou et al., 2009).

The questionnaire that was used for the collection of the energy and environmental data of the hotels (Appendix 1) is split in 9 categories:

1. General information on the hotel, like the location, the category of the hotel, the construction year, the area of the hotel, the occupation pattern, the renovation year, the operation period.
2. Thermal and electrical energy consumption based on bills.
3. The building energy management, whether the energy consumption is recorded by a Building Management System (BMS), whether there is a strategy for energy savings, which area of the hotel may be subject to improvements.
4. The building description including the construction, the building site, available layouts/drawings, characteristics of the building surroundings
5. The heating system and the fuel used for heating
6. The cooling system and the fuel used for cooling
7. The energy consumption for lighting, whether there is any automation
8. The systems used for domestic hot water
9. The record of the electrical appliances

It should be noted that from the above categories information was easily provided for the questions 1-4 apart from the collection of the architectural drawings. Information on questions 4-8 was not available since the minority of the hotels uses BMS to record the energy consumption. The record of the electrical appliances was carried out in a number of hotels, however this could not be used since information on the energy breakdown was not available.

Information on the hotels of climatic zone C was less detailed and only the electrical consumption was available for most of these hotels.

4.3. Location of hotels

The hotels are located around Greece covering the three climatic zones A, B, and C (Figure 16). 32% are located in climatic zone A (most of which in the island of Crete, but also in the island of Kos, Rhodos and Kefalonia), 22% in zone B (most of which in the greater area of Athens but also in the island of Corfu, and Aigaion) and 46% in zone C (in the greater area of Thessaloniki, and Platamonas) (Figure 17) The size of the hotels differ, the smaller one is around 500m^2 and the larger one around 60000m^2.

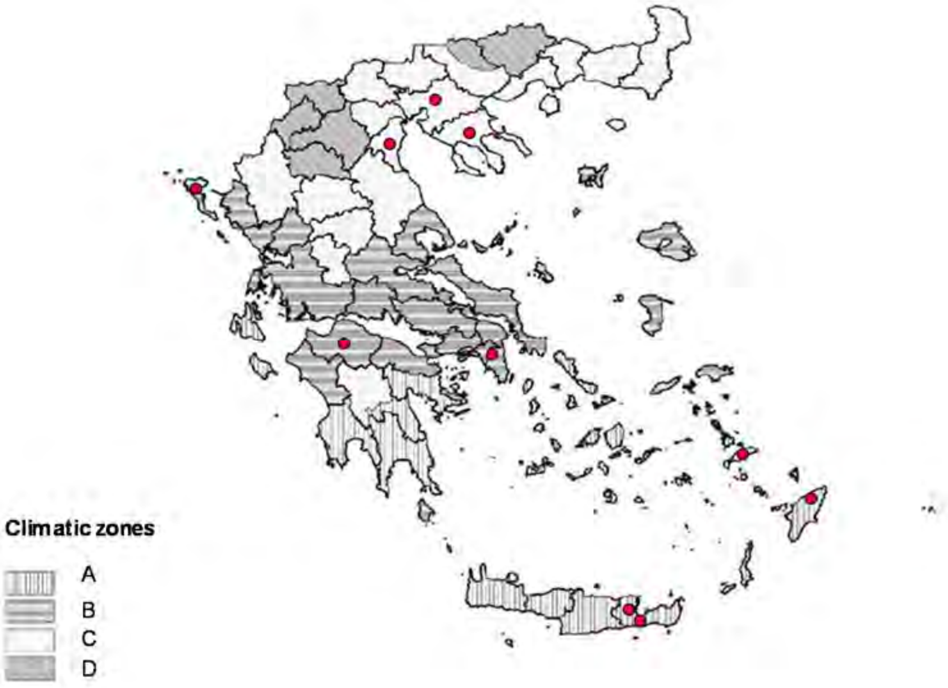


Figure 16 Map showing the location of the hotels and the four climatic zones of Greece according to the new energy legislation (EPBD)

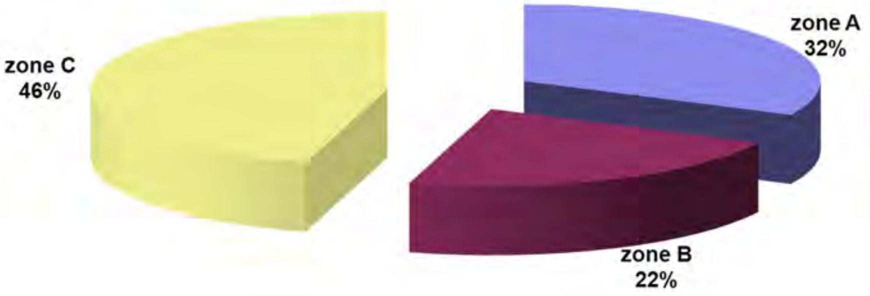


Figure 17 Hotels by climatic zone

4.4. Operation

Almost half of the sample (54% of the sample) operates throughout the year (12 months) whereas a significant portion of the sample, 31% operate during the summer period May-October. 9% operate during 7 months from April to October, whereas a minority operates only for 5 months, from June to October (Figure 18).

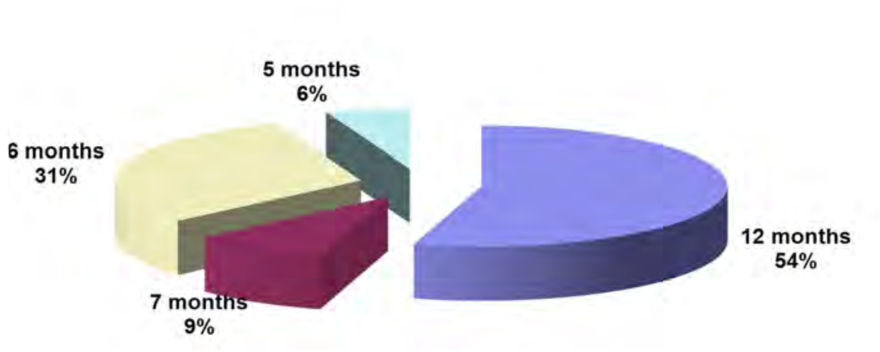


Figure 18 Operation of hotels

4.5. Number of beds

The hotels are grouped according to the number of their beds based on the legislation ΦΕΚ A' 43/7.3.2002: 'small' hotels with beds less than 100, 'medium' hotels with number of beds between 100 and 300, and 'large' hotels with number of beds greater than 300 (Figure 19).

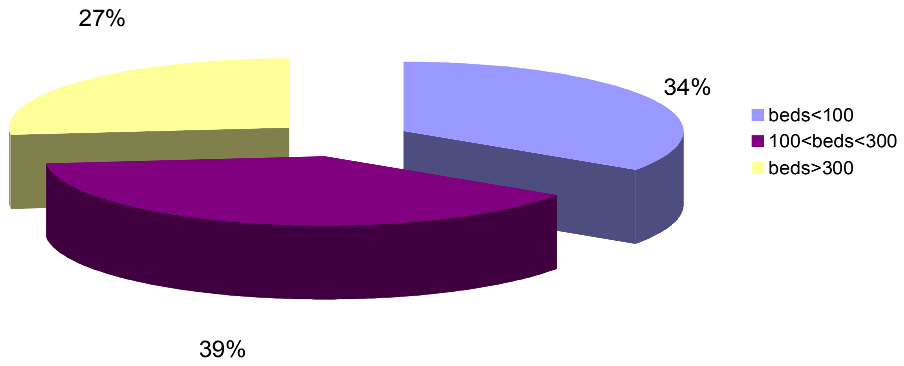
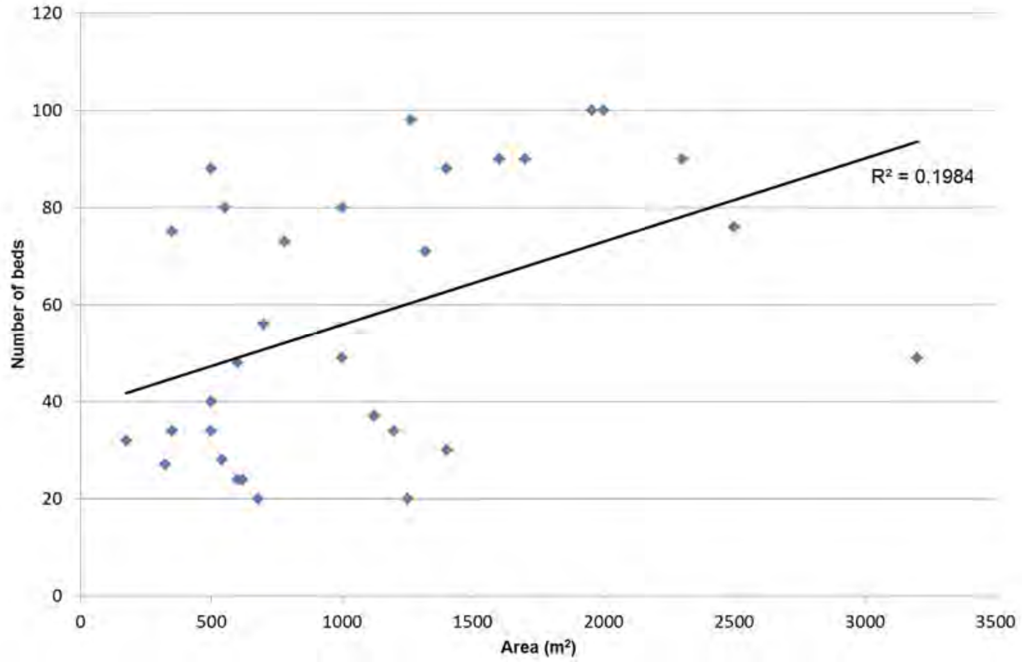
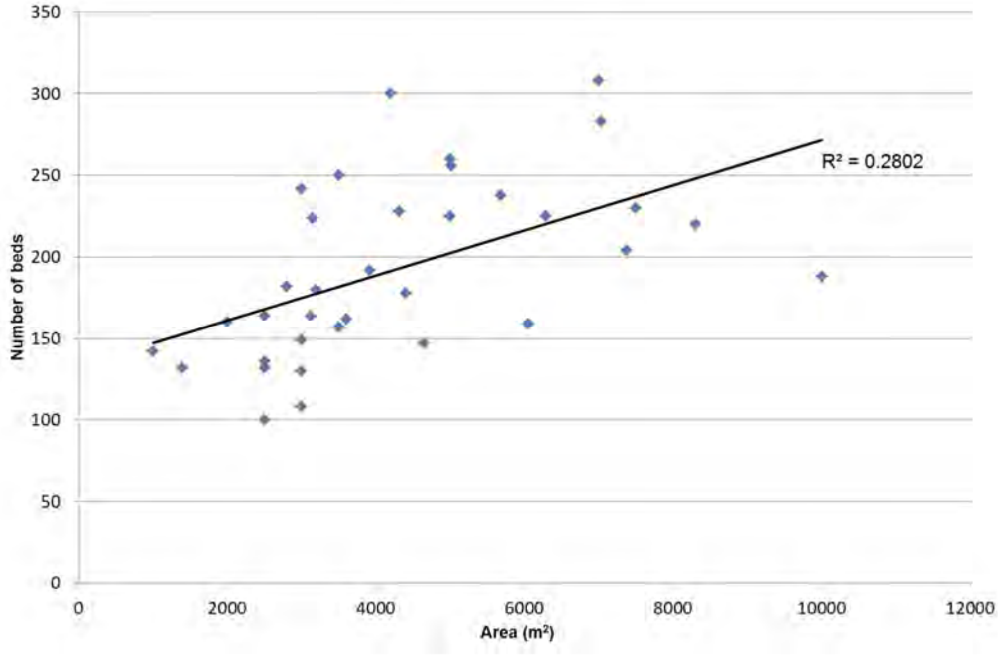


Figure 19 Hotels and number of beds

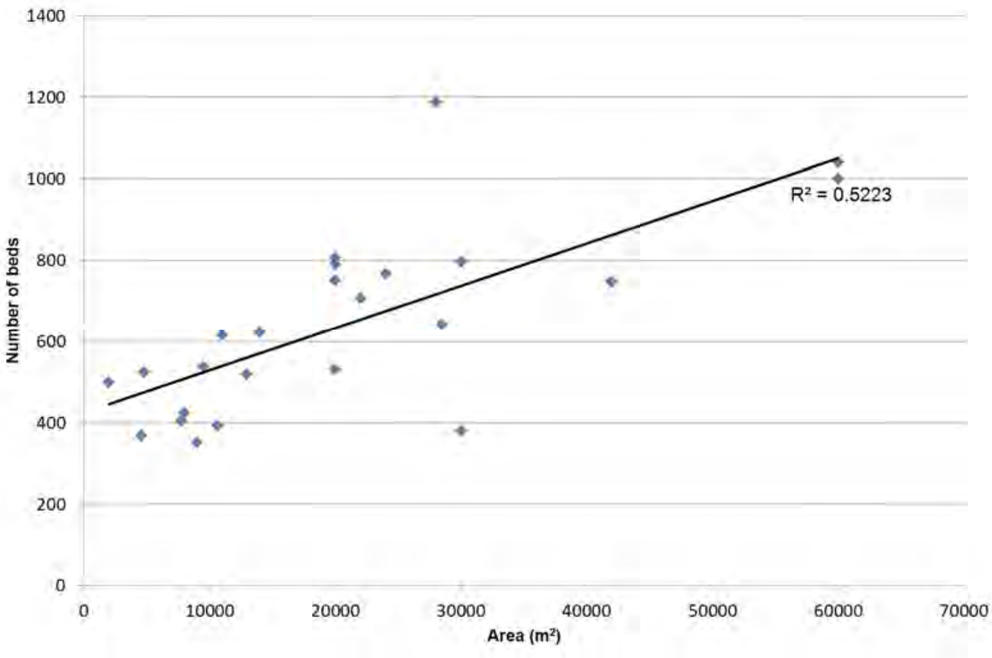
Graph 1, Graph 2 and Graph 3 show the correlation between the number of beds and the area of the hotels for the three cases of hotels a. small, b. medium and c. large.



Graph 1 (a) Number of beds (less than 100) and area (m^2) of hotels



Graph 2 (b) Number of beds (between 100 and 300) and area (m^2) of hotels



Graph 3 (c) Number of beds (> 300) and area (m^2) of hotels

It is shown that no clear correlation exists between the number of beds and the hotel area. For example, a hotel with approx 90 beds has an area of 500 m^2 or greater than 1500m^2 (graph 1). Respectively, a hotel with approx 225 beds has an area less than 4000m^2 or greater than 6000m^2 (graph 2) and a hotel with 780 beds has an area of 20000 m^2 or greater than 40000m^2 (graph 3). However, for the 'large' hotels, the correlation between the number of beds and the hotel area becomes more linear and in this case R squared is equal to 0.5

4.6. Year of construction

From the available sample, 40% of the hotels were constructed before 1979 when the National Thermal Insulation code was put into force. 37% of the sample was constructed between 1979 and 2000. Only 9% was constructed after 2000, (Figure 20).

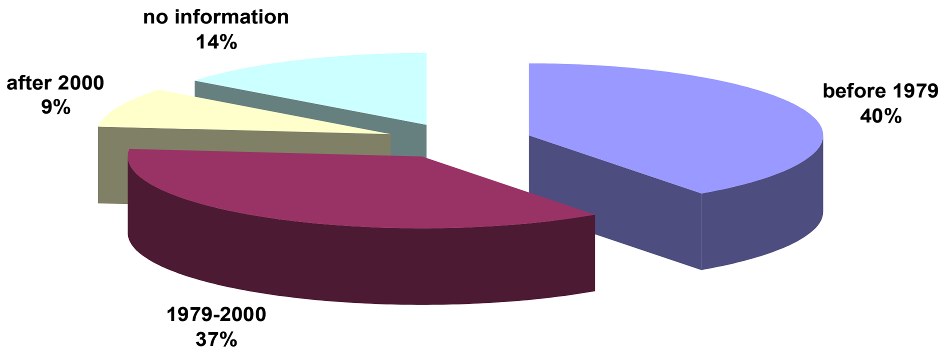


Figure 20 Construction year of the hotels

4.7. Building materials

Information on the building materials is not available for the hotels of climatic zone C that were studied within the framework of the research conducted by the University of Thessaloniki and the University of Ioannina (Boemi, 2011).

Concerning the hotels of climatic zones A and B (50 hotels) the collected data showed that for 8 hotels there is no insulation in their building construction (roof-external walls-ground floor). 7 hotels do not have any insulation on their external walls and ground floor. 7 hotels have non-insulated external walls and 4 hotels do not have any insulation on their floor. It is interesting that for 3 hotels the hoteliers did not know whether their buildings were insulated or not, although for 2 of these hotels it can be assumed that they are non-insulated because of the construction year (1922 and 1978). For the third hotel there is no information. 4 hotels seem to be insulated in all their building materials. For 17 hotels there is no information on their building construction (Figure 21).

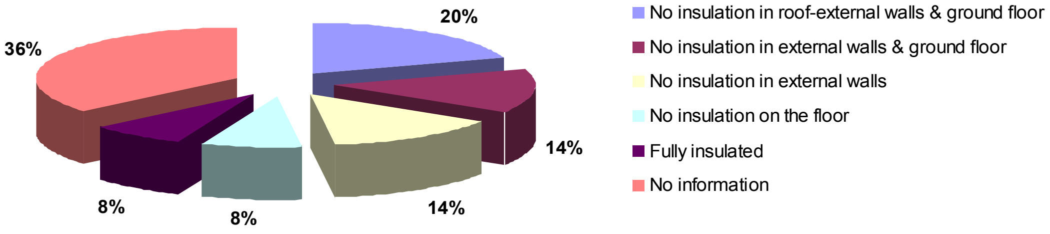


Figure 21 Thermal insulation of hotels

Regarding the construction of the hotels, 71% of these follow the typical construction with external walls from brick and bearing structure from reinforced concrete. 7% of the sample is from concrete whereas 14% are constructed from stone, 4% from cinder block and 4% from double gypsum board, (Figure 22).

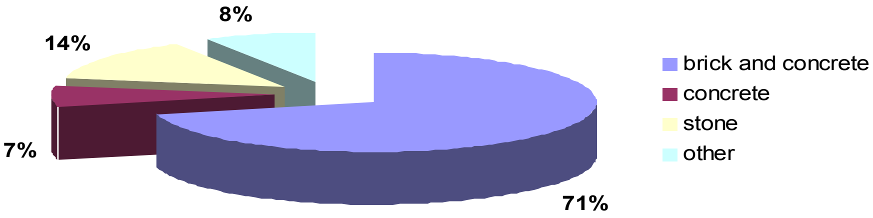


Figure 22 Building materials of hotels

Regarding the building construction for 14% of the sample moisture problems (most of which in the roofs) were identified. All these hotels, apart from one, are located in the island of Crete.

Concerning the glazing, 44% have double glazing, 8% have double reflective windows, 8% have single glazing, 2% triple glazing with sound insulation, 8% single glazing in the rooms and double in the common areas and 2% double glazing in the common areas and double reflective in the rooms, (Figure 23).

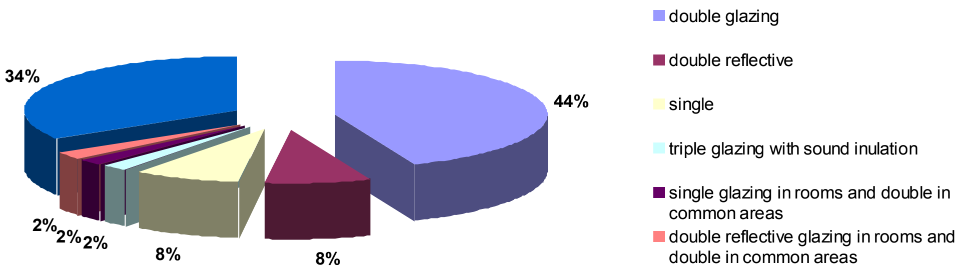


Figure 23 Glazing of Greek hotels

4.8. Building systems

Heating: Out of 50 hotels, 18% of the hotels have central heating (AHU) with ducts in the common areas and fan coil units in each room. 36% of the hotels have central heating via radiators in the rooms using oil or natural gas. The rest of the sample does not have any central heating system as they operate only during the summer months, from May to October. However, in the hotels with no central heating system, split units are installed in each room that can operate for heating and cooling, (Figure 24).

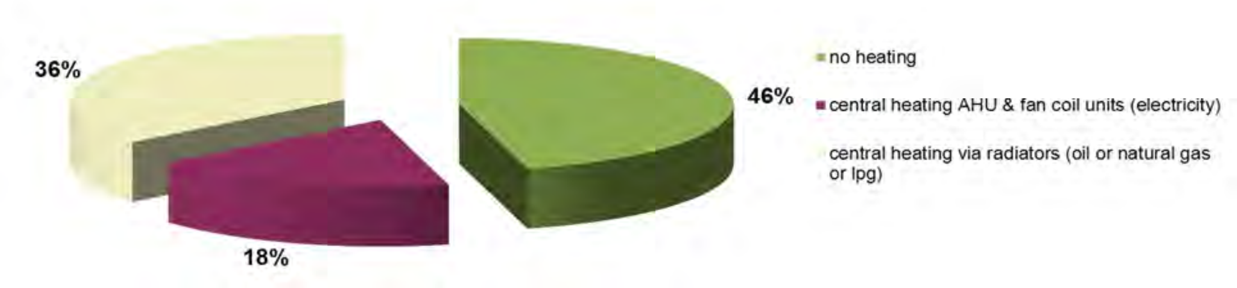


Figure 24 Heating system of Greek hotels

Among the hotels with central heating system, 26% use natural gas for space heating, 7% liquid gas (LPG), 22% oil, 8% use both natural gas and oil. 37% use electricity, (Figure 25).

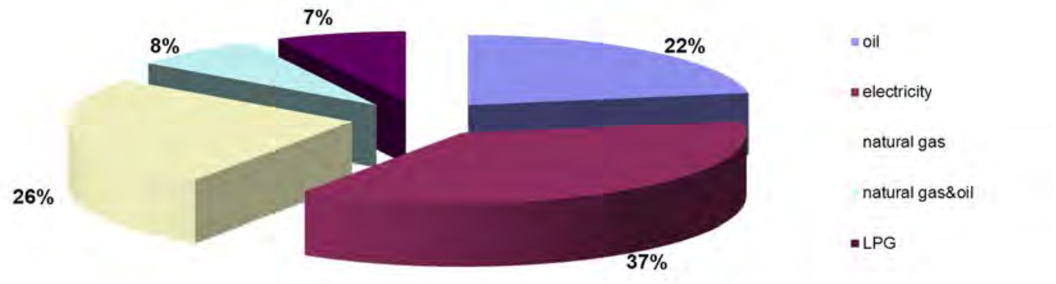


Figure 25 Fuel used in Greek hotels for heating

Cooling: In most hotels there is central cooling with chillers and fan coil units in the common areas and rooms. Only in 6% of the hotels cooling is provided via local split units, (Figure 26). It is interesting to mention the case of one resort hotel located in Crete that uses the temperature of the sea in the cooling procedure. Additionally, this hotel uses heat recovery and exhaust to the sea.

In all hotels electricity is used for cooling apart from one hotel where natural gas is used and in another one where liquid gas is used.

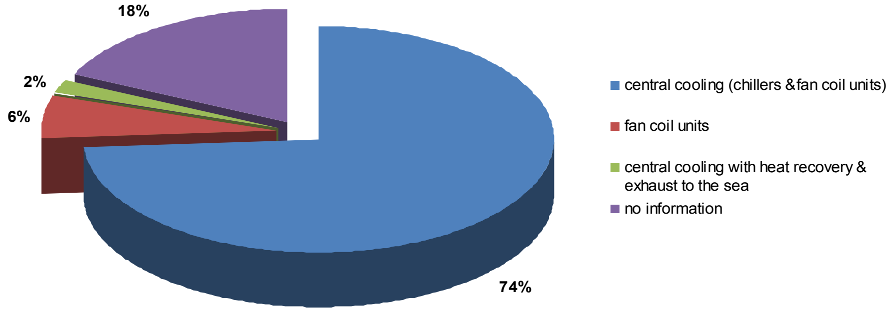


Figure 26 Cooling of Greek hotels

Domestic hot water: Out of 50 hotels, 42% have solar collectors. Almost all these hotels have auxiliary systems running with oil or natural gas. In 18% of the hotels hot water is provided through the central heating system with oil fired boilers. In 18% of the hotels domestic hot water is provided via the central heating system with natural gas and in 2% via liquid gas, (Figure 27).

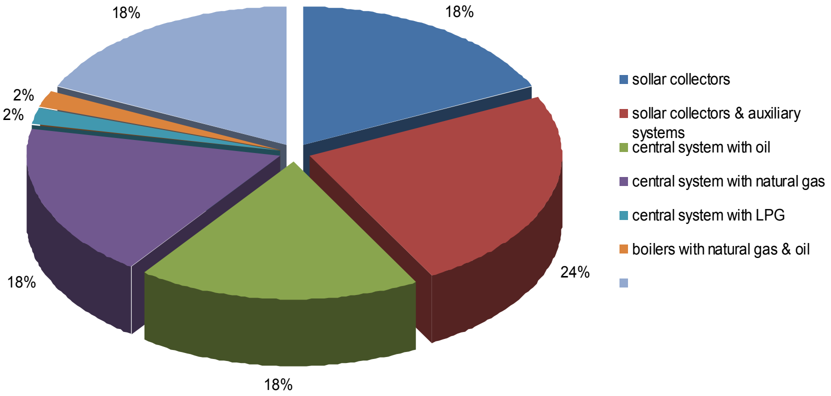


Figure 27 Domestic hot water of Greek hotels

4.9. Energy management

Out of 50 hotels, in 14% there is a Building Management System (BMS) that is connected to the central cooling system. In 52% there is not a BMS. Only in 2 hotels, the energy consumption is recorded by a BMS daily, on an hourly time step. Additionally, in one hotel the temperature of the hot water is recorded, (Figure 28).

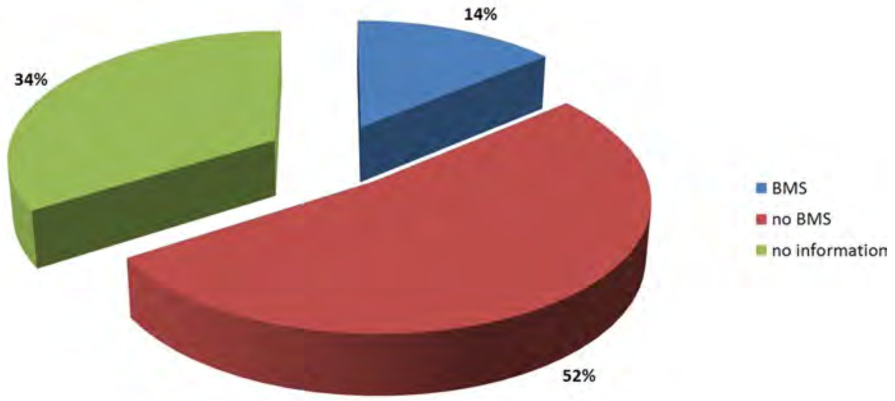


Figure 28 Energy management of Greek hotels

Activities aiming at increasing the awareness of the clients concerning environmental issues have been carried out only in 30% of the hotels. These include distribution of leaflets concerning water savings, seminars to the hotel staff and recycling. Energy measures have been performed in 52% of the hotels. These include the use of control cards in the rooms in order to switch on/off the lights (48%), the use of low energy luminaires (0.06%), the use of air conditioners with inverter (0.06%), the use of low flush toilets (0.04%), and the use of thermostats (0.06%).

Only 13 hoteliers indicated possible renovation measures and parts of their buildings subject to energy rehabilitation. 38% of them mentioned the energy management of their hotel as the first choice, 8% the installation of thermal insulation and 15% the upgrade of all building services (heating, cooling and lighting), (Figure 29).

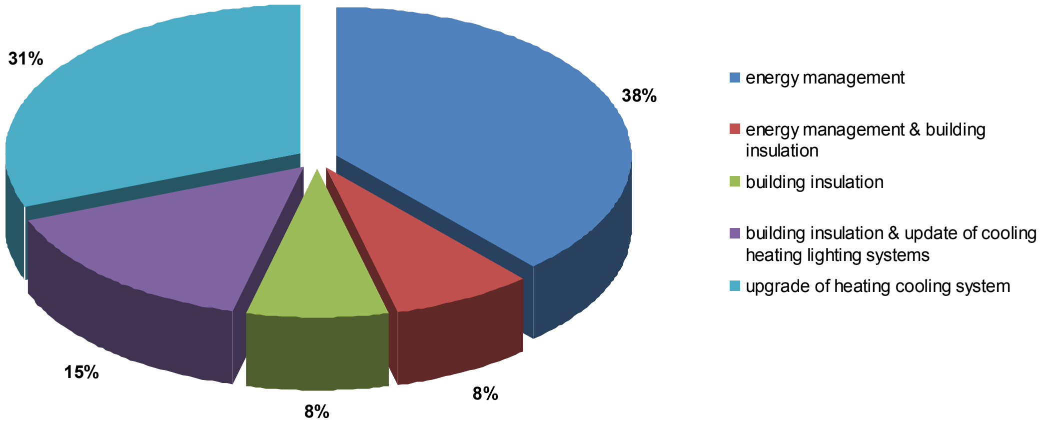


Figure 29 Potential improvements of Greek hotels

4.10. Energy profile of 90 hotels

The number of hotels with available data is summarized in Table 11.

Table 11 Available data of electrical and thermal energy consumption

Available data /number of hotels	
Electrical consumption	
Available data	90 hotels
Annual operation	49 hotels
Seasonal operation	41 hotels
Oil consumption	
Not available information	34 hotels
Oil is not used	26 hotels
Available data	30 hotels
Annual operation	12 hotels
Seasonal operation	18 hotels

Table 12 summarizes the general characteristics and the energy profile (electrical and thermal consumption) of 90 hotels. The data concerning the hotels highlighted in dark grey was collected within a research performed by the University of Thessaloniki in collaboration with the University of Ioannina (Boemi, 2011), and data concerning the hotels highlighted in light grey was collected using the questionnaire that was prepared for the purposes of this research (Appendix 1).

Table 12 Characteristics and energy profile of 90 Greek hotel (*N/A= not available information)

Information on 90 Greek hotels									
hotels	**Climatic zone**	**Construction year**	**Category (*)**	**Area (m²)**	**Operation months**	**Renovation year**	**Electricity kWh/m^2/year**	**Oil kWh/m^2/year**	**Comments on fuels used**
1	B	1900	5*	28,504	12	2003	327.11	0.00	natural gas for space and water heating
2	B	1922	5*	7,375	12	2004	128.81	0.00	electricity for heating, cooling, lighting, appliances, natural gas for water heating
3	B		5*	65,000	12		46.15	0.00	natural gas for water & space heating
4	B	1974	4*	30,000	12	2008	132.00	47.68	oil for water & space heating
5	B	1988	4*	10,620	12	2007	201.27	0.00	natural gas for water & space heating
6	B	2004	5*	4,800	12	2007	828.92	0.00	natural gas for water & space heating
7	B	1965	4*	20,000	12	2004&2006	149.94	18.77	natural gas for water &space heating
8	B	1977	3*	4,314	12	2002	364.08	0.00	electricity for heating, cooling,lighting, appliances
9	B	1968	4*	3,127	12	2003	153.31	0.00	electricity for heating, cooling, lighting, appliances
10	B	1959	4*	9,069	12	2008	100.90	47.32	oil for water & space heating
11	B	1972	4*	39,200	12	1999&2003	22.53	13.50	oil for water & space heating
12	B	1970	4*	4,400	12	2004	242.16	1.35	oil for water & space heating
13	B	1959	4*	2,800	12	2003&2004	116.39	0.00	natural gas for water & space heating
14	B	1981	4*	2,500	12	2004	183.14	205.98	oil for water & space heating
15	B	1990	3*	1,956	8	2004	102.35	26.06	oil for water & space heating, liquid gas for kitchen use
16	A	1972	2*	7,500	7	2001&2004	50.32	0.00	liquid gas for water & space heating
17	A	1980	4*	1,250	7	2004	12.16	4.63	oil for water heating
18	A	1989	3*	1,400	6	2007	12.44	N/A	
19	A	2001	3*	3,000	7		16.30	22.53	oil for water heating, liquid gas for kitchen use
20	A	1940	5*	14,044	6	2003	91.23	0.00	electricity fand liquid gas for kitchen use & water heating
21	A	2006	4*	7,745	6		137.40	7.48	electricity, liquid gas, oil for water heating
22	A	1980	5*	4,600	7	2000	128.06	293.85	electricity for heating, cooling,lighting, appliances, oil for water heating
23	A	1990	3*	5,000	7	2006	60.00	13.79	oil for water heating
24	A	1980	5*	4,200	8	2000	119.41	0.00	Liquid gas for heating,electricity for cooling, lighting, appliances
25	A	1991	3*	2,500	12		111.92	0.00	electricity for heating, cooling,lighting, appliances)
26	A	1995	4*	2,500	6		68.00	0.00	liquid gas for space & water heating
27	A	1978	2*	700	12	1985&2007	223.30	209.38	oil for space heating, electricity for cooling, lighting, appliances
28	A		2*	680	6		25.95	0.00	
29	A	1981	2*	3,000	6	2003	50.65	0.00	
30	A	1974	2*	600	5	2003	18.25	0.00	electricity for heating, cooling,lighting, appliances
31	A	1975	2*	540	3		4.28	0.00	

32	A	1993	5*	8,300	12	2003&2004	563.61	0.00	liquid for heating, electricity for cooling, lighting, appliances
33	B		4*	28,062	6		117.60	40.86	oil for water heating, electricity for cooling, lighting, appliances
34	A		4*	10,994	6		162.50	12.34	oil for water heating, electricity for cooling, lighting, appliances
35	A		4*	20,000	6		120.26	74.58	oil for water heating, electricity for cooling, lighting, appliances, liquid gas for kitchen use
36	A		4*	30,000	6		69.07	36.26	oil for water heating, electricity for cooling, lighting, appliances
37	A		3*	42,000	6		31.38	18.31	oil for water heating, electricity for cooling, lighting, appliances
38	A	1985	4*	20,000	6		138.00	7.47	oil for water heating, electricity for cooling, lighting, appliances
39	A	after 1981	4*	8,000	6		170.30	4.1	oil for water heating, electricity for cooling, lighting, appliances
40	B	after 1981	4*	10,000	6		241.20	0.00	
41	B	after 1981	4*	13,000	6		124.28	114.16	oil for water heating, electricity for cooling, lighting, appliances
42	B			20,000	6		35.16	0.00	
43	A			24,000	6		118.83	3.61	oil for water heating, electricity for cooling, lighting, appliances
44	A	after 1981	4*	9,500	6		134.32	9.18	oil for water heating, electricity for cooling, lighting, appliances
45	A	after 1981	4*	22,000	6		90.07	62.75	oil for water heating, electricity for cooling, lighting, appliances
46	B			7,000	6		329.23	0.00	
47	C			2,000	6		431.40	0.00	
48	A		5*	60,000	12	2001-2003	184.82	0.00	natural gas for space heating
49	C			600	12		28.95	96.23	oil for water and space heating, electricity for cooling, lighting, appliances
50	A	1986	3*	2,000	6		66.67	0.00	
51	C	1992	2*	325	5		32.74	N/A	
52	C	1978	2*	620	12	2005	251.61	N/A	_
53	C	1991	2*	525	12		38.93	139.51	oil for space and water heating, electricity for cooling, lighting, appliances
54	C	1999-2005-2008-2010	3*	1,124	12		21.64	139.77	no cooling, oil for heating
55	C	1920	5*	500	12	2000	353.81	N/A	_
56	C	1996	1*	780	4		40.71	N/A	_
57	C	1987	2*	1,000	6		149.88	N/A	_
58	C	2003	4*	3,200	12		51.03	N/A	_
59	C	2001	1*	500	4		121.57	N/A	_

60	C	1984	2*	350	12	2006 & 2007	116.64	N/A	-
61	C	1974	1*	1,200	6	2002	136.08	N/A	_
62	C	2001	4*	350	12	2001	256.59	N/A	_
63	C	1923	2*	1,320	12	1998 & 2003 & 2005	268.05	N/A	-
64	C	1932	3*	550	12	1997&2000	14.84	N/A	_
65	C	1970	2*	1,600	12	2000	170.10	N/A	_
66	C	1998	4*	2,500	12	2000	163.30	N/A	_
67	C	1963	3*	1,700	12	2004	28.81	N/A	_
68	C	1969	3*	1,264	12	2001	312.21	N/A	_
69	C	1977	3*	1,000	12		256.79	29.69	oil for heating, electricity for cooling, lighting, appliances
70	C	1965	3*	3,000	12	1994 & 1995	52.00	N/A	-
71	C	1985	3*	2,000	4		8.16	N/A	_
72	C	1962	5*	4,650	12	2002	142.00	N/A	_
73	C	1972	4*	6,053	12	2003	93.00	N/A	_
74	C	1968	3*	3,600	12	1997 & 2004	378.00	N/A	-
75	C	2003	5*	10,000	12		136.08	N/A	_
76	C	1969	3*	3,500	12	1990	388.80	N/A	
77	C	1991	4*	4,000	7	1994	23.81	N/A	_
78	C	1981	3*	5,016	12		189.90	N/A	_
79	C	1970	3*	3,150	12		59.99	N/A	natural gas for space & water heating
80	C	1970	4*	5,685	12		133.16	95.96	electricity for heating, cooling,lighting, appliances
81	C	1978	3*	7,030	12	2002	114.00	N/A	_
82	C	1999	5*	7,000	12		156.76	N/A	_
83	C	1988	4*	6,000	6		3.86	N/A	_
84	C	2003	5*	28,000	12		385.71	N/A	_
85	C	1969	5*	31,065	12	2003	20.60	N/A	_
86	C	1988-2003	4*	13,222	6		71.87	20.63	oil for heating, electricity for cooling, lighting, appliances
87	C	1973	4*	11,450	12	1998	141.00	N/A	_
88	C	1967	4*	5,000	12		81.65	N/A	_
89	C	1970	5*	52,520	12		35.88	0	_
90	A	1988	3*	1,400	6	2007	80.52	0.00	

4.11. Energy normalization

Normalization techniques have been applied to the sample regarding:

a. the size of the hotel
b. location of the hotel (climatic zone)

a. Normalization to the size of the hotel

The area of the hotels varies a lot according to the category of the hotel, the number of rooms and the facilities that they offer. The smaller hotel has an area of around 500m^2 and the larger one has an area of 60000m^2. The buildings were normalized in terms of their area in square meters (m^2). The annual energy consumption for space heating and cooling was divided by the total heating/cooling floor area respectively, (to get energy per unit area, kWh/m^2/year) in order to compare buildings of different size.

The procedure can be described by the following equations (Gaitani, 2011):

$$q_{heating} = \frac{Q_{heating}}{A_{heating}} \quad \text{eq. 1}$$

$$q_{cooling} = \frac{Q_{cooling}}{A_{cooling}} \quad \text{eq. 2}$$

Where:

- Qheating is the annual energy for space heating (kWh/m^2/year)
- Qcooling is the annual energy for space cooling (kWh/m^2/year)
- qheating is the normalized energy consumption for heating (kWh/m^2/year)
- qcooling is the normalized energy consumption for cooling (kWh/m^2/year)
- Aheating is the heated area in m^2
- Acooling is the cooled area in m^2

For each building the information concerning the heated and cooled area is given by the hotelier.

b. Normalisation to the climatic zone

As already mentioned the hotels are located in climatic zones A, B and C of Greece that have quite different climatic characteristics. The climate in Greece is typical of the Mediterranean climate, which is mild and rainy winters, relatively warm and dry summers with, generally, long sunshine duration almost all the year. A great variety of climate subtypes, always in the Mediterranean climate frame, are encountered in several regions of Greece. This is due to the influence of topography (great mountain chains along the central part and other mountainous bodies) on the air coming from the moisture sources of the central Mediterranean Sea. Thus from the dry climate of Attiki (the great area of capital, Athens) and generally of East Greece, change over to the wet one of North and West Greece, (EMY, 2011).

In order to be able to compare buildings in different locations, the building energy consumption was normalized in terms of climatic zones. The normalization was based on the degree day method. The heating – cooling degree day method (DDM) is based on the temperature difference between a base indoor temperature and the outdoor temperature multiplied by the duration of the temperature difference. The energy consumption of the hotels that operate seasonally (only during the cooling season) was normalized using the cooling degree days. The energy consumption of the hotels that operate throughout the whole year (12 months, during the heating & cooling season) was normalized with the heating and cooling degree days. Information on the degree days is taken from TOTEE 20701-3/2010 (Technical Chamber of Greece, 20701-3/ 2010) and is presented in Table 13 and Table 14.

Table 13 Heating degree days according to TOTEE 20701-3/2010

Heating degree days (base temperature 18°C)							
Months/Location	Athens	Crete	Corfu	Thes/ki	Rhodes	Kos	Patra
Jan	239	220	257	394	186	217	248
Feb	207	196	216	314	162	210	207
March	177	167	186	254	133	183	171
April	60	66	90	111	42	78	72
May							
June							
July							
August							
Sept							
Oct				53			
Nov	78	72	111	207	39	90	105
Dec	186	167	214	344	140	174	205
Total	947	888	1074	1677	702	952	1008

Table 14 Cooling degree days according to TOTEE 20701-3/2010

Cooling degree hours (base temperature 26C)						
Months/Location	Athens	Crete	Corfu	Thes/ki	Rhodes	Kos
Jan						
Feb						
March						
April						
May						
June	794	497	391	526	158	158
July	1901	1276	1122	1211	870	870
August	1853	1051	1236	1058	1046	1046
Sept	292	157	1		161	161
Oct						
Nov						
Dec						
Total	4840	2981	2750	2795	2235	2235

The degree-day system has several disadvantages (Santamouris et al., 2007; Gaitani et al., 2010). Heat requirements are not linear with temperature and heavily insulated buildings have a lower “balance point”. The heating and cooling loads of a building depend on many parameters besides outdoor temperature: the insulation of the building envelope, the amount of solar radiation reaching the interior of a building, the number of electrical appliances, the climatic characteristics of the building environment like the wind, and individuals’ opinions about what constitutes a comfortable indoor temperature. Another important factor is the amount of relative humidity indoors; this is important in determining how comfortable an individual will be. However, besides the reported disadvantages, the heating degree-day method is commonly used for the estimation of the normalized energy consumption for heating in public, residential, commercial and industrial buildings, (Chung et al., 2006; Gaitani et al., 2010; Eto, 1988; Badescu and Zamfir, 1999).

For the normalization of the Greek hotels, climatic zone B is taken as reference in order to have comparable results with previous research on the energy consumption of Greek hotels in the greater area of Athens (climatic zone B), (Santamouris et al., 1996).

4.12. Average electrical and thermal energy consumption

The average thermal and electrical energy consumption is calculated for 3 cases (Table 15):

- The total of the sample (90 hotels of which only 30 hotels consume oil for water and space heating)
- Hotels with annual operation (49 hotels of which 12 hotels consume oil for space heating and dhw)
- Hotels with seasonal operation (41 hotels of which 18 hotels consume oil for dhw)

Table 15 Average energy consumption kWh/m^2/year (electricity and oil) of hotels

Average energy consumption	**Electricity** (kWh/m^2/year)		**Oil** (kWh/m^2/year)
All sample included – 90 hotels	182	All sample included - 30 hotels	61
Hotels with annual operation (49 hotels)	202	Hotels with annual operation (12 hotels) oil for space & water heating	87
Hotels with seasonal operation (41 hotels)	159	Hotels with seasonal operation (18 hotels) Oil for water heating	43

4.13. Conclusions

Data was collected from 90 hotels located in climatic zones A, B and C. The main outputs of the process of the collected data are:

- Almost half of the sample, 54%, operates throughout the year whereas the rest operates seasonally (May – October).
- 40% of the hotels were constructed before 1979 when the national thermal insulation code was put into force.
- Out of 50 hotels in climatic zones A and B, 20% do not have insulation in their building materials (roof, external wall & ground floor). 14% do not have any insulation in their external wall and ground floor, and 14% do not have any insulation in their external walls. Only 14% are fully insulated (roof, external wall & ground floor). However it should be noted that even the fully insulated buildings do not meet the thermal requirements that are defined by the new energy legislation (EPBD).

- Out of 50 hotels in climatic zones A and B, 18% of the hotels have central heating (AHU) with ducts in the common areas and fan coil units in each room. 36% of the hotels have central heating via radiators in the rooms using oil or natural gas. The rest of the sample does not have any central heating system as they operate only during the summer months, from May to October.
- Among the hotels with central heating system, 26% use natural gas for space heating, 7% liquid gas (LPG), 22% oil, 8% use both natural gas and oil, 37% use electricity.
- In most hotels there is central cooling with chillers and fan coil units in the common areas and rooms. Only in 6% of the hotels cooling is provided via local split units.
- Out of 50 hotels in climatic zones A and B, 42% have solar collectors. Almost all these hotels have auxiliary systems running with oil or natural gas.
- Out of 50 hotels in climatic zones A and B, in 14% there is a Building Management System that is connected to the central cooling system. In 52% there is not a BMS. Only in 2 hotels, the energy consumption is recorded by a BMS daily, on an hourly time step. Concerning possible modifications and parts of the hotels that might be subject to energy rehabilitation, out of 13 hotels, in 38% the installation of an energy management system is indicated, in 8% the installation of thermal insulation is chosen and in 15% all building services (heating, cooling and lighting) need to be upgraded.

As shown from the results, all hotels follow a conventional type of construction and do not present any innovative system apart from one resort hotel that is located in Crete and uses the temperature of the sea in the cooling procedure. The energy management of the hotels is very poor and behind technology; however its use is recognized and it seems to be the preferable measure in the case of a renovation.

Also, given the fact the climate of Greece and the extended hours of solar radiation, the percentage of hotels that use solar collectors is rather small.

After the normalization of the energy data in terms of size (area m^2) and location (climate zone) the average electrical and thermal energy consumption (kWh/m^2/year) is calculated:

- All sample included (annual and seasonal operation): average energy consumption for electricity: 182 kWh/m^2/year and average energy consumption for oil: 61 kWh/m^2/year.

- Hotels with annual operation: average energy consumption for electricity: 202 kWh/m^2/year and average energy consumption for oil: 87 kWh/m^2/year for oil.
- Hotels with seasonal operation: average energy consumption for electricity: 159 kWh/m^2/year and average energy consumption for oil: 43kWh/m^2/year.

Based on a previous research on the energy data of the hotel sector in Greece (Santamouris et al., 1996) , from a sample of 158 hotels most of which located in the greater area of Athens, the average **total** energy consumption (thermal and electrical) was calculated **to 273** kWh/m^2/y. The present findings do not differ a lot from this study.

The next chapter presents the classification of the 90 hotels in terms of their electricity and oil consumption.

CHAPTER 5

Benchmarking and Energy Classification of the Hotel Sample

5 Benchmarking and Energy Classification of the Hotel Sample

5.1. Introduction

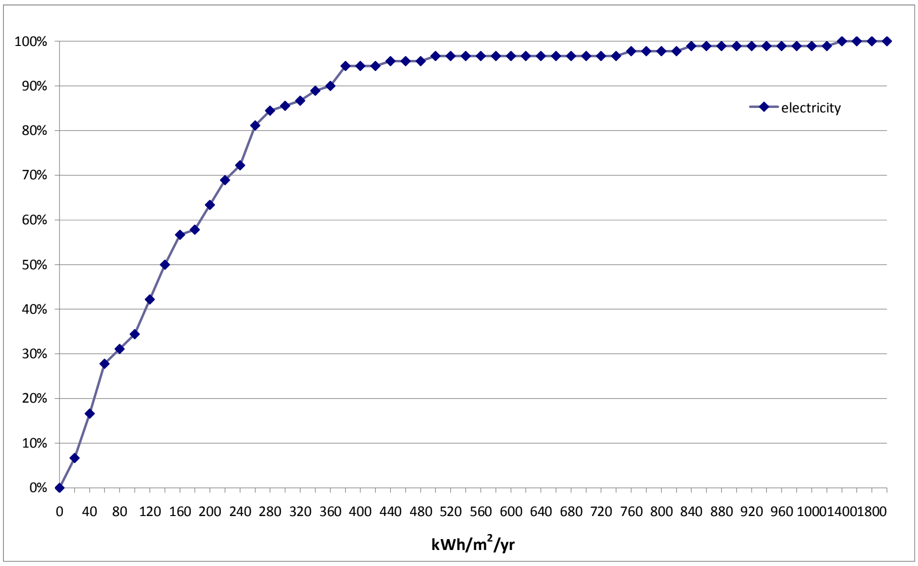
This chapter analyses the normalized energy data of the hotels using the frequency distribution analysis and then it presents a methodology to classify the hotels according to their energy consumption. Given the fact that in Greece there are no official benchmarks for the building stock, a need derives to classify the energy data of the hotels and to set typical values in order to compare the sample between them and with the rest of the building sector. The classification gives an idea of quantitative parameters, and is an attempt of specifying typical and best practice values. For the purposes of the classification the Greek hotels are clustered using the k-means algorithm being one of the most used and efficient clustering methods. The k-means algorithm follows a simple and easy procedure to classify a given data set through a certain number of clusters fixed a priori. The result is a set of clusters that are as compact and well-separated as possible. The optimum number ‘k’ of clusters is controlled with the silhouette plot. The k-means algorithm and the silhouette plot are performed in the MATLAB environment.

5.2. Frequency distribution analysis

Frequency distribution counts the occurrences of values within a particular group or range of values. It is a way of classifying unorganized data. In many studies the cumulative frequency distribution is used to define the median value (50% of the sample), and the quartile boundaries (25% and 75% respectively). Usually the 25% represents the best practice example and 75% the typical value of a sample (Santamouris et al., 2007; Gaitani, 2011; Mihalakakou et al., 1996; Badescu and Zamfir, 1999). Based on the cumulative frequency distribution the following benchmarks apply for the hotel buildings, (Graph 4, Graph 5).

5.2.1. Electricity consumption

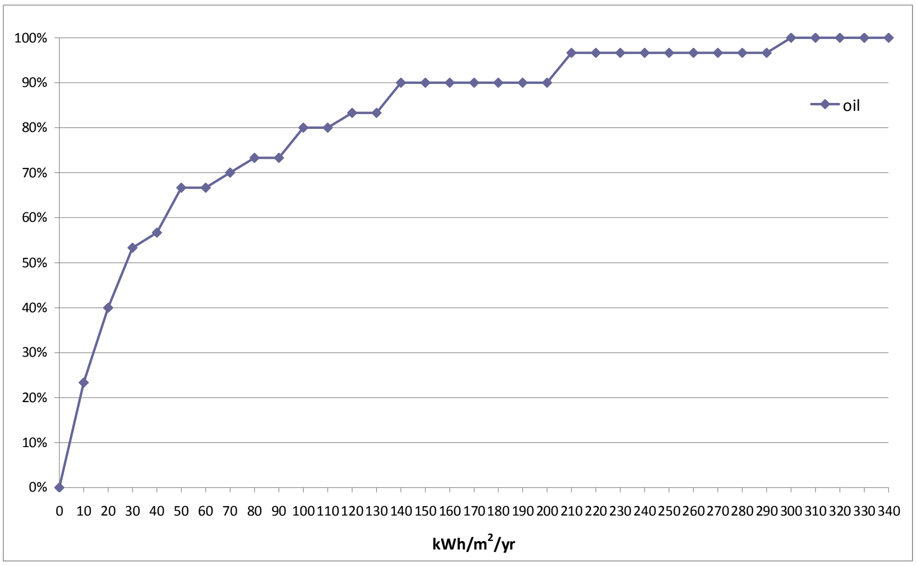
- Typical hotel building (50% of the sample), approx. 140 kWh/m^2/year
- Best practice of the building (25% of the sample) , 58 kWh/m^2/year



Graph 4 Cumulative frequency distribution of the electrical energy consumption for 90 hotels in Greece (year 2007)

5.2.2. Oil consumption

- Typical hotel building (50% of the sample), approx. 28 kWh/m^2/year
- Best practice of the building (25% of the sample) , 11 kWh/m^2/year



Graph 5 Cumulative frequency distribution of the thermal energy consumption (oil) for 30 hotels in Greece (year 2007)

5.3. Benchmarking and energy classification

Classification schemes help to organize a large set of data so that the retrieval of information can be made more efficiently. Describing patterns of similarity and differences among the objects under investigation is made by means of their class characteristics and provides a convenient summary of data. Classification is served in many sciences, wide application is found in the medicine area where it serves for 2 reasons a) prediction by separating diseases that require different treatment and b) aetiology by defining the causes of different types of disease, (Everitt, 1993).

A number of numerical classification techniques are available and this is connected to the growth of the computer use and the need of the technology to undertake large amounts of arithmetic data. Biology, zoology, archaeology, psychiatry, market research and astronomy are other fields where classification techniques find wide application.

The aim of the benchmarking process is the comparative analysis in order to define best practice examples. In the case of buildings, it gives an idea of their energy and/or environmental performance -i.e. in terms of their energy consumption, indoor thermal levels, and highlights the best and worst case studies. Usually the benchmarking system motivates the poor performers to improve their performance.

Methodology used in benchmarking energy efficiency in buildings has largely been standardized. Originally, the word benchmark was used exclusively in topography to precisely define a reference point in terrain or geological analysis. In the 1970s, some companies developed benchmarking tools to allow comparison of key production parameters and thus to check whether improved processes enhanced their performance. The term building energy benchmarking started to be associated with the energy use of buildings of similar characteristics in the 1990s and it consists of a comparison of the Energy Performance Index (EPI) of a building with a sample of similar buildings. A common EPI used for many building types is annual energy use per unit area; however many others can be found in the literature such as energy per worker, energy per pupil, energy per bed etc. The EPI is usually used as a starting point in energy audits and is compared with existing references (benchmarks) of average (typical), above average (good) and excellent (best) practice, (Pérez-Lombard et al., 2009).

Averages are often reported in the literature to allow quick comparisons between similar buildings with respect to energy efficiency because they can be recognized as the most straightforward benchmark. The main disadvantage of this method is that individual buildings with excessive energy intensity may increase averages significantly, especially when the sample is small. In the same sense, a simple ranking of the operational characteristics of buildings may unreasonably penalize others given undeserved high grades (for example, hotels with high occupancy will be penalized if directly compared to hotels with much lower occupancy), (Xuchao et al., 2010). Medians are less sensitive to extremes, but like averages, information derived by such a benchmark is rather limited. Ranking buildings based on their Energy Performance Index (EPI) provides a more informative benchmark.

Energy performance rating and certification are required as part of the EPBD implementation (ΦΕΚ Β ’ 407, 2010). This requires the need of energy benchmarking the building stock (Nikolaou et al., 2009). Countries such as the UK have produced energy benchmarks and performance guides for almost 30 years, as Good Practice Guide that includes typical and best practice values for the building stock. However in Greece the energy consumption of the building sector has not been recorded systematically and there is not any official benchmark system; but information on the energy rating of different type of buildings is given in different studies as aforementioned in chapter 3 (Santamouris et al., 1996; Gaitani, 2011; Argiriou et al., 1994; Santamouris, Dascalaki et al., 1994).

Other benchmarking method that can be found in the literature apart from the simple normalization method that uses a common EPI (usually normalized per floor area and operation hours) is the mathematical method Ordinary Least Square (also called regression analysis) that uses the linear regression model. This method creates the regression line that represents the average energy efficiency level. All buildings above this line can be considered energy inefficient whereas below the line energy efficient, (Chung, 2011; Lowry et al., 2009).

5.4. Clustering algorithms

Finding similar clusters is another methodology of grouping objects. Cluster analysis determines similar groups, or clusters, of data of an initially unclassified set of data. Objects in the same cluster have similar characteristics in a sense, where the profile of objects in different clusters is quite distinct.

Clustering algorithms are generally categorized under two different categories – partitional and hierarchical.

- Partitional clustering algorithms divide the data set into non-overlapping groups, thus in separate clusters. Algorithms k-means, fuzzy k-means, etc, fall under this category. Partitional clustering algorithms employ an iterative approach to group the data into a pre-determined *k* number of clusters (Ahmad and Dey, 2007; Todd et al., 2009). The main drawback of the k-means algorithms is the fact that the number of k clusters should be predefined and that there is no uniqueness of results as the initial conditions may strongly influence the classes structure, (De Smet et al., 2004; Foggia et al., 2009).
- Hierarchical algorithms use the distance matrix as input and create a hierarchical set of clusters. Hierarchical clustering algorithms may be:
  - Agglomerative – where starting with a unique cluster consisting of a single data element, then a hierarchy of clusters is determined by repeatedly merging nearest clusters until only one – final cluster remains which contains all data elements, (Ahmad and Dey, 2007; Seem, 2005).
  - Divisive – in which the initial cluster containing all points is successively split to contain cohesive sub-clusters, till each point belongs to a unique cluster or till some other pre-defined termination condition is reached (Ahmad and Dey, 2007).

Apart from the classical algorithms (partitional and hierarchical) other methods include the graph based algorithms. These algorithms do not require the number of clusters to be provided in advance and use the properties of the graphs (i.e. algorithm based on random walks, theory of spanning tree, etc) in the procedure of clustering, (Foggia et al., 2009).

An important step in most clustering is to select the distance measure between data points. This will influence the shape of the clusters, as some elements may be close to one another according to one distance and further away according to another. Two of the most common distance measures are: the Euclidean distance (most used method), that corresponds to the length of the shortest path between two elements and the city-block distance (the sum of distances along each dimension).

5.4.1. The k-means algorithm

The clustering of the Greek hotels is carried out using the **k-means** algorithm being one of the most used and efficient clustering methods (Ahmad and Dey, 2007; Gaitani, 2011; Foggia et al., 2009; De Smet et al., 2004; Di Piazza et al., 2011). The k-means algorithm assigns each point to the cluster whose center (also called centroid) is nearest. The algorithm uses an iterative algorithm that minimizes the sum of distances from each object to its cluster centroid, over all clusters. This algorithm moves objects between clusters until the sum of distances from all objects in that cluster cannot be decreased further. The centroid for each cluster is the point to which the sum of distances is minimized. The result is a set of clusters that are as compact and well-separated as possible, (MATLAB Help Index, 2002).

The k-means algorithm follows a simple and easy procedure to classify a given data set through a certain number of clusters fixed a priori. The main idea is to define k centroids, one for each cluster. These centroids should be placed in a suitable way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest centroid. When all points are assigned to clusters, the first step is completed. Then it is necessary to re-calculate k new centroids as barycenter of the clusters resulting from the previous step. After we have these k new centroids, a new association has to be done between the same data set points and the nearest new centroid. This continues in a loop where the k centroids change their location step by step until no more changes are done.

Finally, this algorithm aims at minimizing an objective function, in this case a squared error function. The objective function

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|$$

eq. 3

Where $\left\| x_i^{(j)} - c_j \right\|$ is a chosen distance measure between a data point and $x_i^{(j)}$ the cluster centre , is an indicator of the distance of the n data points from their respective cluster centres, (A tutorial on clustering algorithms Available on line; Di Piazza et al., 2011).

As a distance measure the squared Euclidean distance is taken as default. Examples of data clustered using the k-means algorithm are shown in Figure 30.

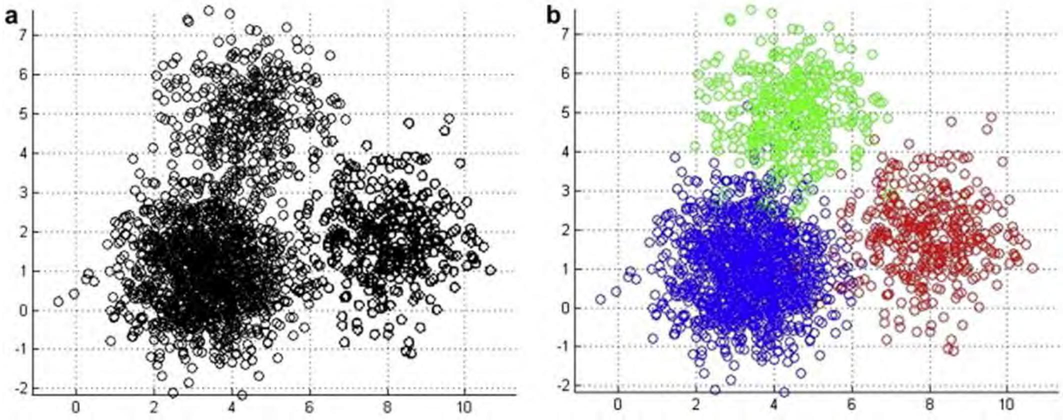


Figure 30 Examples of data clustered with k-means algorithm (Di Piazza et al., 2011)

In general the determination of the correct number of clusters is an issue. A possible way to compare the considered solutions is to look at the average silhouette values for different choices of clusters' numbers. Usually, many attempts are made with a range of values for k, and the final selection of this leads to 'positive' and mostly high silhouette values, (Di Piazza et al., 2011).

The 'Silhouette plot' is the measure that indicates the success of the distinction of objects into the separate clusters. Silhouette ranges from '+1', indicating that objects are well separated and belong to different clusters, through '0', indicating points that are not distinctly in one cluster or another, to '-1' indicating that probably some objects are located into the wrong cluster. By default the silhouette uses the squared Euclidean distance, (Lletí et al., 2004; Gaitani, 2011; Di Piazza et al., 2011).

5.5. Clustering of the Greek hotels

In order to comprehend the correlation of the sample the energy data was classified into different clusters in order to define the 'average/centroid' value of each cluster representing the 'typical' value of that cluster. The electrical and thermal energy consumption of the Greek hotels (kWh/m^2/year) was clustered using the k-means algorithm. The algorithm was performed in the environment of MATLAB®. Several attempts were realized in order to obtain the optimum number of clusters. This was controlled with the silhouette plot.

The classification of the hotels was carried out for:

- The total of the sample (90 hotels of which only 30 hotels consume oil for water and space heating).
- Hotels with annual operation (49 hotels of which 12 hotels consume oil for space heating and dhw). Most of these hotels are city hotels as they are located in dense built contexts, (i.e. Athens, Thessaloniki).
- Hotels with seasonal operation (41 hotels of which 18 hotels consume oil for dhw). These hotels are resort holidays located in the Greek islands (i.e. Crete, Kos, Rhodes, Kefalonia, Kos).

5.5.1. Matlab software

MatLab is an abbreviation for MATrix LABoratory and is a numerical computation tool for algorithm development, data visualization, data analysis, and numeric computation (Sen and Shaykhian, 2009; www.mathworks.com available on line). It is one of the most widely used, very high level programming languages for scientific and engineering computations. It is very user-friendly and needs practically no formal programming knowledge.

Matrix processing is one of the main capabilities of the software.

The main parts of the MATLAB system are:

The MATLAB desktop and Command Window, an editor and debugger, a code analyzer, and browsers for viewing help, the workspace, and folders.

Additionally, the software incorporates a vast library with computational algorithms ranging from elementary functions, like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

The MATLAB language is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features (www.mathworks.com available on line).

In the literature many examples can be found on the Matlab use for assessing the application of fuzzy control systems and artificial neural networks in assessing buildings components / systems (Ekici et al., 2009; Kolokotsa et al., 2001) and / or rating the buildings' energy performance (Gaitani, 2011; Santamouris et al., 2007; Chen et al., 2009; Yu and Dexter, 2010).

5.5.2. Hotels with annual and seasonal operation

5.5.2.1. Electricity consumption

Using the k-means algorithm controlled with the silhouette plot the hotels were clustered in 5 classes, (Figure 31).

The boundaries of each cluster (minimum, maximum and centroid) are shown in Table 16.

Table 16 Clustering of the electrical energy consumption (year 2007) of 90 hotels

Hotels - Electricity consumption (kWh/m^2/year) 90 hotels					
Clusters/ Values **(kWh/m^2/year)**					
	1	2	3	4	5
Minimum	7	86	174	315	623
Maximum	86	174	315	623	1260
Centroid	39	129	234	378	945

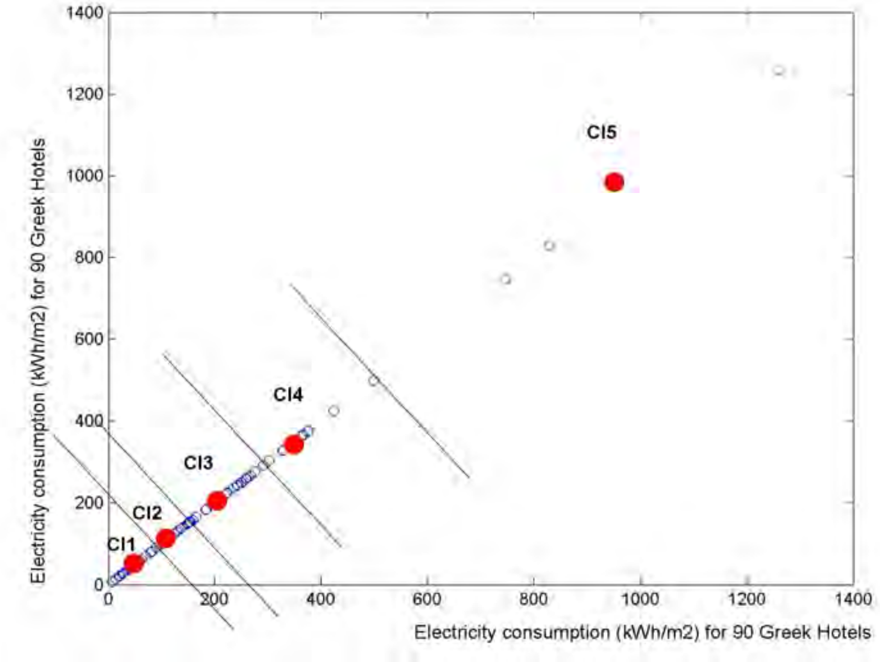


Figure 31 Clustering of the electrical energy consumption (year 2007) of 90 hotels

The analysis of the results shows that 32% of the sample belongs to cluster 1, 26% belongs to cluster 2, 29% to cluster 3, 10% to cluster 4 and 3% to cluster 5.

As mentioned before, the number of clustering was checked with the silhouette plot. Figure 32 shows the allocation of the different values in each cluster. The absence of negative values indicates that the distinction in clusters was successful.

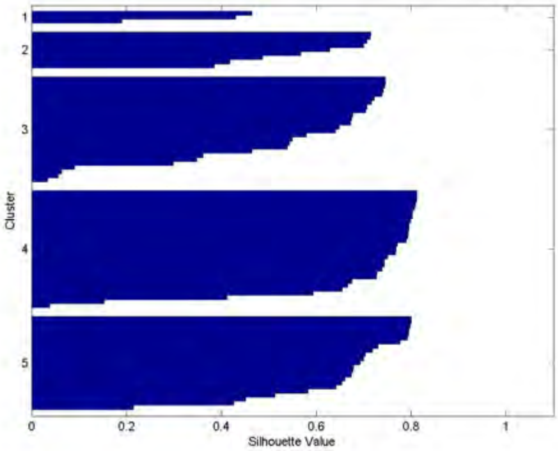


Figure 32 Plot silhouette for the clustering of the electrical consumption of 90 hotels

5.5.2.2. Oil consumption

Using the k-means algorithm the hotels were clustered in 5 classes, (Figure 33).

The boundaries of each cluster (minimum, maximum and centroid) are shown in Table 17:

Table 17 Clustering of the thermal consumption (oil) for 30 hotels in Greece (year 2007)

Hotels -Oil consumption (30 hotels) (kWh/m^2/year)					
Clusters/ Values **(kWh/m^2/year)**					
	1	2	3	4	5
Minimum	1	16	44	86	173
Maximum	16	44	86	173	294
Centroid	8	27	58	117	237

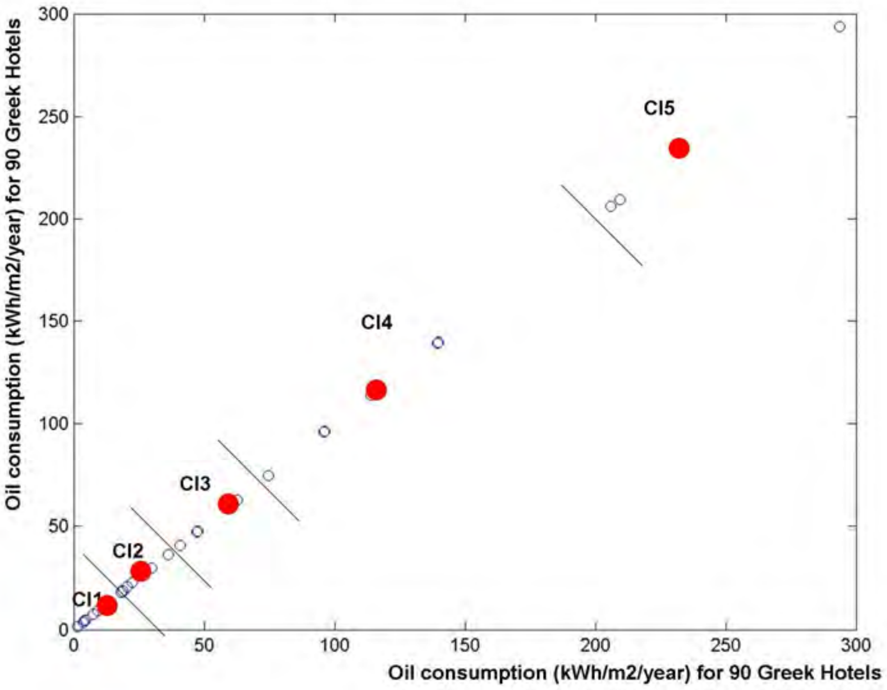


Figure 33 Clustering of the thermal consumption (oil) for 30 hotels in Greece (year 2007)

The analysis of the results shows that 33% of the sample belongs to cluster1, 27% belongs to cluster 2, 13% to cluster 3, 17% to cluster 4 and 10% to cluster 5.

The relevant silhouette plot is shown in Figure 34.

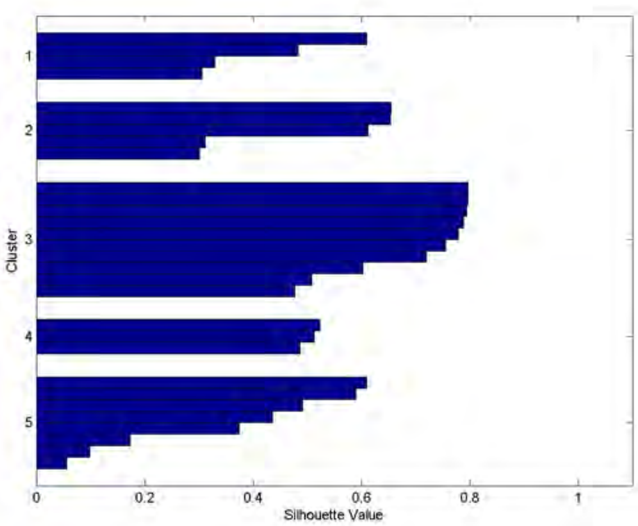


Figure 34 Plot silhouette for the clustering of the oil consumption of 30 hotels

5.5.3. Energy consumption for city hotels with annual operation

49 hotels of the sample operate throughout the year. Electricity data is available for all these hotels of which only 12 hotels consume oil.

5.5.3.1. Electricity consumption

The boundaries of each cluster (minimum, maximum and centroid) are shown in Table 18:

Table 18 Clustering of the electrical consumption of 49 hotels (year 2007)

Hotels with annual operation (49 city hotels) -Electricity consumption (kWh/m^2/year)					
Clusters/ Values **(kWh/m^2/year)**					
	1	2	3	4	5
Minimum	14	85	174	282	664
Maximum	85	174	282	664	1260
Centroid	38	132	225	369	1045

The analysis of the results shows that 26.5% of the sample belongs to cluster1, 32.6% belongs to cluster 2, 20.4% to cluster 3, 16% to cluster 4 and 4% to cluster 5.

5.5.3.2. *Oil consumption*

The boundaries of each cluster (minimum, maximum and centroid) are shown in Table 19.

Table 19 Clustering of the thermal consumption (oil) of 12 hotels (year 2007)

Hotels with annual operation (12 city hotels) **-Oil consumption** (kWh/m^2/year) **Clusters/** Values **(kWh/m^2/year)**				
	1	2	3	4
Minimum	1	25	72	173
Maximum	25	72	173	209
Centroid	11	42	118	208

The analysis of the results shows that 25% of the sample belongs to cluster1, 25% belongs to cluster 2, 33% to cluster 3, and 17% to cluster 4.

5.5.4. Energy consumption for hotels with seasonal operation

41 hotels of the sample operate seasonally. Electricity data is available for all these hotels, whereas only 18 hotels consume oil.

5.5.4.1. *Electricity consumption*

The boundaries of each cluster (minimum, maximum and centroid) are shown in Table 20.

Table 20 Clustering of the electrical consumption of 41 hotels (year 2007)

Hotels with seasonal operation (41 holiday hotels) **-Electricity consumption** (kWh/m^2/year)				
Clusters/ Values **(kWh/m^2/year)**				
	1	2	3	4
Minimum	7	76	175	586
Maximum	76	175	586	746
Centroid	37	117	252	746

The analysis of the results shows that 37% of the sample belongs to cluster 1, 20% belongs to cluster 2, 41% to cluster 3, and 2% to cluster 4.

5.5.4.2. Oil consumption

The boundaries of each cluster (minimum, maximum and centroid) are shown in Table 21.

Table 21 Clustering of the oil consumption of 18 hotels (year 2007)

Hotels with seasonal operation (18 holiday hotels) **-Oil consumption** (kWh/m^2/year)				
Clusters/ Values **(kWh/m^2/year)**				
	1	2	3	4
Minimum	4	20	52	204
Maximum	20	52	204	294
Centroid	9	29	84	294

The analysis of the results shows that 50% of the sample belongs to cluster1, 27.8% belongs to cluster, 17% to cluster 3, and 5% to cluster 4.

5.6. Chapter Conclusions

Using the frequency distribution method, it is shown that out of 90 hotels, 50% (typical building) consumes less than 140 kWh/m^2/year for electricity whereas 25% (best practice) consumes less than 58 kWh/m^2/year.

Respectively, for the oil consumption, out of 30 hotels, 50% consumes less than 28 kWh/m^2/year and 25% consumes less than 11 kWh/m^2/year.

Given the fact that in Greece there are not official benchmarks for the building stock, a need derives to classify the energy data of the hotels and to set typical values in order to compare the sample between them and with the rest of the building sector. The energy data was classified into different clusters in order to define the 'average/centroid' value of each cluster representing the 'typical' value of that cluster. For the clustering the algorithm k-means was used in the MATLAB environment.

The electrical and thermal energy consumption was clustered for three cases:

a. the sample in total (90 hotels annual & seasonal operation)
b. hotels with annual operation
c. hotels with seasonal operation

For each case the number of clusters was controlled via the silhouette plot.

The average values for each cluster and the percentage of the sample in each cluster are given in Table 22,

Table 23 and Table 24.

Table 22 Clustering of hotels with annual & seasonal operation (average values and percentage of sample in each cluster)

	Hotels with annual and seasonal operation				
Clusters	**1**	**2**	**3**	**4**	**5**
Electricity – average values of clusters (kWh/m^2/year) **90 hotels**	39	129	234	378	945
Number of hotels (percentage) in the cluster	32%	26%	29%	10%	3%
Oil - average values of clusters (kWh/m^2/year) **30 hotels**	8	27	58	117	237
Number of hotels (percentage) in the cluster	33%	27%	13%	17%	10%

Table 23 Clustering of hotels with annual operation (average values and percentage of sample in each cluster)

	Hotels with annual operation				
Clusters	**1**	**2**	**3**	**4**	**5**
Electricity (kWh/m^2/year) for **49 hotels**	38	132	225	369	1045
Number of hotels (percentage) in the cluster	27%	33%	20%	16%	4%
Oil(kWh/m^2/year) for **12 hotels**	11	42	118	208	
Number of hotels (percentage) in the cluster	25%	25%	33%	0.17%	

Table 24 Clustering of hotels with seasonal operation (average values and percentage of sample in each cluster)

	Hotels with seasonal operation			
Clusters	**1**	**2**	**3**	**4**
Electricity (kWh/m^2/year) **41 hotels**	37	117	252	746
Number of hotels (percentage) in the cluster	37%	20%	41%	2%
Oil(kWh/m^2/year) **18 hotels**	9	29	84	294
Number of hotels (percentage) in the cluster	50%	28%	17%	5%

The next chapter presents the characteristics of a 'typical' hotel of cluster 1 that will serve as the demonstration – reference hotel of the study. Cluster 1 was selected because the classification of the 90 hotels based on their electricity consumption resulted in five well separated clusters (see Table 16) and the analysis of the results showed that the majority of the hotel sample (32%) belongs to cluster 1 (section 5.5.2.1).The demonstration hotel as it is presented in the next chapter, belongs in climatic zone B and for the year 2007 (reference year) its electricity consumption (based on bills) is 246400 kWh for the period 23/10/2006 – 20/12/2007 (Table 27) or 202240 kWh for the period 26/03/2007 – 23/10/2007 (Table 32) therefore its consumption varies between 40 kWh/m^2/yr to 49 kWh/m^2/yr, close to the centroid value of cluster 1 (39 kWh/m^2/yr, see Table 16), therefore it can be considered as 'typical' hotel for cluster 1.

CHAPTER 6

Demonstration Hotel

6 Demonstration Hotel

6.1. Introduction

This chapter presents the energy performance of the Long Beach Hotel. The main objectives of this section are: a. to present the real energy profile of the hotel b. to simulate the energy performance of the hotel and c. to correlate the simulation results with the real energy consumption and to discuss any possible declinations.

The Long Beach hotel is located in the greater area of Patras (south of Greece) in climatic zone B. It is a '3' star hotel and belongs to the 'medium' hotels (100<beds<300) according to the national legislation ΦΕΚ Α' 43/7.3, 2002. For the year 2007 (reference year), the hotel presents quite low electricity consumption, and this is attributed to the absence of a central HVAC system and the provision of cooling via local split units only in the rooms. The electricity consumption of the hotel varies between 40 $kW/m^2/yr$ – 49 $kW/m^2/yr$ and according to the classification of the hotels it could comprise a 'typical' hotel of cluster 1.

The electricity consumption of the hotel is based on monthly bills that were provided by the hoteliers and concern the years 2007, 2008, 2009 and 2010. The variation of the electricity consumption is studied with reference to the year 2007 and taking into account the weather and occupancy normalization for the years 2008-2010.

Additionally, the electricity consumption of the hotel is simulated. The simulations were carried out using the dynamic software TRNSYS. The climatic file that is used for the simulations is extracted from the METEONORM software. The simulation results (cooling loads) are converted to consumption according to the Energy Efficiency Ratio (EER) of the system and the weather and occupancy factors of the different years. An attempt is made to correlate the simulation results with the real energy consumption and to discuss the declinations.

6.2. Long Beach hotel – description

The Long Beach hotel belongs to the company TOURISTIC ENTERPRISES A.E.E. It is located in Peloponese, in the Loggos area, 7.5 km away from the city of Aigion, and west of Athens, (Figure 35).

The Long Beach Hotel is a '3' star hotel and its construction dates back to 1972.

The hotel has a total floor area of 5000m^2 and comprises 115 rooms, reception area, restaurant and kitchen facilities, lounge with bar, and one meeting room.

According to the national legislation ΦΕΚ Α' 43/7.3, 2002 the hotel is characterized as 'medium' (100<beds<300).

The hotel operates during the spring and summer months, from April to October. The most occupied period is between July and August when the hotel is 90% occupied. Occasionally, the hotel is open during the heating period, i.e. during the Christmas holidays.

Figure 35 Aerial view of the location (googlearth)

6.2.1. Building description

The hotel is located in an open area, next to the sea. It is a freestanding building with no other buildings nearby. The building has a rectangular layout with the main facades facing northwest and southeast.

The areas are developed in ground floor with a mezzanine and four levels, with the common areas (reception, restaurant, lounge, shop) in the ground floor, the meeting room in the mezzanine and the rooms in the ground, first, second, third and fourth levels, (Figure 36, Figure 37).

All the main areas of the hotel (common areas and rooms) have northern orientation (northwest), whereas the corridors and circulation areas have southern (southeast) orientation.

Figure 36 Ground floor

Figure 37 Floor B' – typical floor

6.2.2. Building construction

Building materials: The bearing structure (roof, columns and floor) is from concrete and the external walls are from brickwork (plaster – brick – plaster).

The building components (external walls, roof, floor) have no insulation.

Glazing: The common areas with northern orientation (kitchen, restaurant, lounge) have single glazing with aluminum frame.

The corridors to the rooms with southern orientation have double glazing with aluminum frame.

The rooms with northern orientation have single glazing with wooden frame.

Shading: The floor slabs and balconies of the rooms provide shading to the southeast and northwest windows of the floors below.

6.2.3. Building systems

6.2.3.1. Heating-cooling

Central heating is with gas via radiators and operates in the rooms and the common areas of the hotel. The gas was installed in the year 2000; previously oil was used for heating. Central heating operates occasionally during the heating period, when the hotel is open, i.e. during the Christmas period.

The set temperature for heating is 21-23 °C and the control is performed centrally; no other temperature control is available.

There is no central cooling in the hotel. Cooling is possible only in the rooms (cooled area: 2550m^2) with local A/C split units (model Panasonic, 9000 Btu). The split units were installed in 2000, and the last maintenance of the system was carried out in year 2007.

6.2.3.2. Ventilation

All areas of the hotel are naturally ventilated via openable windows. There is some extract ventilation in the kitchen. However, no mechanical ventilation is installed in the main areas of the hotel.

6.2.3.3. Lighting system

The lighting system consists of fluorescent tubes and bulbs in the reception, kitchen and entrance and incandescent lamps in the rooms and corridors. All lamps are controlled by manual switch on/off.

Detailed description of the luminaires is given in Table 25.

Table 25 Details of lighting installation in the Long Beach Hotel (year 2007)

Area	**Type of lights –number of luminaires**	**Watts**	**Control**
Common areas			
Reception	3 (F tubes)	36/lamp=108 W	M (manual)
Lounge	84 (14x6) spots SI	60/lamp=5040 W	M
Dining room-restaurant	144 (24x6 spots) SI 7 (suspending) Compact fluorescent 6 (surface mounted luminaires – SI below the mezzanine)	60/lamp=8640W 25/lamp=325W	M
Kitchen	12 F	60/lamp=720 W	M
Cafeteria/bar	12 (spots)	35/lamp=420W	M
Entrance	4 (F tubes)	23/lamp=92W	M
Mezzanine	16 surface mounted luminaires - SI		
Shop	7 lamps – SI	60/lamp=420 W	M
Corridors – circulation areas			
Ground floor	5 – SI	175 W	M
A’ floor	5 – SI	175W	M
B’ floor	10- SI	350W	M
C’ floor	10- SI	350W	M
D’ floor	10- SI	350W	M
Rooms			
Bedrooms	4 SI	60/lamp=240W	M
WC	2 SI		M
Type of lights: SI: Standard Incandescent, F: Fluorescent			

6.2.3.4. *Hot water system*

Hot water for shower, washing and cooking is supplied with glazed flat plate solar collectors. In total 120 panels (each panel area approx. 1x2 m) are installed on the terrace of the hotel, facing south with a tilt of 36.87°. The hot water of the collectors serves the rooms and the kitchen of the main hotel building. The solar heating system is equipped with three storage tanks 2000lt each (total storage 6000lt).When the needs exceed the available hot water produced by the collectors there is a back up system of an oil fired boiler.

6.2.3.5. *BMS*

No Building Management System (BMS) or any other automated control is installed in the hotel.

6.2.4. Building renovation

The building went under major renovation in 2008. The following tasks were materialized:

- **Upgrade of the building systems – HVAC system**

-Installation of central heating, cooling and ventilation in the common areas (lounge, reception area, meeting room and restaurant area).

-Use of water heat exchanger (Carrier Aquasnap 30RH-140B) for heating and cooling. The heat exchanger is designed for optimum energy savings and uses the refrigerant charge R-407C that does not have any impact to the ozone layer. This type of heat exchanger uses the energy of the environment for the production of heat and cool therefore reduces the total energy consumption and minimizes the CO_2 emissions.

- Installation of 10 air handling units (CARRIER) in the reception, restaurant, lounge and mezzanine area.

- Installation of air ducts for the supply and outlet of the air. The air ducts are installed above the false ceilings. The air speed is less than 5m/s in order to avoid noise disturbance. For optimum quality of air, simultaneous fresh air is supplied between 20% and 100%. (Total supply of fresh air: 13.000m^3/h.)

- **Upgrade and redesign of the lighting installation**

-Redesign of the lighting system in the common areas and the use of low energy luminaires.

-Use of daylight compensation techniques

Table 26 shows the luminaire types in the common areas after the renovation. The design aims at the operation of different scenario according to the occupancy, the different events and the maximization of the daylight. In Table 26, the luminaires marked with the same colour represent the different scenario.

Table 26 Details of the lighting installation in the Long Beach Hotel (year 2008)

Area	**Number of luminaires**									
Ground floor	Spot Ha GU5,3 50W	Ha Halospot 50W	FL 58W	LEDs 1W	Decorative projectors with HA 50W	Ha GY6,35 35W	Luminaires 40W/m	FL 23W		Watts
Entrance	39		7 7	14						2370
Circulation area	13 13									650
Shop	8									400
Reception	24 12		3 3				8m 8	4 4		1786
Lounge	31	16 8	10					6 6		3068
Reading		4	4 4							432
WC	6 6		10		4 4	6	6,85m			1564
Office								1		23
Office								3		69
Restaurant area	Spot Halogen GU5,3 50W	LEDs 3W	Decorative projectors with HA 50W	IN 50 W	FL 24W	FL 54W	FL 39W	FL 80W	FL 23W	Watts
General lighting	53 25		6	6	11	14	1	5	6 6	4847
Circles	39	72								2166
Hidden								12		960
A Level	Spot Halogen GU5,3 50W	LEDs 1W	IN 50 W	FL 54W	FL 24W	FL 13W	FL 39W			Watts
Entrance	24	4	4 4							1404
Meeting area		19		12	4	24				1075
Office							2			78

Type of lights:

IN: Standard Incandescent, FL: Fluorescent , HA: Halogen

- **Upgrade of the building envelope**

- Replacement of single glazing with double low e glazing in the common areas (restaurant, kitchen and lounge) and use of aluminum frames with thermal breaks.

All glazing facing north, of total area 179m^2, is replaced with double low e glazing.

❖ Installation of Building Management System

- **Building Management System** (BMS) is a system of continuous energy management that helps to achieve cost and energy savings. Buildings using this kind of control systems are usually called “intelligent buildings”. In this way the system is directly connected to energy conservation matters, adjusting the comfort levels of the occupants. Depending on the type of the hotel building the savings arisen from a BMS can be from 10-50%,(Gaglia et al., 2007).

A BMS system is installed in the Long Beach hotel in order to:

- Operate and control the building systems (heating, cooling, demand control ventilation and lighting system in the common areas) and
- Record the indoor environmental conditions (internal temperatures and relative humidity levels) in the common areas.

The main parts of the system include the follows:

- Indoor sensors, that measure internal temperature, humidity, air quality and luminance.
- Outdoor sensors that measure external temperature
- Controllers
- Decision units that interact with the sensors controlling the energy profile of the building and selecting the proper intervention, communicating with the building controllers at the same time.
- Database, where all the building energy characteristics are recorded.

Unfortunately in the case of the hotel Long Beach, the BMS never operated properly and finally was disused. The explanation given by the hotel owner, concerning the malfunction of the BMS, was the fact that the technician who was responsible for the BMS installation was not experienced and not expertise in this field and was not able to resolve the problems arisen. The fact that the hotel owner was not addressed to a professional can be attributed to financial reasons.

The renovation was partially funded by the European Community.

6.3. Electricity consumption for the years 2007-2010

Table 27 presents the electricity consumption (kWh) for the period 23/10/2006 – 25/01/2011. The energy consumption is based on the electricity bills that were provided by the hoteliers.

Table 27 Electricity consumption (kWh) for the period 23/10/2006-25/01/2011 (information based on bills)

Electricity consumption (kWh)	
23/10/2006 - 20/12/2007	246400
22/12/2007 -23/12/2008	352480
23/12/2008 -23/12/2009	464400
23/12/2009 -25/01/2011	341520

6.4. Normalisation of the energy consumption

The electricity consumption is normalized according to:

- Weather - based on the degree day method.
- Occupancy pattern – overnight stays

6.4.1. Weather normalization

6.4.1.1. Degree day

The weather normalization is based on the degree day method. According to the national EPBD (Technical Chamber of Greece, 20701-1/ 2010) the base temperature for HDD is 18°C and for CDD is 26°C, however, as analysed in section 7.4 of this study, different base temperatures for heating and cooling can be found in the literature. It is noted that in all calculations of heating and cooling degree days the author uses the base temperatures as these are defined by the national EPBD. However, in this section, the number of the heating and cooling degree days for the past years 2007, 2008, 2009 & 2010 is given from the website www.wunderground.com that as default uses base temperature 18°C for the calculation of both heating and cooling degree days.

The year **2007** is used as reference year. HDD that were used for the normalization are presented in Table 28 and Table 29. The weather normalization factors for the years 2008, 2009 and 2010 are presented in Table 30.

Table 28 HDD for the years 2006-2010

Heating degree days (base temp 18^{o}C)					
	2006	**2007**	**2008**	**2009**	**2010**
January	588	456	468	388	436
Febr	424	389	455	459	362
March	376	313	280	410	355
April	164	184	181	143	147
May	56	13	39	35	32
June	6	0	0	0	2
July	0	0	0	0	0
August	0	0	0	0	0
Sept	0	7	13	0	0
Oct	35	50	39	39	51
Nov	328	233	169	235	88
Dec	414	469	379	299	350
Total	2391	2114	2023	2008	1823

Table 29 CDD for the years 2006-2010

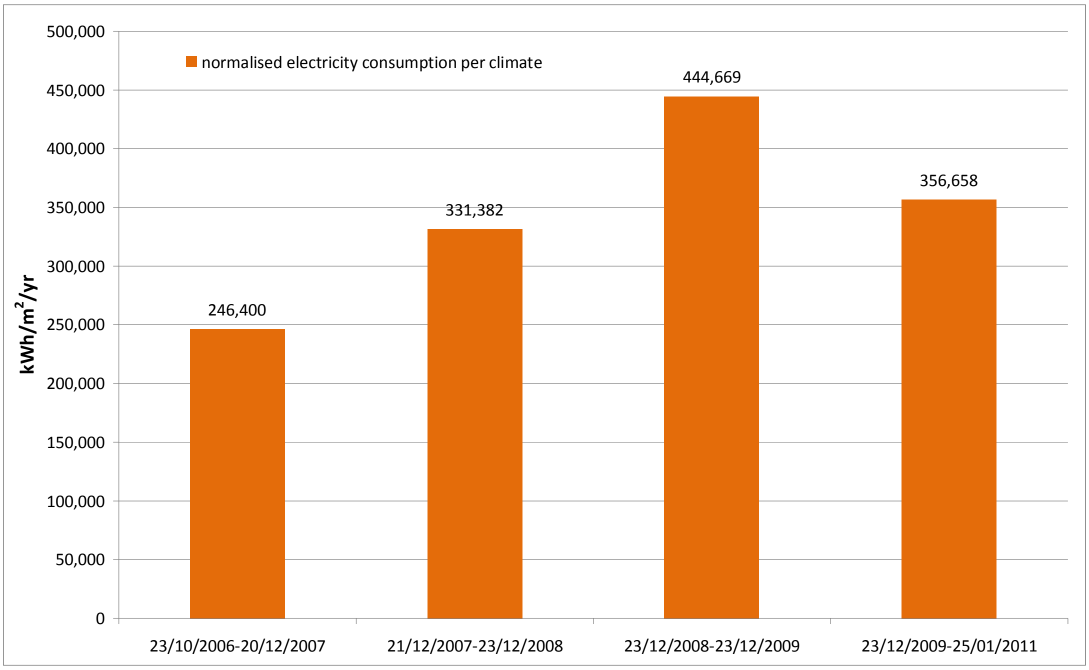
Cooling degree days (base temp 18^{o}C)					
	2006	**2007**	**2008**	**2009**	**2010**
January	0	0	0	0	0
Febr	0	0	0	0	0
March	0	0	0	0	0
April	1	4	9	3	6
May	89	93	72	135	72
June	237	284	337	263	236
July	435	466	444	426	406
August	433	445	503	479	463
Sept	0	170	220	262	224
Oct	73	78	57	52	51
Nov	0	3	12	4	20
Dec	0	0	0	0	11
Total	1268	1543	1654	1624	1489

Table 30 Weather normalization factors for the years 2008, 2009 & 2010

Reference year 2007	**2007**	**2008**	**2009**	**2010**
HDD	1	1.05	1.05	1.16
CDD	1	0.93	0.95	1.04

6.4.1.2. Electricity consumption normalized per climate

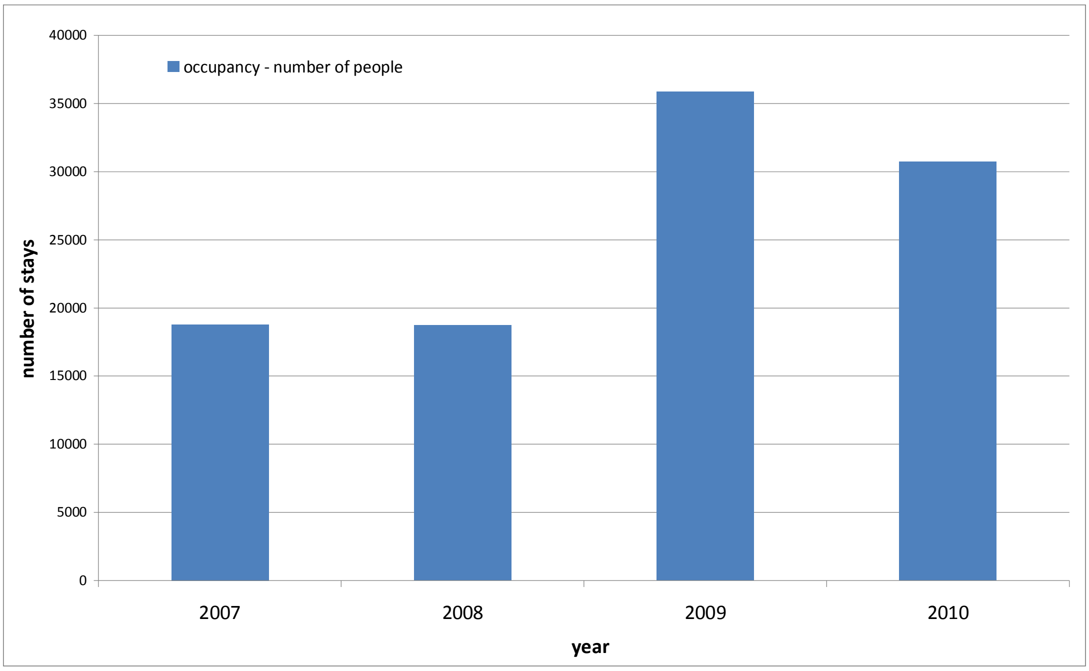
Graph 6 shows the electricity consumption taking into account the weather normalization.



Graph 6 Normalised electricity consumption (kWh) (weather normalization) for the period 23/10/2006-25/01/2011

6.4.2. Occupancy normalization

According to the information provided by the hotel owner, the occupancy of the hotel for the years 2007, 2008, 2009 and 2010 is shown in Graph 7.



Graph 7 Occupancy pattern for the years 2007-2010

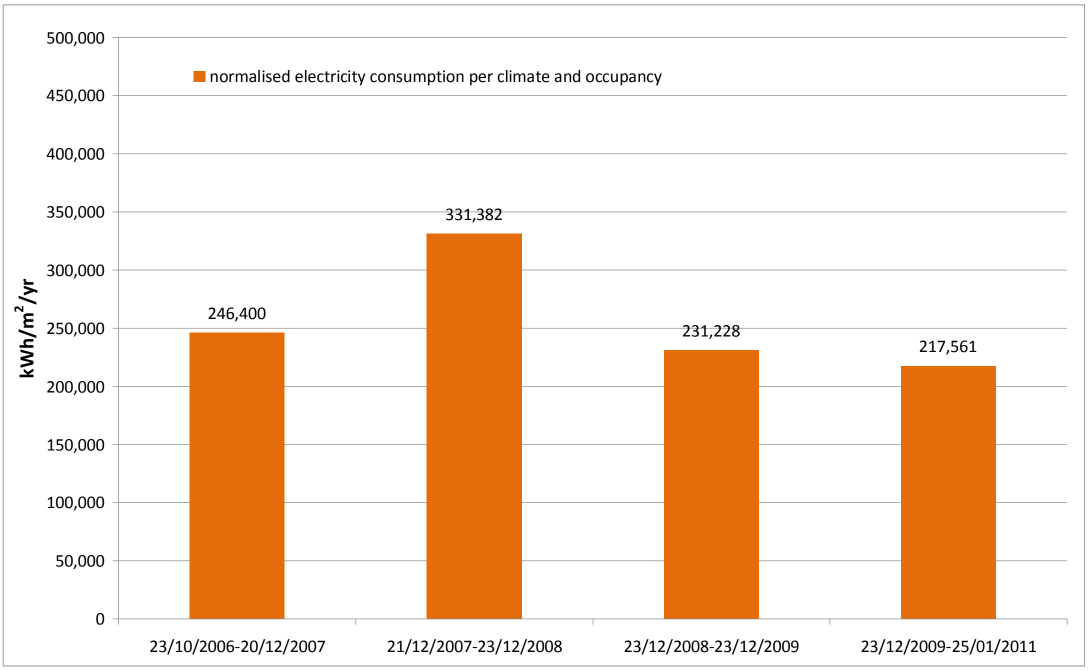
The occupancy normalisation factor for the years 2008, 2009 and 2010 is shown in Table 31.

Table 31 Occupancy normalization factors for the years 2008, 2009 & 2010

	2007	**2008**	**2009**	**2010**
Number of stays	18800	18721	35884	30710
Normalisation factor (reference year 2007)	1	1	0.52	0.61

6.4.3. Normalised energy consumption (weather and occupancy)

Graph 8 shows the annual electricity consumption after taking into account the weather and occupancy normalization.



Graph 8 Normalised electricity consumption (kWh) (weather & occupancy normalization) for the period 23/10/2006-25/01/2011

Compared to the year 2007 the annual electricity consumption is increased in the year 2008 and decreased in the years 2009 & 2010.

6.5. Breakdown of the electricity consumption for the year 2007

The electrical energy consumption for the period April 2007– October 2007 is shown in Table 32.

Table 32 Electricity consumption for the period April 2007 to October 2007

Electricity consumption (kWh) according to the bills	
26/03/2007 - 25/04/2007	22160
25/04/2007 - 25/05/2007	17760
25/05/2007 - 25/06/2007	27840
25/06/2007 - 24/07/2007	38960
24/07/2007 - 23/08/2007	47520
23/08/2007 - 21/09/2007	33600
21/09/2007 - 23/10/2007	14400
Total	**202240**

According to the record of the luminaires the electricity consumption for lighting is calculated as shown in Table 33.

Table 33 Electricity consumption for lighting

Electricity consumption for lighting	kWh	Assumptions
Rooms	68220 – 90960	2 lamps out of 5 switch on for 3 or 4 hours / day
Common areas	16600	
External lighting	2140	Switch on 10 hours / day
Total	**86960 – 109700**	

According to the record of the electrical appliances in the different areas of the hotel, the electricity consumption is shown in Table 34.

Table 34 Electricity consumption for electrical appliances

Electricity consumption for electrical appliances	kWh	Assumptions
Electrical appliances of rooms	6220	TV
Electrical appliances	4260	(refrigerator, cafeteria, dish washing machine, computers, vacuum, etc)
Total	**10480**	

From Table 33 & Table 34 the electricity consumption for cooling is calculated between 82050 kWh and 104790 kWh. The electricity consumption for lighting, electrical appliances and cooling is shown in Table 35 and in Figure 38.

Table 35 Breakdown of the electricity consumption for the period April 2007 - October 2007

Electricity consumption for year 2007	**kWh**
Lighting	**86960 – 109700 (average 98330)**
Electrical appliances	10480
Air –conditioning (cooling)	82050 – 104790 (**average 93420**)
Total	**202240**

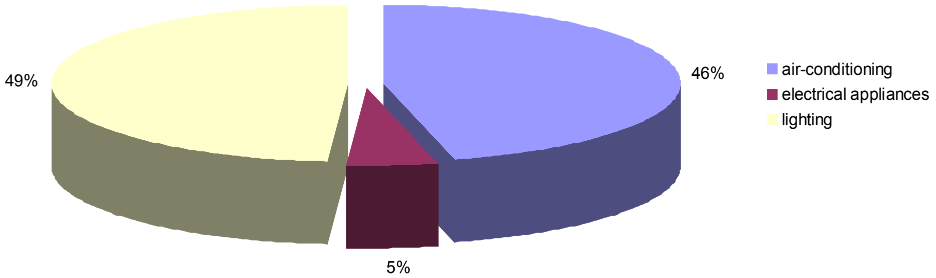


Figure 38 Breakdown of electricity consumption (April 2007 – October 2007).

6.6. Electricity consumption for year 2008 after the renovation

The electrical energy consumption for the period April 2008 – October 2008 (after the renovation) is shown inTable 36.

Table 36 Electricity consumption for the period April 2008 to October 2008

Electricity consumption (kWh) according to the bills	
23/03/2008 - 21/04/2008	12480
21/04/2008 - 25/05/2008	32880
25/05/2008 - 25/06/2008	33920
25/06/2008 - 25/07/2008	55840
25/07/2008 - 25/08/2008	72800
25/08/2008 - 21/09/2008	38640
21/09/2008 - 21/10/2008	25120
Total	**271680**

The normalized electrical energy consumption for the years 2007 and 2008 is shown in Table 37.

Table 37 Electricity consumption for the years 2007 and 2008

	Year 2007 26/03/2007 - 23/10/2007	**Year 2008** 23/03/2008 - 21/10/2008
Consumption (kWh)	202240	271680
Consumption (kWh) after weather and occupancy normalization **(reference year 2007)**	**202240**	**255380**

As shown from Table 37, despite of the partial upgrade of the building envelope and the new lighting installation, there is an increase of the electricity consumption. This is attributed to the installation and operation of the HVAC system in the common areas (lounge-bar, reception – entrance, restaurant area and meeting room). Additionally, the BMS was not installed properly and it was not feasible to control the energy consumption. Taking into account the weather & occupancy normalization, the increase of the electricity consumption (cooling) is calculated to be 255380kWh – 202240kWh = **53140 kWh , or 26%.**

6.7. Electricity consumption for year 2009

The electrical energy consumption for the period April 2009 – October 2009 (after the renovation) is shown in Table 38.

Table 38 Electricity consumption for the period April 2009 to October 2009

Electricity consumption (kWh) according to the bills	
27/04/2009 - 27/05/2009	42960
27/05/2009 - 26/06/2009	55520
26/06/2009 - 26/07/2009	62960
26/07/2009 - 25/08/2009	73600
25/08/2009 - 22/09/2009	52480
22/09/2009 - 22/10/2009	31920
Total	**319440**

Taking into account the weather & occupancy normalization, compared to year 2007 (before the energy retrofitting) the electricity consumption for the year 2009 becomes 157800 kWh,(Table 39), therefore is reduced by 14%. According to the hoteliers, the reduction of the electricity consumption is attributed mainly to the rare operation of the HVAC system in the common areas.

Table 39 Electricity consumption for the years 2007 and 2009

	Year 2007 25/04/2007 - 23/10/2007	**Year 2009** 27/04/2009 - 22/10/2009
Consumption (kWh)	**180080**	319440
Consumption (kWh) after weather and occupancy normalization **(reference year 2007)**	**180080**	**157800**

Table 40 shows the variation of the electricity consumption for the years 2007, 2008 and 2009. The normalization is realized to the year 2007.

Table 40 Electricity consumption for the years 2007, 2008, 2009

	Year 2007 26/03/2007 - 23/10/2007	**Year 2008** 23/03/2008 - 21/10/2008	**Variation (%) compared to 2007**	**Year 2007** 25/04/2007 - 23/10/2007	**Year 2009** 27/04/2009 - 22/10/2009	**Variation (%) compared to 2007**
Consumption (kWh)	202240	271680		180080	319440	
Consumption (kWh) after weather and occupancy normalization **(reference year 2007)**	202240	255380	**+26%**	180080	157800	**-14%**

6.8. Simulations of the demonstration hotel

This section presents the simulation activities that were carried out in order to assess the energy performance of the hotel 'Long Beach'.

6.8.1. Methodology

The energy behavior of the hotel was simulated using the TRNSYS software. TRNSYS is a dynamic simulation software with a modular structure, used to simulate the behavior of transient systems (http://www.trnsys.com/ 2011). TRNSYS is composed of two parts: a system description language (an 'engine' called the kernel) that reads and processes the input file iteratively solves the system, determines convergence, and plots system variables. The kernel also provides utilities that (among other things) determine thermophysical properties, invert matrices, perform linear regressions, and interpolate external data files. The second part is an extensive library of components. The modular nature gives the programme the flexibility to facilitate the addition of mathematical models not included in the standard TRNSYS library. TRNSYS simulates the energy consumption of multi-zone buildings, taking into account the exact geometry of the building, its orientation, the building materials, the building systems, and the schedule of operation. Heating and cooling loads as well as indoor temperatures are some of the outputs of the simulations. The simulations are carried out on an hourly step.

For the purposes of this study the model is built in the TRNBuild – The Building visual interface (formely known as Prebid), where all the building structure details are specified (building elements, orientation) as well as everything that is needed to simulate the thermal behavior of the building, such as cooling, heating , ventilation schedules and internal gains. Then the simulations are carried out using the TRNSED application.

6.8.2. Climatic file

Climatological data is used for the region of Patras (latitude 38.15, 21.44 E). The reference year is extracted from the software Meteonorm v. 5.1 (www.meteornorm.com). METEONORM is a climatological database providing developers, designers and users of engineering design programs to access to a comprehensive uniform data basis. There are 7 different site types to choose from: cities, weather stations, design reference years (DRY's), user-defined sites, sites with imported monthly values (User (month)), sites with imported hourly values (User (hour)) and WMO/OMM stations, (METEOTEST, 2010).

For weather stations, monthly average values are stored. If hourly values are required, these are generated accordingly. For cities, the monthly average values (10-year average) are interpolated and then the hourly values generated. For other sites, the monthly values are likewise interpolated and hourly values generated. For the purposes of this research, climatic data for the city of Patra is available and extracted in hourly values.

The monthly characteristics of the climatic file of Patra are shown in Table 41

Table 41 Climatic data for the area of Patras according to METEONORM

	Solar radiation on the horizontal plane					Wind
	Global (kWh/m^2)	Hours of sunshine	Hours of sunshine /day	Air temperature (°C)	Relative humidity (%)	Speed (m/s)
Jan	55	143	4.6	9.9	68	2.9
Febr	67	141	5	10.5	66	2.9
March	107	186	6	12.6	64	3
April	152	215	7.2	15.8	65	3.1
May	194	288	9.3	20.3	63	2.6
June	211	250	8.3	24.1	61	2.7
July	216	359	11.6	26.4	59	2.6
Aug	190	339	10.9	26.6	58	2.6
Sept	146	271	9	23.7	62	2.6
Oct	93	207	6.7	18.9	66	2.5
Nov	57	152	5.1	14.5	70	2.6
Dec	44	131	4.2	11.4	70	2.8

6.8.2.1. Normalisation of the climatic file

The climatic file was normalized in order to make comparison with the real climatic data of the years 2007 – 2008.

The normalization was carried out using the degree day method based on the following equations:

$$D_d = \frac{\sum_{j=1}^{24} \left(\theta_b - \theta_{o,j}\right)_{\left(\left(\theta_b - \theta_{o,j}\right) > 0\right)}}{24}$$

eq. 4

$$D_d = \frac{\sum_{j=1}^{24} \left(\theta_{o,j} - \theta_b\right)_{\left(\left(\theta_{o,j} - \theta_b\right) > 0\right)}}{24}$$

eq. 5

Where:

Dd = the daily degree-days for one day

θ_b = the base temperature (in that case θ_b =18 ^oC)

$\theta_{o,j}$= the outdoor temperature in hour j

The subscript note denotes that only positive values are taken, (CIBSE TM 41, 2006).

The characteristics of the year 2007 and the reference year are shown in Table 42.

Table 42 Climatic characteristics of the reference year (METEONORM) and year 2007

	Min temp (^oC)	**Max temp (^oC)**	**Aver temp (^oC)**	**Heating Degree Days (base 18 ^oC)**	**Cooling Degree Days (base 18 ^oC)**
Year 2007 (www.wunderground.com)	**-3**	**42**	**17**	**2114**	**1543**
Reference year (METEONORM)	**-0.2**	**36.5**	**17.8**	**1121**	**1056**

6.8.3. Assumptions for the ‘reference’ building

6.8.3.1. Building elements

The building construction dates back to 1970’s and is not insulated. The main construction is from brickwork. For the purposes of the thermal simulations the U-values of the building elements comply with the typical values for constructions before 1979 as these are defined in the national legislation TOTEE 20701-1/2010, (Table 43).

Table 43 U-values of the building elements considered in the simulations

Building element	**U-value (W/m^2K) (typical values for constructions before 1979 TOTEE 20701-1/2010 ppg 46/47)**	**Required U-value (TOTEE 20701-1/2010) for climatic zone B (ppg 43 table 3.3a)**
External wall: Plaster – brick – plaster, with plaster externally & internally	2.20	0.50
External wall-concrete frame, with plaster externally & internally	3.40	0.50
Roof: Plaster - concrete – plaste	3.05	0.45
Floor (concrete slab) to external air	2.75	0.45
Ground floor : concrete slab	3.10	0.90
Windows (glazing & frame)		
Common areas: single with aluminum frame	Ugl:5.68 Ufr: 7.00	3.00
Corridors to the rooms (facing south): double with aluminum frame	Ugl: 2.95 Ufr: 7.00	3.00
Bedrooms: single with wooden frame	Ugl:5.68 Ufr: 2.20	3.00

6.8.3.2. *Infiltration*

The infiltration is calculated for each thermal zone based on default values for infiltration defined in the Technical Guideline (TOTEE 20701-1/2010), (Table 44).

Table 44 Infiltration values according to the national legislation

Opening	**Infiltration** (TOTEE 20701-1, table 3.26, ppg 79)
	Opening ($m^3/h/m^2$)
Wooden frame	
Single glazing, not air-tight (sliding opening)	15.1
Double glazing, with certification (sliding opening) Double glazing , not certified (folding opening)	12.5
Double glazing , air-tight and certified	10.0
Aluminum or plastic frame	
Single glazing, not air-tight (sliding opening)	8.7
Double glazing, with certification (sliding opening) Double glazing , not certified (folding opening)	6.8
Double glazing , air-tight and certified	6.2

The average infiltration for the whole building is calculated to 0.40 ach (see analytical calculations in Appendix 9).

6.8.3.3. *Shading*

The floor slabs provide shading to the southeast (Figure 39) and northwest windows (Figure 40). The section in Figure 41 shows the angle between the window and the shading element (floor slab).

Figure 40 Northwest elevation (rooms)

Figure 39 Southeast elevation (corridors to the rooms)

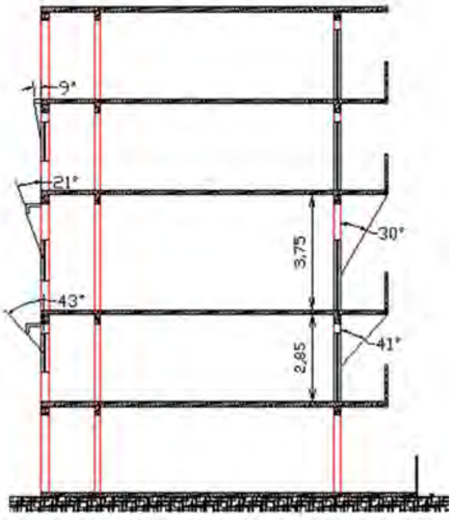


Figure 41 Section showing the angles of the shading elements and the windows

According to the angles between the window and the shading element, the shading factors are given in table 3.19 pp71 (Technical Chamber of Greece, 20701-1/ 2010) and are the following:

Shading factor for windows (southeast) of 1st and 2nd floor (cooling period) : 0.43

Shading factor for windows (southeast) of 3rd and 4nd floor (cooling period) : 0.14

Shading factor for windows (northwest) of rooms with 2.85m height (cooling period): 0.28

Shading factor for windows (northwest) of rooms with 3.75m height (cooling period): 0.2

6.8.3.4. Internal gains

The hotel is assumed to be fully occupied according to its capacity.

Number of people

Rooms: 2 people / room (capacity of rooms)

Office areas: 1 people / 10m^2 (TOTEE, 20701-1/2010 pg 26)

Common areas of hotels: 30 people / 100 m^2 (dining room: 94 people, lounge: 56 people, meeting room: 30 people (TOTEE, 20701-1/2010 pg 26)

Entrance – reception: 5 people, circulation areas: 5 people

Schedule occupancy pattern

Different schedule patterns are assigned to the areas according to their use:

Rooms: 24.00- 9.00 (100%), 15:00-18:00 (100%) and 22.00 -24.00 (50%),

Common areas (lounge): 8.00-11.00 (30%), 11.00-13.00 (40%), 13.00-15.00 (60%), 15.00-18.00 (20%) and 18.00-24.00 (80%)

Restaurant area: 8.00-10.00, 13.00-15.00 and 20.00-23.00

Office areas: 8.00-17.00 (100%)

Mezzanine meeting room: 10.00-12.00 (weekdays)

Lighting

Lighting is assumed to be 19 W/m^2 in the common areas (dining room, bar-lounge, kitchen and reception area) and 17 W/m^2 in the rooms, circulation areas and office areas.

Design Temperature

Heating period: 20^{o}C

Cooling period: 26 ^{o}C

It is noted that cooling operates only in the rooms and the office areas.

Schedule for systems (Table 45).

Table 45 Schedule for heating, cooling and lighting

	Heating	Cooling	Lighting
Rooms	00:00-24:00	22:00-9.00 & 15:00-18:00	13:00 – 18:00, 22:00-24:00
Restaurant area	8.00-10.00, 13.00-15.00 & 20.00-23.00	-	13.00-15.00, 20.00-23.00
Common areas	08.00-24.00	-	12:00-24:00
Office areas	8.00-17.00	08:00-17:00	13:00-17:00

6.8.3.5. Ventilation

Ventilation is defined according to the national building regulations TOTEE 20701-1, (page 26, table 2.3). The airflow rates are:

Common areas: 9 m^3/h/m^2

Room : 1.2 m^3/h/m^2

Office areas: 3 m^3/h/m^2

6.8.3.6. Thermal zones

The building is split in 30 thermal zones (as shown in Table 46 and Appendix 4) for the purposes of the thermal simulations.

Table 46 Thermal zones assumed for the purposes of the simulations

a/a	Floor		Area (m^2)	Heated/cooled
1	ground floor	Dining room	314	Heated
2	ground floor	Lounge	189	Heated
3	ground floor	Kitchen	224	Heated
4	ground floor	Entrance-reception	185	Heated
5	ground floor	Circulation area	78	Heated
6	ground floor	Corridors to the rooms	77	Heated
7	ground floor	Rooms	250	Heated/Cooled
8	ground floor	Office	27	Heated/Cooled
9	ground floor	Office & storage	76	Heated
10	ground floor	WC	33	Heated
11	ground floor	Storage (external area)	107	-
12	a’ floor	Meeting room	109	Heated
13	a’ floor	Lobby of meeting room	90	Heated
14	a’ floor	Office	47	Heated/Cooled
15	a’ floor	Rooms (height 3.75m)	112	Heated/Cooled
16	a’ floor	Rooms (height 2.85m)	138	Heated/Cooled
17	a’ floor	Office & storage	71	Heated
18	a’ floor	Corridors to the rooms	120	Heated
19	b’ floor	Rooms (height 2.85m)	523	Heated/Cooled
20	b’ floor	Rooms (height 3.75m)	138	Heated/Cooled
21	b’ floor	Corridors to the rooms	210	Heated
22	b’ floor	Office & storage	102	Heated
23	c’ floor	Rooms	638	Heated/Cooled
24	c’ floor	Room (study case)	23	Heated/Cooled
25	c’ floor	Corridors to the rooms	210	Heated
26	c’ floor	Office & storage	102	Heated
27	d’ floor	Rooms	638	Heated/Cooled
28	d’ floor	Room (study case)	23	Heated/Cooled
29	d’ floor	Corridors to the rooms	210	Heated
30	Floors	Lift	4	-

Taken into account the described data thermal simulation was performed.

6.8.4. Simulation results for the reference building - year 2007

The simulation results for the electricity consumption for year 2007 are shown in Table 47. According to TOTEE 20710-1/2010 (pg 94) the Energy Efficiency Ratio (EER) of local heat pumps (air – conditioning units) is defined to:

- of 10 years old : EER=2
- of 20 years old : EER=1.5

In the case of the Long Beach hotel, the split units were installed in 2000 and the factor EER is assumed to be 2.

Then the weather normalization is taken into account (Table 47) between the reference year (METEONORM) and the year 2007. (normalization factor = 1.5, according to Table 42).

Table 47 Electricity consumption for the year 2007 according to the simulation results

	Electricity consumption – Simulation results		
Reference case (year 2007)	Cooling load (TRNSYS output) kWh	Consumption (kWh) (divide with EER=2)	Consumption (kWh) after weather normalization (multiply x 1.5) To year **2007**
Cooling (setpoint 26^{O}C)	104700	52350	**78525**
Cooling (setpoint 25.5^{O}C)	116700	58350	**87525**

The energy breakdown of the electricity consumption (Table 35) shows that the consumption for cooling is estimated between **82050-104790** kWh (average 93420 kWh).

6.8.5. Simulation results for year 2008

The hotel went under renovation during the year 2008. For the simulations for year 2008, the following interventions are taken into consideration:

Double low e glazing with thermal break is applied in all the common areas with northern orientation: restaurant area and lounge.

Ugl: 1.7 and Ufr: 3.5 W/m^{2}K (TOTEE, 20710-1/2010 pg 61, table 3.10)

Infiltration: 0.38 ach

Cooling: Cooling is applied in the common areas: restaurant area, kitchen area, reception, lounge and meeting area, (EER=3).

Design Temperature: Cooling period: 26 ^{o}C

Schedule

Restaurant area & kitchen: 8.00-10.00, 13.00-15.00 and 20.00-23.00

Common areas (reception, lounge): 08.00-20.00

Meeting room: 10.00-12.00 (weekdays)

Ventilation: Total supply of fresh air in the common areas: 13.000m^3/h

Lighting is redesigned for the common areas and offices of ground and first floor (restaurant area, lounge, entrance, reception, meeting room and lobby of meeting room). According Table 26 the lighting capacity is calculated to:

Office areas: 5 W/m^2

Restaurant area: 12 W/m^2

Meeting room: 12 W/m^2

Lounge-bar-reception area: 19 W/m^2

The simulation results for the years 2008 & 2009 are shown inTable 48.

Table 48 Simulation results (cooling loads and normalized electricity) for the years 2008 & 2009 when the cooling set point in the rooms is set to 26^{o}C

Electricity consumption (setpoint 26^{o}C in the rooms)				
After renovation	**Cooling loads** (TRNSYS output) kWh	Electricity consumption for cooling (kWh) (reference year)	Electricity consumption (kWh) Weather normalization	Electricity consumption (kWh) Weather & occupancy normalization To year **2007**
With cooling in common areas (year 2008) **(setpoint 26^{o}C)**	171100	(rooms) 106000/EER=2 + (common areas) 65100/EER=3 = 74700	To year **2008** 117000	**108812**
Without cooling in common areas (year 2009) **(setpoint 26^{o}C)**	106000	(divide with EER=2) 53000	To year **2009** 81508	**40265**

The variation of the electricity consumption, based on the simulation results between the reference case (year 2007) and the years 2008 and 2009, is shown in Table 49, Table 50 and Table 51.

Table 49 Variation of the normalized electricity consumption according to the simulation results when the cooling setpoint in the rooms is set to 26°C

Year	**Normalised electricity consumption (kWh) (simulation results)**	**Variation (%) From year 2007**	
2007 **(setpoint 26°C)**	**78525**	Simulation results	Real data
2008	108812	+38.5%	+26%
2009	40265	-48%	-14%

Table 50 Simulation results (cooling loads and normalized electricity) for the years 2008 & 2009 when the cooling setpoint in the rooms is set to 25.5°C

Electricity consumption (setpoint 25.5°C in the rooms)				
After renovation	**Cooling loads** (TRNSYS output) kWh	Electricity consumption for cooling (kWh) (reference year)	Electricity consumption (kWh) Weather normalization	Electricity consumption (kWh) Weather & occupancy normalization to year **2007**
With cooling in common areas (year 2008) **(setpoint 25.5°C)**	182300	117900/EER=2 + 64400/EER=3 = 80417	To year **2008** 125956	**117139**
Without cooling in common areas (year 2009) **(setpoint 25.5°C)**	117900	(divide with EER=2) 58950	To year **2009** 90658	**44785**

Table 51 Variation of the normalized electricity consumption according to the simulation results when the cooling setpoint in the rooms is set to 25.5°C

Year	**Normalised electricity consumption (kWh) (simulation results)**	**Variation (%) From year 2007**	
2007 **(setpoint 25.5°C)**	**87525**	Simulation results	Real data
2008	117139	+33.8%	+26%
2009	44785	-48%	-14%

6.9. Discussion – correlation of simulation results with real data

Reference case – year 2007

The simulation results for the reference case (energy profile of the hotel for the year 2007) have a small variation from the real situation. The energy breakdown of the electricity consumption showed that the electricity consumption for cooling would vary between **82050-104790 kWh** with an average value around 93420 kWh.

When applying in the model the initial assumptions as described in section 3, with no any calibration, the deviation of the simulation result is 15% from the estimated average consumption and 4% of the lowest value (82050 kWh).

When reducing the setpoint of cooling by 0.5°C, then the simulation results decline by the real average consumption by 6%.

Year 2008 –year 2007

After the installation of the HVAC system a significant increase of the electricity consumption is noted. This is attributed to the operation of the HVAC system and the mal-installation and malfunction of the BMS system that did not give any information on the energy consumption of the hotel. According to the electricity bills the electricity consumption increased by 26% compared to the year 2007. According to the simulation results the increase of the electricity consumption is 38%.

Year 2009 –year 2007

According to the electricity bills the electricity consumption decreased in year 2008 by 14% compared to the year 2007.

When withdrawing the operation of the cooling in the common areas the simulation results show a reduction in the cooling loads by 48%.

The above variations can be explained as follows:

- The HVAC system operated in the periods 2008 & 2009 in some exceptions and extreme climate phenomena (i.e. heatwaves, manifestations, weddings). However it was not feasible to simulate the period of its operation since the hoteliers did not keep any record.

- Concerning the double low e glazing that is installed in the northern areas of the hotel; there is available information only for the u-value of the product. There is no data available for other characteristics of the glazing like the g-value and the shading factor. However, the simulation results show that the impact of the use of the double low e glazing on the electricity consumption is offset by other parameters like the operation of the HVAC system and the internal gains. Additionally, the small impact of the double low e glazing on the electricity consumption could be explained by the restricted glazing area (178m^2 out of 660m^2) and its northern orientation.
- As expected the adjustment of the setpoint has a significant impact on the cooling loads of the hotel. A reduction of the setpoint by 0.5^{o}C results in an increase of the cooling loads by 11.5% and an increase of the normalized consumption by 10% (for the year 2007).
- Although the use of double low e glazing, the small reduction of internal gains due to the redesign of the lighting installation and the withdrawal of the cooling operation, it is noted a small increase of the cooling loads in the year 2009. This can be attributed to the increase of the ventilation loads by 2.3% after the renovation. However, the normalized energy consumption of the year 2009 is reduced compared to the year 2007 (Table 49, Table 51) and this is mainly because of the increased occupancy.

This chapter presented the case study hotel and thermal simulation results. Some calibration was carried out according to weather and occupancy/heat gain patterns and an acceptable calibrated model was created. This model is used for the next analysis of this thesis. Before continuing with further simulation results, the next chapter presents a brief introduction on the climate change, its impact on the building sector and in particular on the demonstration hotel.

CHAPTER 7

Impact of Climate Change on the Demonstration Hotel and Generation of Future Files for the Area of Patra

7 Impact of Climate Change on the Demonstration Hotel and Generation of Future Files for the Area of Patra

7.1. Introduction

This chapter focuses on the future climate change and what impact this may have on the building sector. It is divided in two sections. The first section gives a brief overview of the future climate change and presents its impact on environmental aspects. More specifically the chapter focuses on the impact of the climate change on the energy consumption of buildings and the thermal comfort of their users. Furthermore, the Impact of the climate change on the demonstration hotel is assessed via hourly simulations using real monitored data for the period 1970 – 2010.

The second section presents the future weather files created that will be used in the simulations. The future files are generated using the CCWorldWeather Generator tool developed by Southampton University. The procedure followed is based on the 'morphing method' as developed by (Belcher et al., 2005).

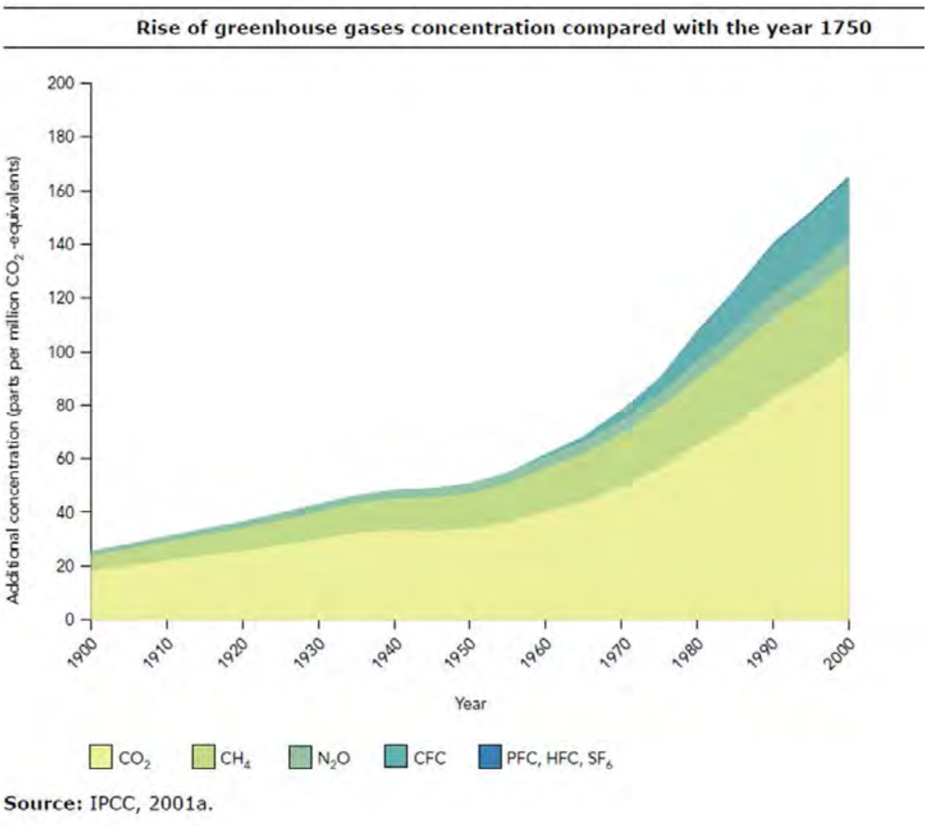
7.2. Future Climate Change

The future climate change is defined by an increase in the Greenhouse Gas emissions (GHG) and in turn in the global mean temperatures (IPCC, 2011; European Environment Agency, 2004) as a result of the human activities like the burning of fossil fuel and the land-use changes (mainly deforestation). The main greenhouse gas attributable to human activities is carbon dioxide (CO_2) derived from burning fossil fuels (coal, oil, gas). The CO_2 concentration in the atmosphere increased by 34% compared to the pre-industrial period and the main rise was noted since 1950. The pre-industrial concentration of 280 ppm increased to 375 ppm in 2003. Additionally, the global average temperature increased by 0.7^{o}C and the European average temperature increased by 0.95^{o}C. (Th.Frank, 2005; European Environment Agency, 2004). This climate change has considerable effects on human society and the environment. The evaluation of the climate change is uncertain since the climate process is not totally predictable and the socio-economic development is a complex procedure. However, using projections of greenhouse gas emissions in the future, several scenarios have been modelled combining possible future CO_2 concentration and social-economic development in order to predict possible increase of mean temperature. The main aim of these scenarios is to achieve stabilization of the GHG concentration in the future (CO_2 at a level that would not be dangerous for the human being). The main policy towards this aim is described in the Kyoto Protocol (entered into force on February 2005 (Wikipedia, the free encyclopedia, 2011) that sets upper limits for six GHG (CO_2, CH4,N_2O, and three groups of fluorinated gases) (European Environment Agency, 2004). Concerning the CO_2 emissions, the Article 3 of the Kyoto Protokol defines a reduction by at least 5% below 1990 levels in the commitment period 2008-2012.The EU has defined an indicative long-term global temperature target of not more 2^{o}C above pre-industrial levels while the CO_2 concentration would range at a level of 550 ppm. The German Advisory Council suggests the same global temperature target but a CO_2 concentration target of 450 ppm. (European Environment Agency, 2004; Met Office Hadley Centre, 2004; Met Office Hadley Centre, 2008).This in turn implies that global emissions of CO_2 will need to be reduced by 50-85% below 2000 levels by 2050, (IPCC, 2011).

7.2.1. Environmental consequences

The increase of the Greenhouse gases in the atmosphere is significant. Compared to the pre-industrial period (1750), the carbon dioxide (CO_2) concentration has been increased by 34%, methane (CH_4) by 153% and nitrous oxide (N_2O) by 17%. If expressing each greenhouse gas as a CO_2 –equivalent (Figure 42), then the total concentration of GHG has increased by 170 ppm CO_2 –equivalents since the pre-industrial period (CO_2 by 61%, CH_4 by 19% N_2O by 6% and from the halocarbons CFCs and HCFCs by 13% Concentrations of CO_2 and N_2O increase at rates similar to those of the past decades whereas concentrations of fluorinated greenhouse gases (PFCs, HFCs, &SF6) increase rapidly mainly because they are substitutes for ozone depleting gases, (European Environment Agency, 2004).

As already mentioned, because of the increase of the GHG there is an increase of the global mean temperature by 0.7^{o}C over the past 100 years. The warmest year was 1998 followed by 2002 and 2003 (European Environment Agency, 2004; Th.Frank, 2005). The increase of the European mean temperature was higher with a 0.95 ^{o}C increase since 1900. The projected temperature increase between 1990 and 2100 is likely to range between 1.4-5.8^{o}C for the global mean and 2-6.3^{o}C for Europe.


Rise of greenhouse gases concentration compared with the year 1750

Source: IPCC, 2001a.

Figure 42 Rise of GHG concentration for the period 1750 – 1990 (European Environment Agency, 2004)

The increase of the European temperature will be higher in the parts of Southern Europe (Spain, Italy and Greece) and northeast, i.e. western Russia. This temperature increase will result in droughts, more frequent forest fires, increasing heat stress and risks for human health.

Additionally precipitation changes are expected. This will have an impact on ecosystems and biodiversity, agriculture (food production and yields) water resources and flooding. In winter, Europe, apart from the Balkans and Turkey, is likely to become wetter. In summer northern Europe might become wetter by 2%, whereas Southern Europe may become drier up to 5%.Other environmental consequences of climate change include the retreat of glaciers and frozen mountain areas, less snowfall in lower mountain areas, rise of sea level, increase of the global sea surface temperature, changes in the marine growing season, possible extinction of some species. On the other hand, the climate change and the increasing atmospheric CO_2 concentration is expected to enhance yields for most crops, in many parts of Europe, (plant photosynthesis is strongly related to CO_2 concentration). Many studies have been realized on the European agriculture and the impact of the future climate change on the production of several crops (wheat, soybean, maize). However, the benefit of the increasing CO_2 concentration to the boost of yields is offset by the temperature increase; each degree rise above 32^{o}C is expected to reduce yields of rice by 5%. Furthermore maize production is affected negatively by the E-Nino like conditions that most climate models predict, (Parry et al., 2004; Olesen et al., 2002; Ingram et al., 2008). However, the scenarios of enhanced yield and stimulated plant growth in the different areas of Europe are subject to the water resources and the scenarios of future precipitation as well as the socio-economic capability of the different countries to react to the climate change. It seems that parts of Southern Europe, like northern Spain, southern France, Italy and Greece are most influenced, (Olesen et al., 2002, European Environment Agency, 2004).

7.3. Emission scenarios and climatic files

7.3.1. Introduction

A major effort was made within the frames of the EU- financed projects ENSEMBLE (http://ensemblert3.dmi.dk) and the PRUDENCE (http://prudence.dmi.dk) to predict regional climatic scenarios and to create future projected climatic files (Giannakidis et al., 2011).

The ENSEMBLE project was an EU funded project (under the 6th Framework Programme), with duration from September 2004 – December 2009. The project was led by the UK Met Office. The partners of the project were mostly from European countries (66 institutes from 20 countries) but also partners across the world were involved. The ENSEMBLE project was based on the results of previous projects like PRUDENCE, STARDEX, MICE and DEMETER. The project informs policy makers (researchers, decision makers, businesses) on the climate and its future changes on a global and regional scale through the use of the latest climate modelling and tools.

The aim of the ENSEMBLES project is to enable to measure the uncertainties in the climate projections in order to predict the future climate. These uncertainties are summarized below:

- The size of resolution of global and regional Earth system models developed in Europe and validated across the gridded datasets on seasonal to centennial time-scales.

- The representation of physical, chemical, biological and human –related activities correlated with the water resources, the land use, the CO_2 concentration.
- The correlation of the outputs of the models with applications like agriculture, food chain, water resources, etc (Paul van der Linden and Mitchell, 2009).

The emissions scenarios are developed by the Intergovernmental Panel on Climate Change (IPCC). Four base scenarios have been developed, A1, A2, B1 and B2, with varying weight factors among economic growth, environmental protection, social development and globalization. For the A scenarios, the economic growth is the weighty parameter, whereas for the scenarios B the environmental protection has the primal role. Scenarios 1 assume more globalization whereas scenarios 2 more regionalization. The scenario A1 is split into 3 categories: **A1F**, **A1B** and **A1T** (Paul van der Linden and Mitchell, 2009)**.**

7.3.2. Emission scenarios for Greece

The climate in Greece is typical of the Mediterranean climate which is mild and rainy winters, relatively warm and dry summers with, generally, long sunshine duration almost all the year. A great variety of climate subtypes, always in the Mediterranean climate frame, are encountered in several regions of Greece, (EMY, 2011). The complex topography of Greece highly affects the regional climate of different regions. The mainland of Greece is divided into two distinct climatic zones by the chain of mountains that is oriented from south to north. Additionally the characteristics of climatic variables as wind velocity, temperature, rainfall and solar energy is diversified in the different regions, i.e. between the mainland and the Aegean Sea, (Giannakidis et al., 2011).

In order to study the emission scenarios, Greece was divided in 13 climatic areas based on its topography (mountain chain, islands), the differences between the continental and insular areas and the temperature differences across the country. Climatic indexes were calculated at 60 stations, as shown in Figure 43 (Giannakidis et al., 2011). The 13 climatic areas are the follows: 1. West Greece (WG), 2. Central and East Greece (CEG), 3. West and Central Macedonia (WCM), 4. East Macedonia – Thraki (EMT), 5. West Peloponnese (WP), 6. East Peloponnese, 7. Attiki (AT), 8. Crete (C), 9. Dodecanese (D), 10. Cyclades (CY). 11. East Aegean (EA), 12. North Aegean (NA) and 13. Ionian (I). For the above 13 areas, the climatic change was calculated of the mean annual values of six climatic parameters (mean air temperature (^{o}C), rainfall (mmm/year), relative humidity (%), cloud factor (%), global solar radiation on the ground (W/m^{2}) and air velocity at 10m height from the ground (m/s), for the reference period 1961-1990 and the periods 2021-2050 and 2071 – 2100.

The Research Centre Physics for Atmospheric Physics and Climatology of the Academy of Athens developed climate change simulation data based on the emission scenarios A2, A1B, B2 and B1. The main characteristics of the scenarios are the following (Committee for the Study of Climate Change Impact, 2011):

Scenario A1B: This scenario refers to a socially and culturally unified planet, where the financial growth is occurred rapidly. The energy consumption will be intense as well as the dissemination of energy efficient technologies. The variation of the land use will not be large. The world population will be increased rapidly; by the year 2050 it will reach 9 billion and then it will decrease gradually. Different energy sources will be used (renewable and fossil fuel). The CO_2 concentration will increase rapidly during the 21st century and in 2100 will be **720 ppm**.

Scenario A2: This scenario refers to a world split in independent nations whose population is growing rapidly. This scenario is characterized by moderate increase in the average per capita income and intense increase of the energy consumption. The technological development will be slow and the variations in the land use will be moderate to large. The CO_2 concentration will reach **850 ppm** in 2100.

Scenario B1: This scenario refers to a world with increased income per person and low energy consumption; accompanied with reduced use of fossil fuels and increased use of renewable energy sources. The CO_2 concentration will increase especially after 2050 and will reach 550ppm in 2100**.**

Scenario B2: This scenario refers to a planet that is split in independent nations; however the world environmental consciousness is very developed. Like scenario A2, the growth population will increase but with a lower rate. The decisions concerning the financial, social and environmental issues are made locally. The world financial growth will be moderate and the technological changes will not be as large as these of scenario A1 and B1. The CO_2 concentration will be **620 ppm** in 2100.

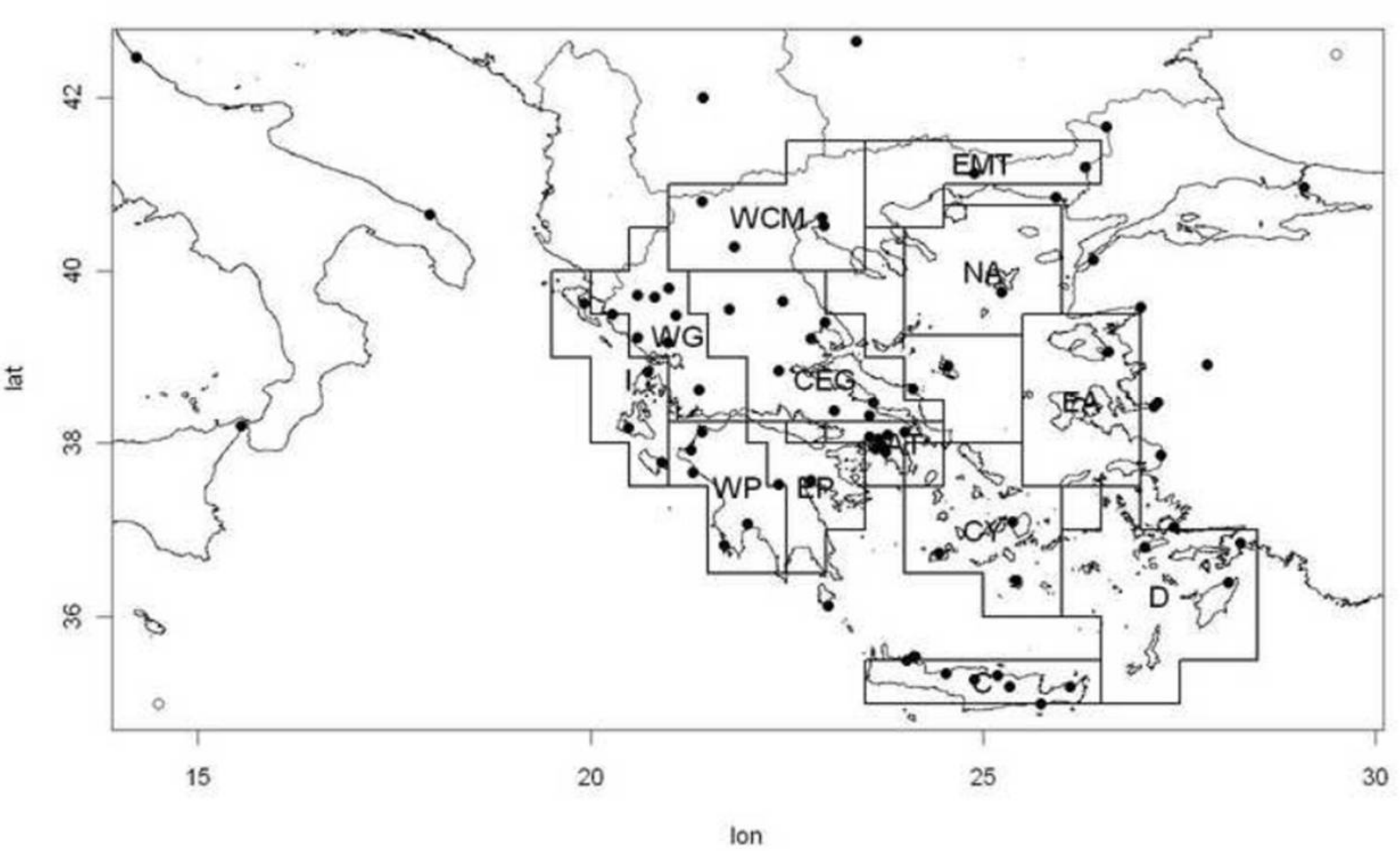


Figure 43 Map of Greece showing the 60 weather stations (Committee for the Study of Climate Change Impact, 2011)

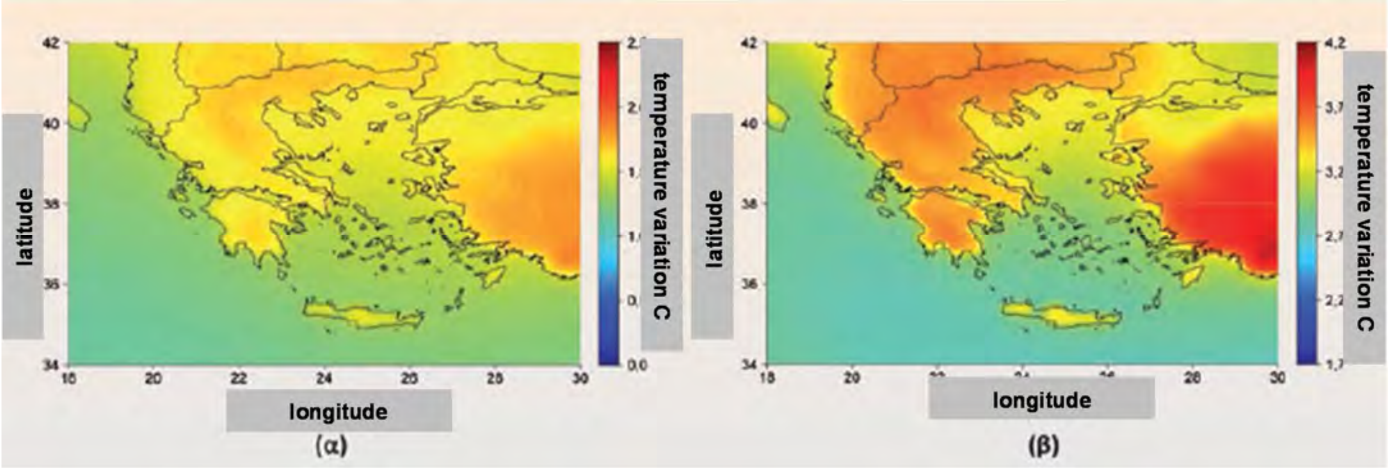


Figure 44 Variation of mean air temperature between the periods (a) 2021-2050 and 1961 – 1990 and (b) 2071 – 2100 and 1961 – 1990 for the scenario A1B (Committee for the Study of Climate Change Impact, 2011) (pg 77)

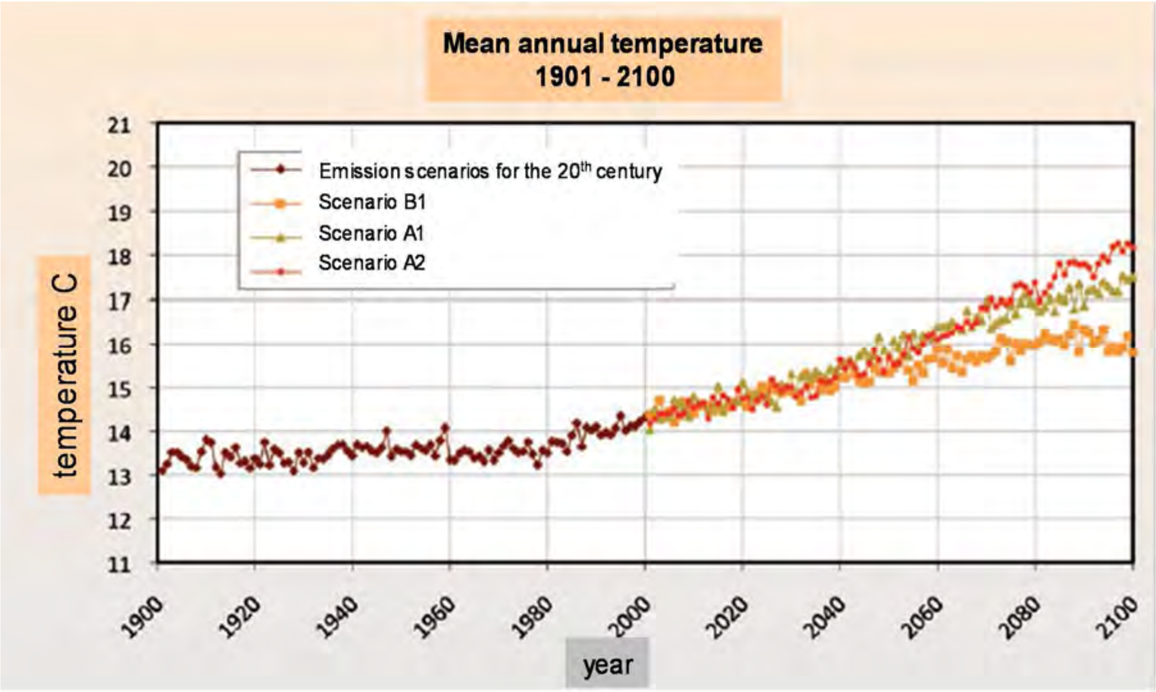


Figure 45 Increase of mean temperature for the different scenarios A1, B1, A2 for the period 1901 – 2100 for Greece (Committee for the Study of the Climate Change Impact, 2011) pg 77

Figure 44 shows the variation of the mean air temperature between the periods (a) 2021-2050 and 1961 – 1990 and (b) 2071 – 2100 and 1961 – 1990. It is shown that for the period 2021 – 2050 all areas of Greece are expected to have higher mean annual temperatures by 1.5°C. For the decade 2091-2100, the mean temperature for Greece is predicted to be higher than this of the reference period (1961-1990) by 3.5 ^{o}C.

Figure 45 shows that the increase of the air temperature for scenario B1 is milder compared to the other scenarios, A1 and A2. The maximum air increase occurs with scenario A2. For the period 2071-2100, the trend for the air temperature increase is 0.5 ^{o}C/decade for scenario A2, 0.4 ^{o}C/decade for scenario A1B, 0.25 ^{o}C/decade for scenario B2 and 0.1 ^{o}C/decade for scenario B1, (Committee for the Study of the Climate Change Impact, 2011).

7.4. Impact of the climate change on energy use and indoor comfort in the Mediterranean area and particular in Greece

The energy use in buildings is correlated to the external temperature. As this relation is non-linear, the method of the degree days is used to calculate the energy consumption of buildings according to the variations of the external temperature (Giannakopoulos et al., 2009; Committee for the Study of the Climate Change Impact, 2011; CIBSE TM41, 2006; Cartalis et al., 2001; Tselepidaki et al., 1994). The degree days show the daily variation of the mean temperature from a base temperature. The base temperature is used to represent a reference outdoor temperature; when the actual temperature exceeds this then cooling is required whereas when the actual temperature drops below this then heating is required. Thus, accumulation of a large number of degree days above the base temperature (Cooling degree days) indicates intense need for cooling whereas accumulation of a large number of degree days below the base temperature implies intense need for heating. The base temperature for heating and cooling may be different or the same, and varies in the literature. For example, in the case of Greece, the reference base values are 15.5°C and 18.0°C for HDD and CDD, respectively (Cartalis et al., 2001), for the specific calculation of the CDDs for the four summer months (June to September), base temperatures of 25 °C and 28 °C are used (Tselepidaki et al., 1994), temperature of 15 °C for the calculation of HDDs and 25 °C for the calculation of CDDs are used, (Giannakopoulos et al., 2009). According to the national guidelines (Technical Chamber of Greece, 20701-1/2010) of the EPBD legislation, the base temperature for HDD is 18°C and for CDD is 26°C.

The differences in the cumulative numbers of CDDs and HDDs between the reference and the future period show the changes in the energy demand of buildings.

In general, due to the climate change and the increase of the air temperature, more cooling will be required in the Mediterranean countries. The increase in cooling requirements will be larger over Southern Spain, the Eastern parts of Greece, Western Turkey and more so over Cyprus/North Africa, (Figure 46). The largest requirements of cooling will be required during the dry period in the summer. It is calculated that in the North Africa more than one additional month of heavy cooling will be required whereas over parts of Southern Spain and Italy, Eastern Greece, Western Turkey and Cyprus 15 more days of heavy cooling will be needed. Until now, the increase of the cooling requirements in Greece is correlated to the increased use of air-conditioning and the associated problems of supply of electric power during the peak periods (i.e. blackout) and the sick -building syndrome.

On the other hand, the heating requirements will be decreased during all seasons, especially spring and winter. Continental areas of Europe like Northern Spain, central Italy, Greece and Turkey will require less heating, (Figure 47). It is calculated that the days that will require heating more than 5°C will be less by 20 in these countries and by one week in the islands of the Mediterranean sea for the period 2021–2050 (Giannakopoulos et al., 2009; Committee for the Study of the Climate Change Impact, 2011). The decrease of the heating requirements is involved with the less use and dependency on fuel (i.e. oil).

Due to the climate change in Greece, it is predicted an increase on the number of days that external temperature will be higher than 35°C, thus increasing the thermal dissatisfaction of the population. In the mainland of Greece, Thraki and Central Macedonia 20 more ‘warm’ days will be experienced in the period 2021-2050 (compared to the reference year 1961-1990) and 40 more ‘warm’ days in the period 2071-2100. In Crete and Attiki the number of additional ‘warm’ days is calculated to around 15.

Additionally the number of ‘warm’ nights when the minimal temperature is above 20 °C will be increased. This also influences the thermal dissatisfaction of the population, during the periods of heatwaves. Crete and the coastal areas will be affected more where the additional ‘warm’ nights are predicted to 40 for the period 2021-2050 and to 80 for the period 2071-2100.

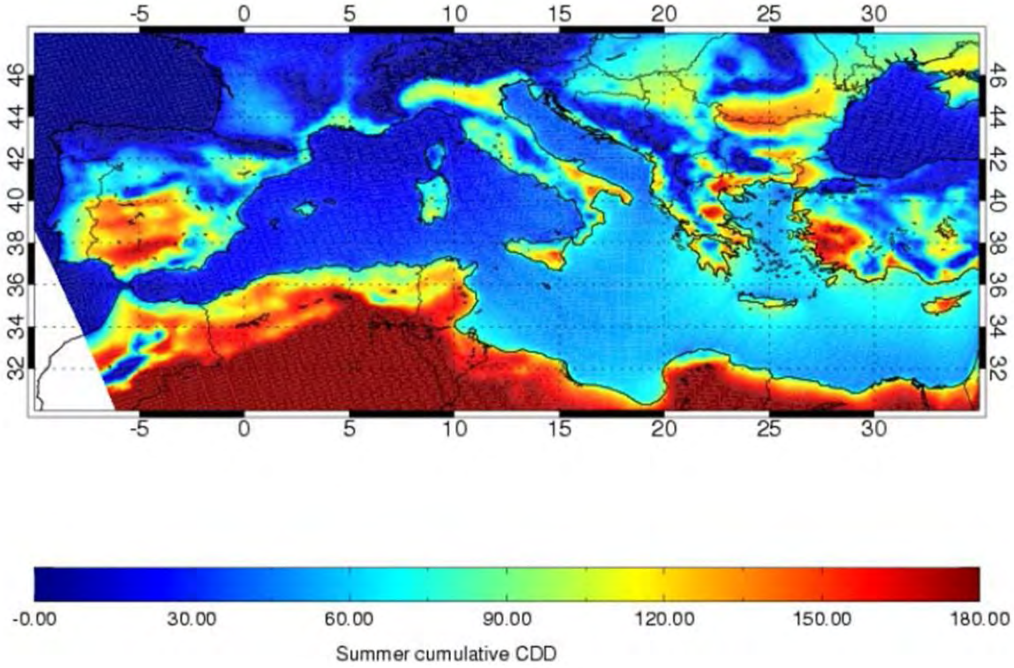


Figure 46 Change in cumulative CDD between the reference period and 2021-2050 (Ch. Giannakopoulos et al., 2009)

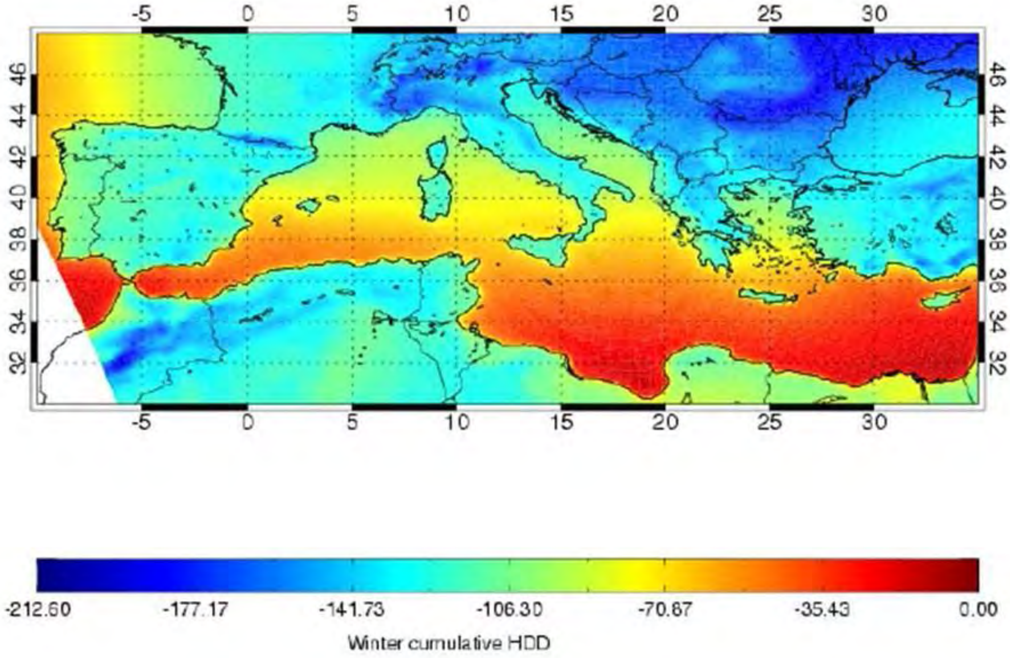


Figure 47 Change in cumulative HDD between the reference period and 2021-2050 (Ch. Giannakopoulos et al., 2009)

7.5. Impact of the climate change on the demonstration hotel

The impact of the climate change on the demonstration hotel was assessed via hourly simulations using real monitored data provided by the Hellenic National Meteorological Service. The monitored data is for the area of Athens and refers to the period 1970-2010. The monitored data includes 2 weather variables: temperature (°C) and relative humidity (%) on hourly basis.

7.5.1. Analysis of the monitored data

For the analysis of the monitored data, maximum, minimum and average values are calculated of the weather variables through the years, and the mean degree hours.

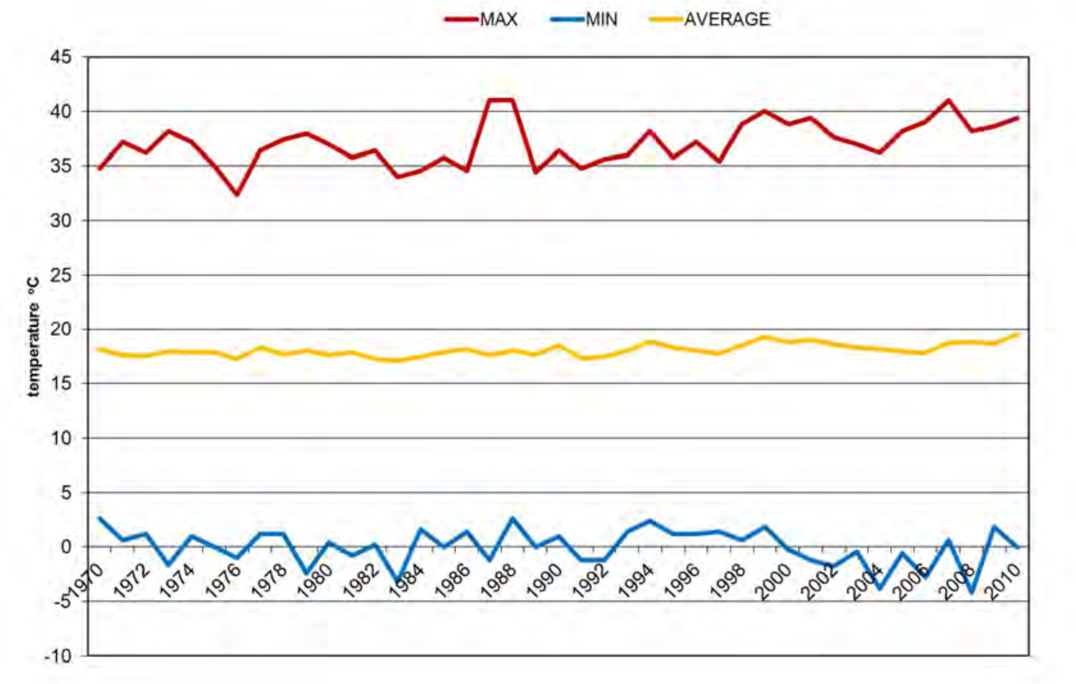
- **Maximum, minimum and average values**

Table 52 presents the characteristic (maximum, minimum and average) values of the climatic data.

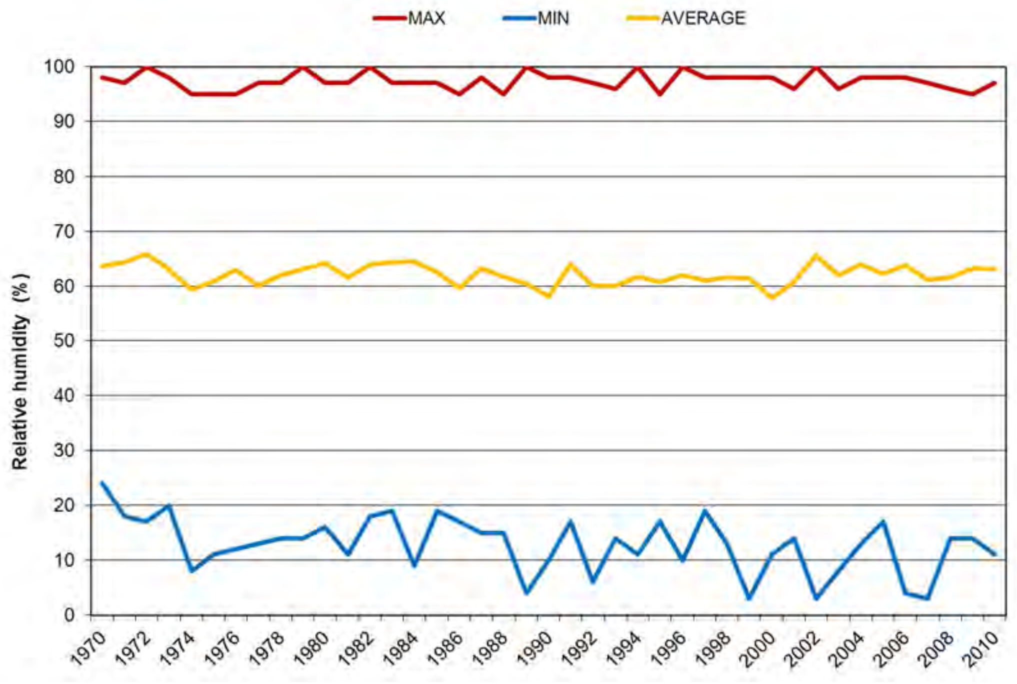
Graph 9 presents the monitored data for temperature and Graph 10 presents the monitored data for relative humidity.

Table 52 Characteristic values for the weather variables temperature (°C) and relative humidity (%)

TEMPERATURE (C)					RELATIVE HUMIDITY %		
YEARS	**MAX**	**MIN**	**AVER**		**MAX**	**MIN**	**AVER**
1970	34.8	2.6	18.1		98	24	64
1971	37.2	0.6	17.6		97	18	64
1972	36.2	1.2	17.5		100	17	66
1973	38.2	-1.6	17.9		98	20	63
1974	37.2	1.0	17.9		95	8	59
1975	35.0	0.0	17.9		95	11	61
1976	32.4	-1.0	17.3		95	12	63
1977	36.4	1.2	18.3		97	13	60
1978	37.4	1.2	17.6		97	14	62
1979	38.0	-2.4	18.1		100	14	63
1980	37.0	0.4	17.6		97	16	64
1981	35.8	-0.8	17.9		97	11	62
1982	36.4	0.2	17.2		100	18	64
1983	34.0	-3.2	17.1		97	19	64
1984	34.6	1.6	17.4		97	9	65
1985	35.8	0.0	17.9		97	19	63
1986	34.6	1.4	18.2		95	17	60
1987	41.0	-1.2	17.6		98	15	63
1988	41.0	2.6	18.0		95	15	62
1989	34.4	0.0	17.7		100	4	60
1990	36.4	1.0	18.5		98	10	58
1991	34.8	-1.2	17.3		98	17	64
1992	35.6	-1.2	17.5		97	6	60
1993	36.0	1.4	18.0		96	14	60
1994	38.2	2.4	18.9		100	11	62
1995	35.8	1.2	18.3		95	17	61
1996	37.2	1.2	18.1		100	10	62
1997	35.4	1.4	17.8		98	19	61
1998	38.8	0.6	18.5		98	13	62
1999	40.0	1.8	19.3		98	3	61
2000	38.8	-0.2	18.8		98	11	58
2001	39.4	-1.2	19.0		96	14	61
2002	37.6	-1.8	18.6		100	3	66
2003	37.0	-0.4	18.3		96	8	62
2004	36.2	-3.8	18.2		98	13	64
2005	38.2	-0.6	18.0		98	17	62
2006	39.0	-2.8	17.8		98	4	64
2007	41.0	0.6	18.8		97	3	61
2008	38.2	-4.2	18.8		96	14	62
2009	38.6	1.8	18.7		95	14	63
2010	39.4	0.0	19.5		97	11	63



Graph 9 Monitored data for temperature (°C) for the area of Athens for the years 1970 - 2010



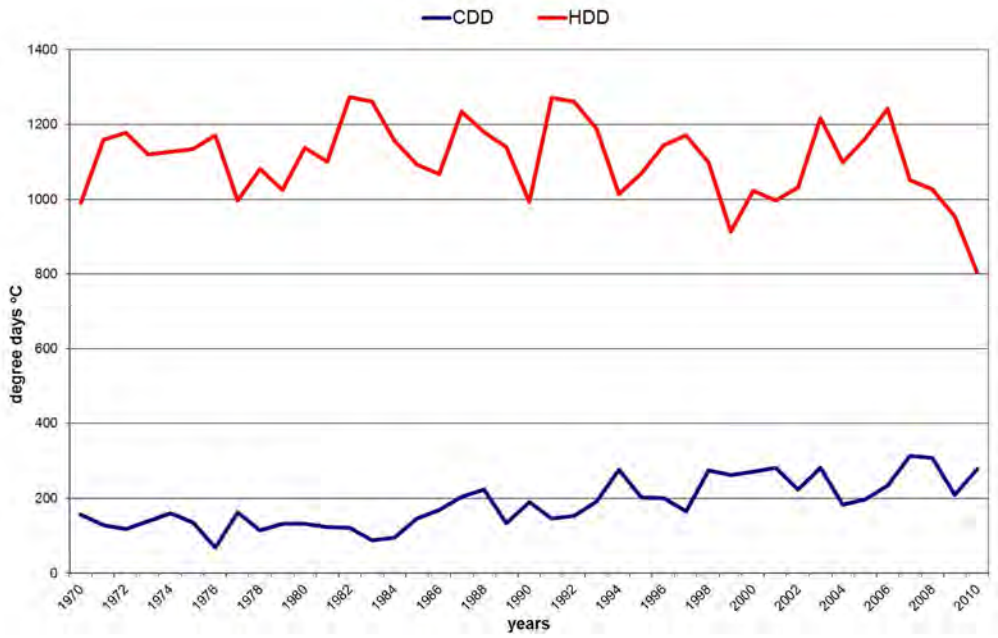
Graph 10 Monitored data for relative humidity (%) for the area of Athens for the years 1970-2010

Degree days

Table 53 and Graph 11 present the mean degree cooling and heating hours for the area of Athens for the period 1970-2010.

Table 53 Mean degree hours for the area of Athens for the period 1970-2010

Mean degree hours for the area of Athens					
	CDD	**HDD**		**CDD**	**HDD**
1970	156	991	**1991**	145	1271
1971	128	1159	**1992**	153	1261
1972	118	1178	**1993**	191	1189
1973	139	1120	**1994**	276	1013
1974	160	1127	**1995**	201	1069
1975	136	1134	**1996**	200	1145
1976	68	1171	**1997**	165	1171
1977	162	996	**1998**	275	1098
1978	114	1082	**1999**	262	914
1979	131	1024	**2000**	271	1023
1980	131	1138	**2001**	282	996
1981	124	1101	**2002**	223	1032
1982	122	1273	**2003**	281	1217
1983	87	1260	**2004**	184	1099
1984	95	1156	**2005**	196	1161
1985	145	1093	**2006**	234	1242
1986	169	1067	**2007**	313	1052
1987	203	1234	**2008**	308	1026
1988	222	1180	**2009**	209	954
1989	133	1139	**2010**	278	805
1990	190	993			



Graph 11 Mean heating and cooling degree days for the area of Athens for the years 1970-2010

Apart from the years 1987 and 1988 where extreme maximum temperatures were monitored, the temperature curve presents high fluctuations and is characterized by an increasing trend from 1970 to year 2010 (Graph 9). This increasing trend is very obvious in the case of the maximum temperatures and less in the case of the average temperatures. Characteristically, the recorded maximum temperatures take values from 34.8°C to 38.2°C for the first decade (1970-1980) whereas the maximum temperatures for the last decade (2000-2010) vary from 36.2°C to 41°C. Concerning the minimum temperatures, these present high fluctuations, with higher positive values during the period 1992-2000 and the lowest negative values during the period 2000-2008, and the lowest value -4.2°C recorded in year 2008, (Table 52).

Relative humidity is the ratio of the actual amount of water vapor in a given volume of air to the amount which could be present if the air were saturated at the same temperature. Since warm air will hold more moisture than cold air, the percentage of relative humidity is expected to decrease when the air temperature increases. This decrease of the relative humidity is noted in the average values and is more evident in the case of the minimum values. In means of maximum values the relative humidity also presents a slight increase of 1-2% through the years, (Graph 10).

The degree days present also a high fluctuation following the temperature variations. Therefore, the increasing trend that characterizes the air temperature results in an increasing trend of the mean cooling degree days and a decreasing trend of the heating degree days. Between the years 1970 – 2010 the increase in the mean cooling degree hours is calculated to 78% whereas the decrease of the heating degree days is 18%, (Table 53, Graph 11).

7.5.2. Simulations results for the period 1970-2010 and discussion

Table 54 and Graph 12 present the heating and cooling loads (kWh/m^2/yr) of the reference building for the period 1970-2010 for the area of Athens.

Table 54 Simulation results for the demonstration hotel using real data for the period 1970-2010

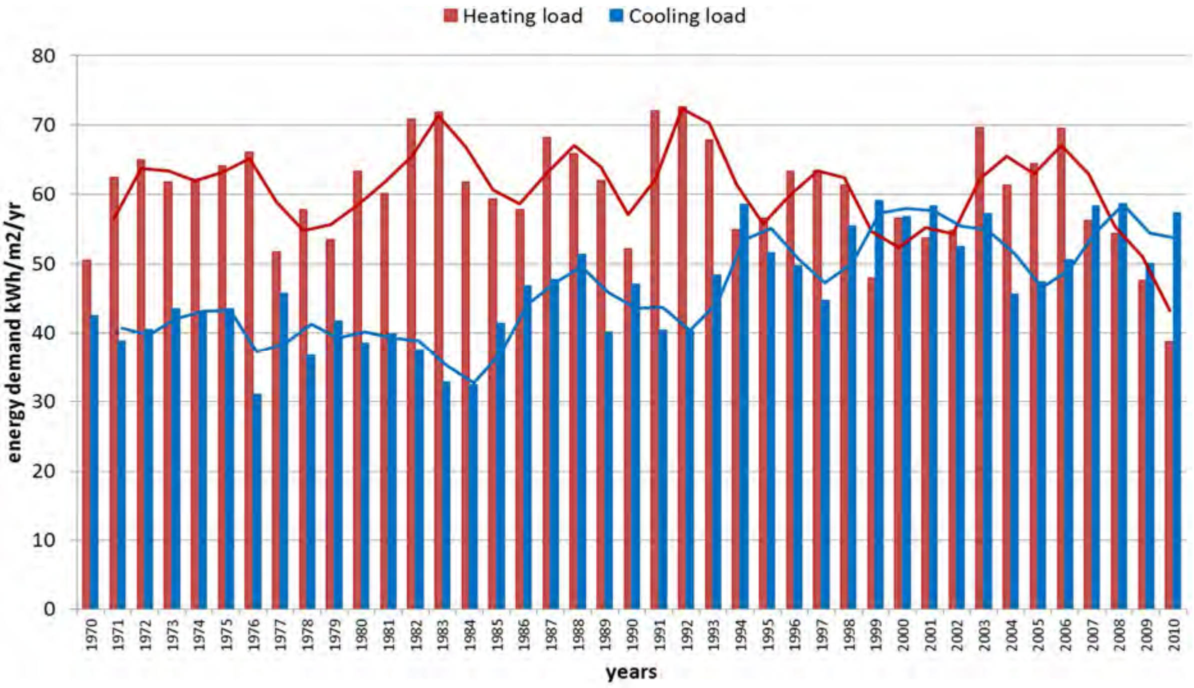
Reference building - Energy demand for the years 1970 - 2010					
Years	Heating loads (kWh/m^2/yr)	Cooling loads (kWh/m^2/yr)	Years	Heating loads (kWh/m^2/yr)	Cooling loads (kWh/m^2/yr)
1970	50	43	1991	72	40
1971	62	39	1992	73	40
1972	65	41	1993	68	48
1973	62	43	1994	55	59
1974	62	43	1995	57	52
1975	64	44	1996	63	50
1976	66	31	1997	64	45
1977	52	46	1998	61	56
1978	58	37	1999	48	59
1979	53	42	2000	57	57
1980	63	39	2001	54	58
1981	60	40	2002	55	53
1982	71	38	2003	70	57
1983	72	33	2004	61	46
1984	62	32	2005	65	47
1985	59	41	2006	70	51
1986	58	47	2007	56	58
1987	68	48	2008	54	59
1988	66	51	2009	48	50
1989	62	40	2010	39	57
1990	52	47			

The energy demand of the building presents high variations through the years as a result to the variation of the weather conditions. The variation of the heating and cooling loads is not linear, but it is evident that for the period 1970-2010, due to the increase of the air temperature there is also an increase of the cooling loads and a decrease of the heating loads. With year 1970 as the reference, the cooling loads increased by 33% (or 14 kWh/m^2/yr) and the heating loads decreased by 22% (or 11 kWh/m^2/yr) in year 2010.

The first decade 1970-1980, the cooling loads varied from 31 kWh/m^2/yr (in year 1976) to 46 kWh/m^2/yr (in year 1977) while the years 2000-2010 the cooling loads took values from 46 kWh/m^2/yr (in year 2004) to 59 kWh/m^2/yr (in year 2008).

The heating loads took values from 50 kWh/m^2/yr (in year 1970) to 66 kWh/m^2/yr (in year 1976) the period 1970 – 1980, and 39 kWh/m^2/yr (in year 2010) to 70 kWh/m^2/yr (in year 2003 and 2006).

The decreasing trend of the heating loads is not as clear as the increasing trend of the cooling loads. Furthermore, the calculation of the heating degree days show that the number of degree days is more than 1200 HDD for the years 1982 (1273 HDD), 1983 (1260 HDD), 1987 (1234 HDD), 1991 (1271 HDD), 1992 (1260 HDD), 2003 (1217 HDD) and 2006 (1242 HDD). However, the heating loads decrease significantly after year 2006.



Graph 12 Heating load and cooling load (kWh/m^2/yr) of the reference building for the years 1970 - 2010

7.6. Generation of future climates for building simulation

7.6.1. Methodology

The first step in order to perform the simulations is to use the right climatic files for the present and the future periods. Weather data of the different emission scenarios of Greece is not available in an hourly step; thus weather data is extracted from the METEONORM software and is used for the generation of future climatic files. The 'morphing' procedure is used for the generation of the climatic files, using the CCWorldWeather Generator tool developed by Southampton University, (Southampton University, 2010).

Many studies treat the generation of future files in order to be used in building simulations, (Oxizidis et al., 2008; Eames et al., 2012; Guan, 2009; Guan, 2012; Jentsch et al., 2008). In the literature four methods appear for the preparation of future weather data, these include: the extrapolating statistic method, the morphing procedure based on the imposed offset method, the stochastic weather model and global climate models. The comparison and analysis of these four methods conclude that the morphing method is the one most reliable for building simulations (Belcher et al., 2005; Guan, 2009). The main advantage of the method is that the future climates are produced by reliable present day climates and the main disadvantage is that the future climates rely on the variability and character of the present – day files.

The 'morphing method' is developed by (Belcher et al.,2005). The 'morphing' methodology is published by the Chartered Institution of Building Services Engineers (CIBSE) and is utilised as a baseline for transforming current CIBSE Test Reference Years (TRY) and Design Summer Years (DSY) into climate change weather years (Jentsch et al., 2008).

As described in the literature, 'Morphing involves shifting and stretching the climatic variables in the present –day weather time series to produce new weather time series that encapsulate the average climate change while preserving the physically realistic weather sequences of the source data' (Belcher et al., 2005; Chan, 2011).

The algorithms used in the morphing method are described by the following equations (Belcher et al., 2005; Chan, 2011):

$x = x_o + \Delta x_m$, (shift), eq. 6

$x = \alpha_m x_o$ (linear stretch), eq. 7

$x = x_o + \Delta x_m + \alpha_m X (x_o - (x_o)_m)$ (a combination of shift and stretch), eq. 8

where:

x_o: the existing hourly climatic data,

Δx_m : the absolute change in monthly-mean climatic variable for month m,

α_m : the fractional change in monthly –mean climatic variable for month m and

$(x_o)_m$: the climatic variable xo average over month m.

7.6.2. Future climates for the demonstration hotel

The future files for the building simulations were generated using the CCWorldWeather Generator tool, developed by Southampton University (Southampton University, 2010; Jentsch, 2010; Jentsch et al., 2008). The tool enables the generation of future climatic files ready for use in building simulation programs. It is Microsoft Excel based and transforms 'present-day' EPW or TMY files into future files (Jentsch et al., 2008). The toolkit uses IPCC TAR model summary data of the **HadCM3 A2** experiment ensemble which is available from the IPCC Data Distribution Centre.

The morphing method requires a baseline climate, in a **'EPW' format**. Weather data for more than 2100 locations throughout the world is provided by the U.S. Department of Energy, Energy Efficiency and Renewable Energy. The data is free of charge and can be downloaded through the link: http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm.

Available approved WMO climatic files exist for three areas of Greece, Andravida, Thessaloniki and Athens. Andravida (N 37° 55', E 21° 16') is approximately 60 km from the greater area of Patra (N 38°15′, E 21°44′) where the study case is located, (Figure 48). A comparison between the climatic files of Patra (extracted by the METEONORM) and Andravida is performed in order to decide which climatic file will be used for the building simulations.

Figure 48 Map showing the location of the demonstration hotel (near Aigion) and its distance from Patra and Andravida

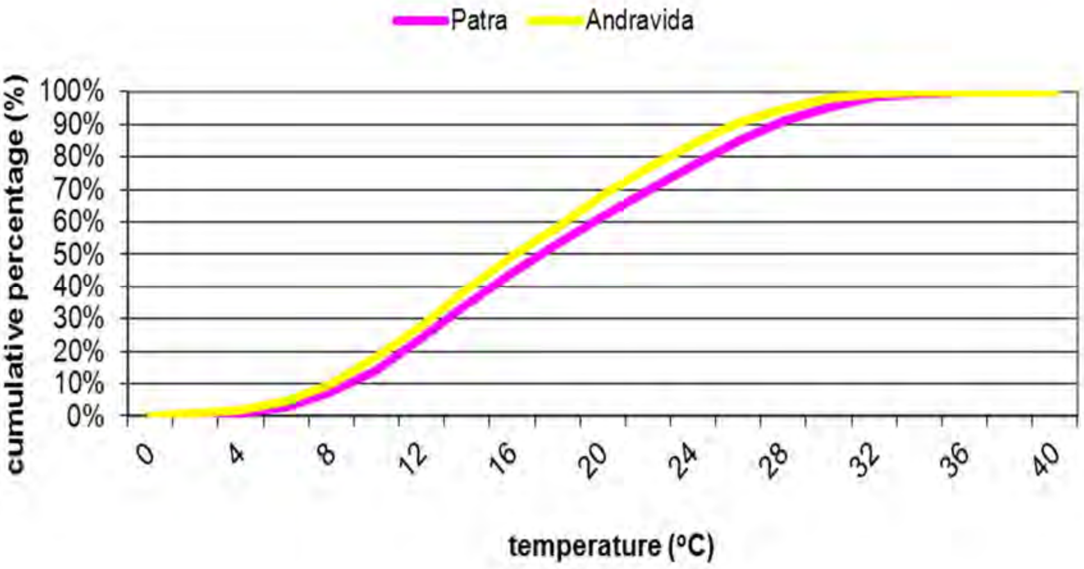
7.6.3. Comparison of climatic files between Patra and Andravida

The weather variables temperature (°C), global and diffuse radiation radiation (kJ/m^2h), relative humidity (%), wind speed (m/s) and direction for the area of Patra (climatic file extracted by METEONORM) and Andravida (available in http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm) are shown in tabular format (Table 55) and graphically (Graph 13 - Graph 18)

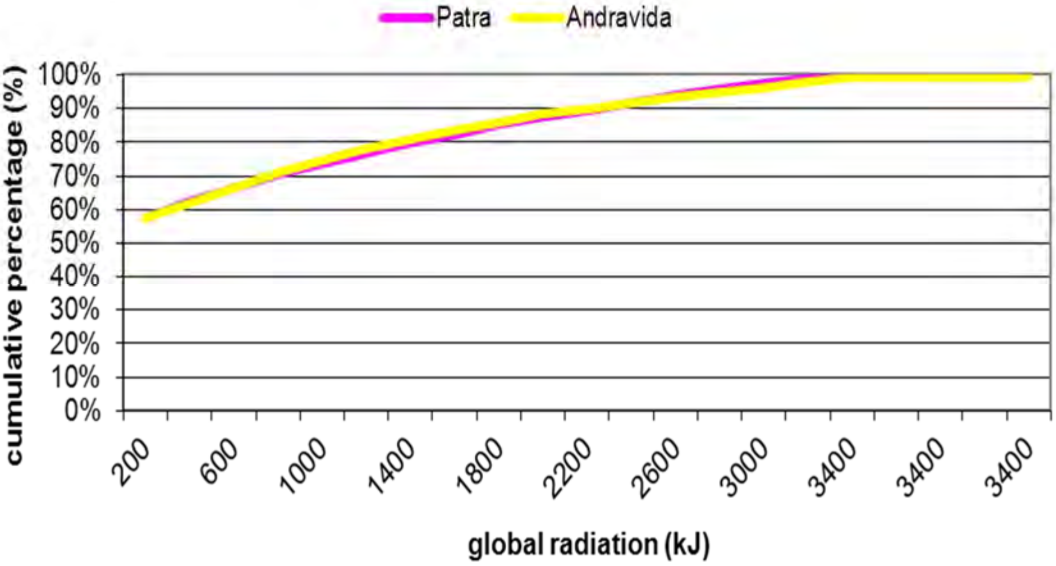
Table 55 Comparison of weather variables between Andravida and Parta for the baseline climate file

	Temperature (°C)		Global radiation (kJ/m^2h)		Diffuse radiation (kJ/m^2h)	
	Andravida (.wea) 1960-1990	Patra METEONORM	Andravida (.wea) 1960-1990	Patra METEONORM	Andravida (.wea) 1960-1990	Patra METEONORM
Maximum	36.8	36.6	3586	3392	2336	1629
Minimum	-1.8	-0.2	0	0	0	0
Average	16.7	17.8	624	628	304	318
Median	16.2	17.5	18	0	18	0
Mode	12.0	11.6	0	0	0	0
Variance	45.6	49.9	868142	847016	163929	175968
Standard deviation	6.8	7.1	932	920	405	419

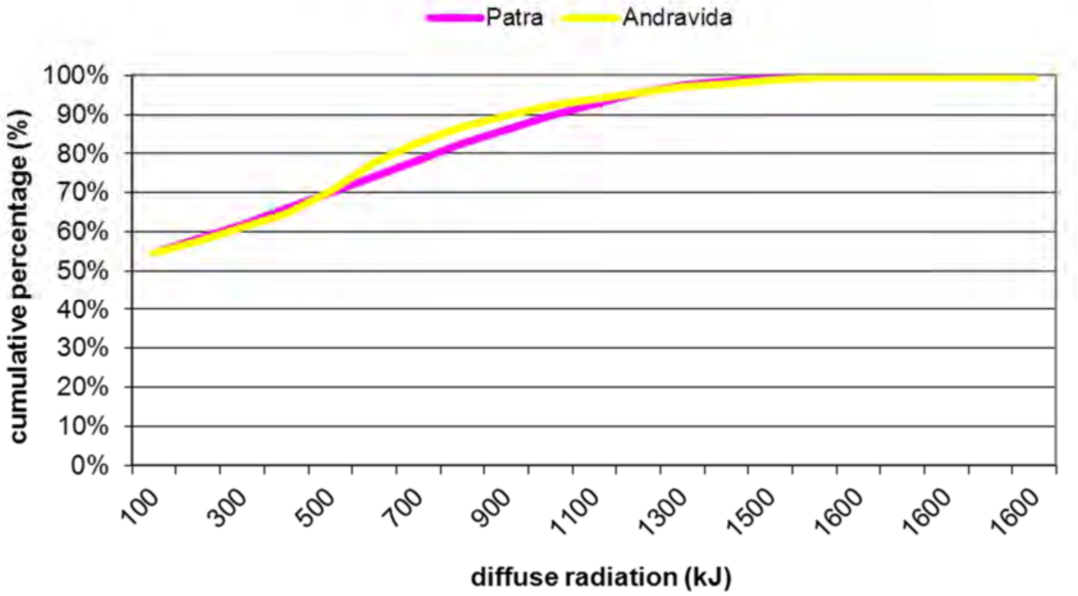
	Relative humidity (%)		Wind speed (m/s)		Wind direction	
	Andravida (.wea) 1960-1990	Patra METEONORM	Andravida (.wea) 1960-1990	Patra METEONORM	Andravida (.wea) 1960-1990	Patra METEONORM
Maximum	100	100	16.40	15.00	360	360
Minimum	15	39	0.00	0.00	0	0
Average	74	66	2.75	2.74	142	145
Median	77	66	2.30	2.20	140	85
Mode	87	69	0.00	1.60	0	28
Variance	302	134	6.54	4.85	18430	16056
Standard deviation	17	12	2.56	2.20	136	127



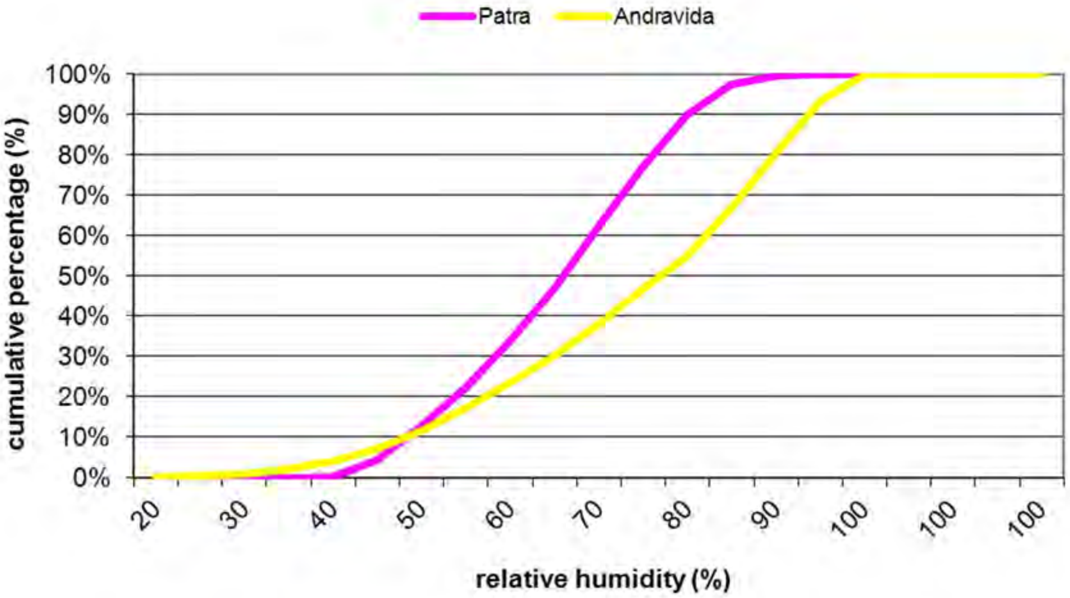
Graph 13 Temperature (°C) for Patra and Andravida



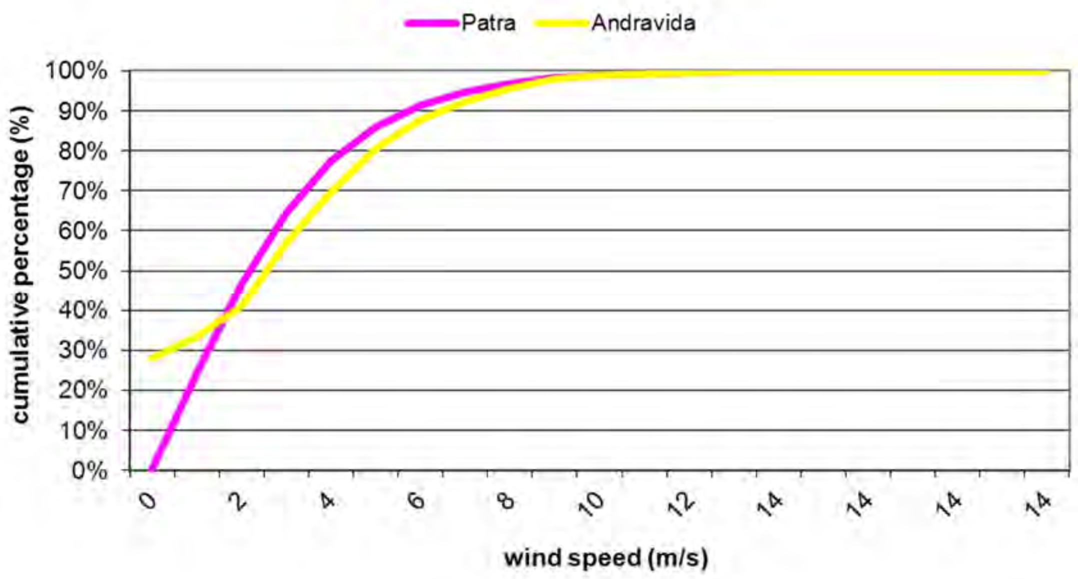
Graph 14 Global radiation (kJ) on horizontal plane for Patra and Andravida



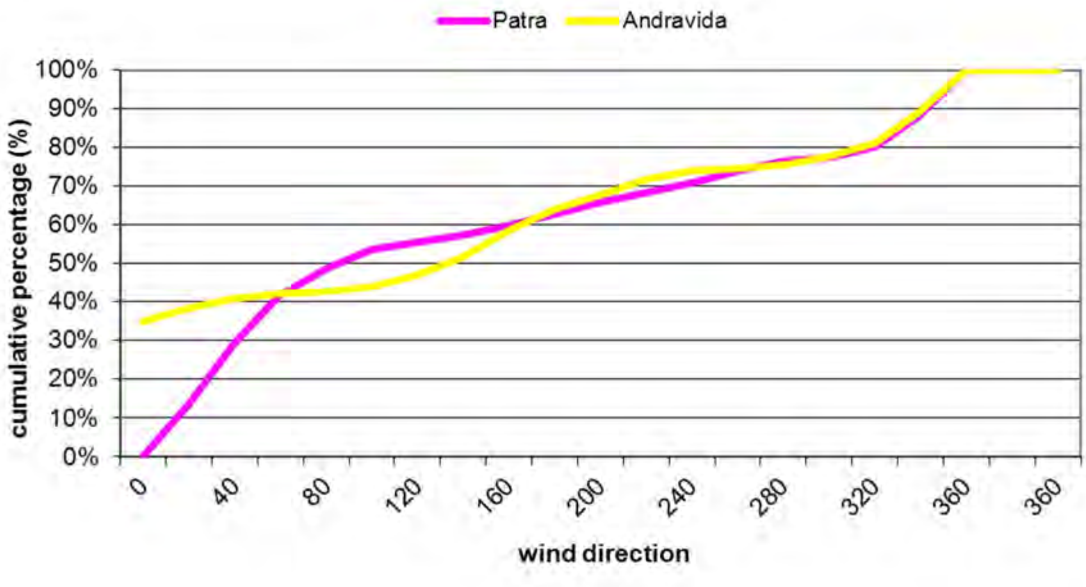
Graph 15 Diffuse radiation (kJ) on horizontal plane for Patra and Andravida



Graph 16 Relative humidity (%) for Patra and Andravida



Graph 17 Wind speed (m/s) for Patra and Andravida



Graph 18 Wind direction for Patra and Andravida

As it can be seen in Table 55 and Graph 13 - Graph 18 the weather files for the area of Patra and Andravida are almost identical. The largest difference is noted in the weather variable of relative humidity.

The microclimate of an area plays an important role in the formation of the weather variables as well as topographic characteristics like the presence of water in cities or around cities (Demanuele et al., 2011). As the study case is located next to the sea and closer to the city of Patra, it is decided to use **the climatic file of Patra** for the building simulations.

The present day climatic file (Patra) is obtained by METEONORM in a 'TMY2' format. The 'TMY2' weather file is converted in an 'EPW' format using the EnergyPlus Weather Converter tool. Then, the parameters below are 'morphed' using the CCWorldWeather Generator tool:

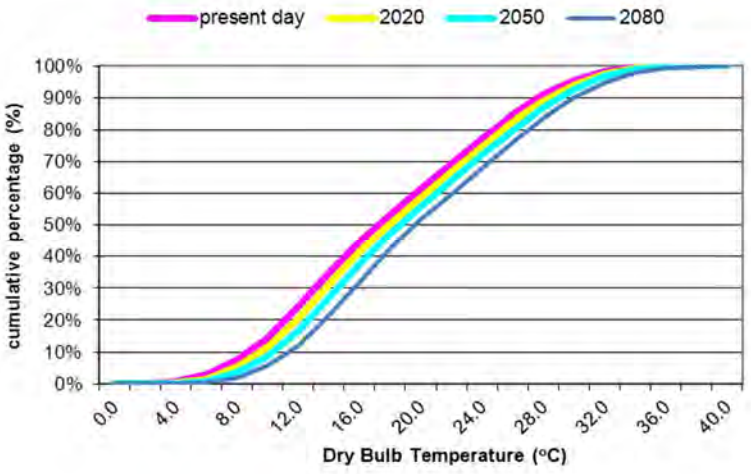
- dry bulb temperature (℃)
- relative humidity (%)
- global radiation (kJ)
- diffuse radiation (kJ)
- wind speed (m/s)

The characteristics of each weather variable (maximum, minimum, average values etc) for the 4 periods (present day, year 2020, year 2050 and year 2080) are shown in Table 56.

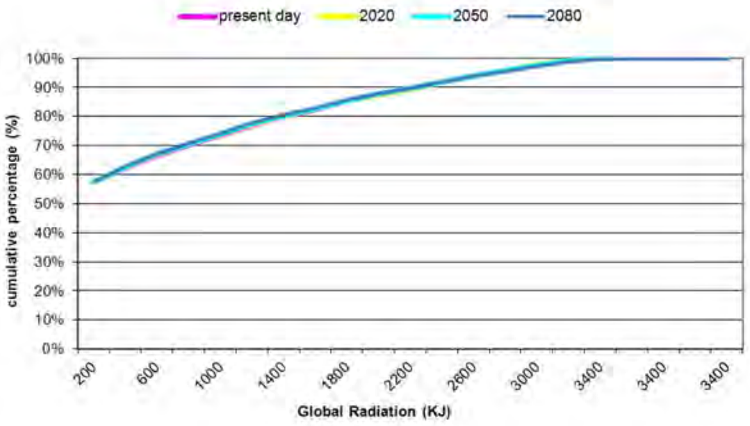
Table 56 Characteristics of weather variables for the area of Patra for 4 periods present day, year 2020, year 2050 and year 2080

Weather variables for the area of Patra				
Temperature (°C)				
	Present day	**2020**	**2050**	**2080**
maximum	36.5	37.22	37.98	38.99
minimum	-0.2	0.58	1.42	2.53
average	17.8	18.49	19.25	20.26
Median	17.5	17.93	18.68	19.69
Mode	11.6	10.89	11.70	12.73
variance	49.9	49.24	48.90	48.51
standard deviation	7.1	7.02	6.99	6.96
Global Radiation (kJ)				
	Present day	**2020**	**2050**	**2080**
maximum	3394.80	3365.05	3375.20	3440.60
minimum	0.00	0.00	0.00	0.00
average	628.03	622.24	618.99	617.03
median	0.00	0.00	0.00	0.00
mode	0.00	0.00	0.00	0.00
variance	844126.89	832880.28	830773.19	837667.97
standard deviation	918.76	912.62	911.47	915.24
Diffuse Radiation (kJ)				
	Present day	**2020**	**2050**	**2080**
maximum	1774.80	1760.88	1748.83	1806.34
minimum	0.00	0.00	0.00	0.00
average	318.79	315.54	313.37	311.39
median	0.00	0.00	0.00	0.00
mode	0.00	0.00	0.00	0.00
variance	176986.49	174225.65	172724.83	172276.44
standard deviation	420.70	417.40	415.60	415.06
Relative Humidity (%)				
	Present day	**2020**	**2050**	**2080**
maximum	100.00	100.00	100.00	100.00
minimum	35.00	35.76	36.41	37.56
average	65.61	66.32	66.95	67.78
median	66.00	67.13	67.79	68.73
mode	71.00	76.05	77.50	79.40
variance	135.12	136.50	139.30	143.92
standard deviation	11.62	11.68	11.80	12.00
Wind speed (m/s)				
	Present day	**2020**	**2050**	**2080**
maximum	14.90	15.21	16.50	18.22
minimum	0.00	0.00	0.00	0.00
average	2.74	2.79	2.91	3.09
median	2.20	2.25	2.33	2.50
mode	1.60	0.00	0.00	0.00
variance	4.85	5.04	5.52	6.37
standard deviation	2.20	2.25	2.35	2.52

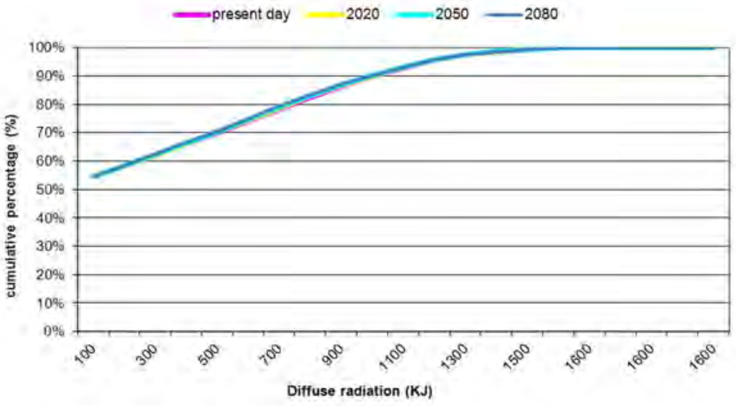
7.6.4. Comparison of present day, year 2020, 2050 and 2080 for the area of Patra



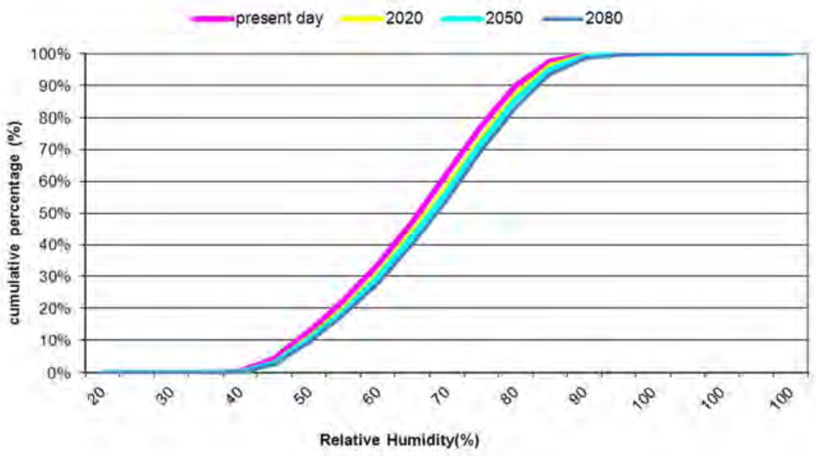
Graph 19 Temperature (°C) for the present day file and years 2020, 2050 and 2080



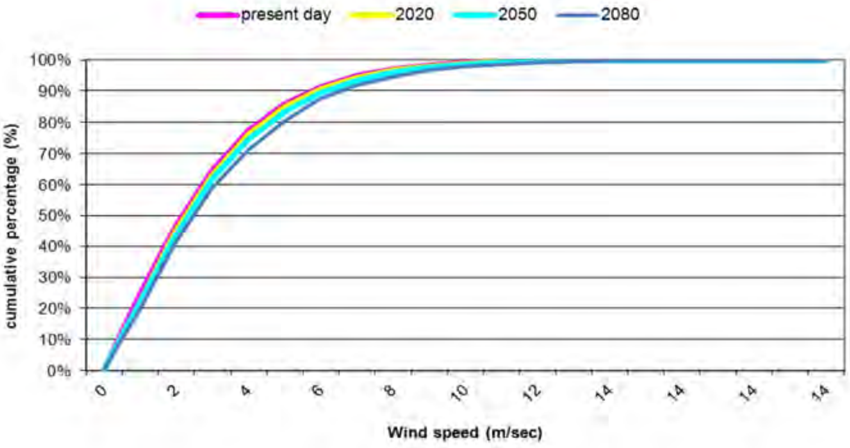
Graph 20 Global radiation (kJ) for the present day file and years 2020, 2050 and 2080



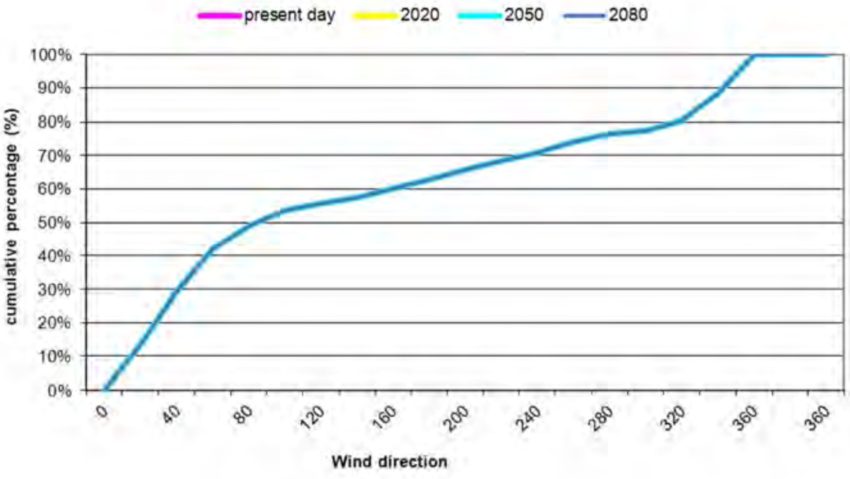
Graph 21 Diffuse radiation (kJ) for the present day file and years 2020, 2050 and 2080



Graph 22 Relative humidity (%) for the present day file and years 2020, 2050 and 2080



Graph 23 Wind speed (m/s) for the present day file and years 2020, 2050 and 2080



Graph 24 Wind direction for the present day file and years 2020, 2050 and 2080

As shown in Table 56 and Graph 19 - Graph 24, for the **HadCM3 A2** scenario, the temperature and the relative humidity are increasing in time. Global and diffuse radiation vary within the same levels for the present day and the years 2020 and 2050, however a slight increase is noted for the year 2080. The wind speed is also being increased. As a first estimation the above modifications in the weather variables would imply an increase in the energy demand of air-conditioned buildings, and a risk of overheating in naturally ventilated buildings.

7.7. Chapter Summary

The climate change has various impacts on the environment, the society and the global economy. At the building level, the increase of the air temperature is linked to the increase of the building energy consumption. The correlation is not linear and many studies use the degree day method to predict the variation of the energy demand in conjunction with the increase of the air temperature.

As a general rule, the differences in the cumulative numbers of CDDs and HDDs between the reference and the future period show the changes in the energy demand of buildings.

In particular, more cooling will be required in the Mediterranean countries. The increase in cooling requirements will be larger over Southern Spain, the Eastern parts of Greece, Western Turkey and more so over Cyprus/North Africa. The largest requirements of cooling will be required during the dry period in the summer.

On the other hand, the heating requirements will be decreased during all seasons, especially spring and winter. Continental areas of Europe like Northern Spain, central Italy, Greece and Turkey will require less heating.

Using real monitored data for the period 1970 – 2010, the simulation results show an increase of the cooling loads of the demonstration hotel by 33% and a decrease in the heating demand by 22%.

For the investigation of the climate change on the demonstration hotel in the future, climate files are generated using the the CCWorldWeather Generator tool developed by Southampton University for the years 2020, 2050 and 2080. As the baseline for the generation of these climates it is decided to use the present climate file as provided by the METEONORM.

The next chapter presents a number of mitigation strategies for the demonstration hotel in order to tackle the climate change, in the present year and in years 2020, 2050 and 2080. The majority of the mitigation strategies focus on the building envelope.

CHAPTER 8

Energy Use Mitigation Strategies for the Demonstration Hotel

8 Energy Use Mitigation Strategies for the Demonstration Hotel

8.1. Introduction

This chapter aims to investigate a number of mitigation strategies for the demonstration hotel in order to tackle the climate change. The majority of the mitigation strategies concerns the building fabric and is based on the methodology described in CIBSE TM36, (CIBSE TM 36, 2005). They are characterized by the following principles: 'absorb & switch off' by adding thermal insulation to lower the U-values and increase the effective thermal response factor, 'reflect' by applying cool materials, 'switch off' by controlling the solar gains using shading and appropriate glazing, 'blow away' illustrated by implementing day time and night-time intelligently controlled ventilation and 'convection' by using ceiling fans. For each of the above techniques a number of scenarios are studied in order to detect the ones that result in maximum energy savings.

8.2. Methodology

The mitigation strategies are investigated via simulations using the validated software TRNSYS. The impact of the mitigation strategies is studied by means of modification of the heating and cooling loads and their variation compared to the present situation (reference building).

The simulations are carried for the whole year for each of the following periods: present day, year 2020, year 2050 and year 2080. The following steps are followed:

1. Assess the impact of the climate change on the energy consumption of the hotel prior to any energy intervention (reference building) for the periods 2020, 2050 and 2080 compared to the present situation.
2. Propose measures in order to alleviate the environmental and energy consequences of the climate change in the building energy demand.
3. Define the highest energy saving techniques that will be applied in the energy efficient building.

8.2.1. Demostration hotel – reference building

The reference – demonstration building that is simulated is described in chapter 6. Briefly:

Construction: It is a non-insulated building dated back in 1970s.

External walls: Plaster – brick – plaster, with plaster externally & internally

Roof: Plaster - concrete – plaster

Ground floor: concrete slab

Windows**:** Single with aluminum frame in common areas, double with aluminum frame in corridors/circulation areas, single with wooden frame in rooms

Infiltration: 0.40ach (calculations based on TOTEE, 20701-1/2010, table 3.26, ppg 79)

Air flow rates: Fixed air flow rates based on the national legislation TOTEE, 20701-1/2010, (page 26, table 2.3)

Common areas: 9 $m^3/h/m^2$

Rooms: 1.2 $m^3/h/m^2$

Office areas: 3 $m^3/h/m^2$

Shading: As defined in TOTEE, 20701-1/2010 pg 71 table 3.19

Shading factor for windows (southeast) of 1st and 2nd floor (cooling period) : 0.43

Shading factor for windows (southeast) of 3rd and 4nd floor (cooling period) : 0.14

Shading factor for windows (northwest) of rooms with 2.85m height (cooling period) : 0.28

Shading factor for windows (northwest) of rooms with 3.75m height (cooling period) : 0.2

Design Temperature

Heating period: 20°C

Cooling period: 26 °C

Thermal mass: The thermal mass of the construction is calculated to understand the thermal behaviour of the building and the effectiveness of night cooling that will be investigated. The thermal response factor (f_r) is given by the equation

$$f_r = \frac{\Sigma (A\,Y) + C_v}{\Sigma (A\,U) + C_v}$$, (CIBSE Guide A 2006) eq. 9

$$C_v = \frac{1}{3} N\,V$$, (CIBSE Guide A 2006) eq. 10

Where: A is the surface areas (m^2),Y is the thermal admittance (W/m^2K), U is the thermal transmittance (W/m^2K), Cv is the ventilation conductance (W/K), V is the volume of the room (m^3), N is the room air change rate (ach).

Infiltration is important to the calculation of the heat losses through the fabric and to the determination of the thermal response factor. Infiltration is the undesirable leakage of air from the environment into the conditioned spaces of buildings, through the cracks and joints of the building construction. Its direct result is an increase of energy consumption to maintain desired levels of indoor conditions.The thermal properties of the materials of the demonstration hotel (Table 57) are based on CIBSE Guide A, tables 3.49-3.53.

Table 57 Building construction properties for the calculation of the thermal response factor f_r

	Area (m^2)	U (W/m^2K)	AU (W/K)	Y (W/m^2K)	AY (W/K)
external wall	2864.00	2.21	6332.30	3.55	10167.20
internal partition	5289.32			3.76	19887.82
internal floor	3383.00			5.44	18403.52
Roof	1580.00	3.06	4830.06	5.06	7994.80
glazing single	353.00	5.68	2005.04	5.68	2005.04
glazing double	295.00	2.95	870.25	2.95	870.25
Ground floor	1580.00	3.09	4885.36	3.59	5672.20
Sum	**15344.32**		**18923.01**		**65000.83**
			Σ(AU)		Σ(AY)

The building volume is calculated to 16,967 m^3 and the building air change is calculated to 0.4 ach (section 6.8.3.2), therefore Cv equals to 2262.2 W/K.

Using equation 6 and thermal properties as shown in Table 57, the thermal response factor is calculated to $f_r = 3.17 < 4$.

Buildings with a high thermal response factor (f_r >4) are referred to as heavyweight buildings and those with a low thermal response factor (f_r <4) as lightweight buildings, (CIBSE Guide A, 2006), thus the construction of the reference building (f_r=3.17) is referred to as a lightweight. This is because the building has no insulation in its building components and results in high U-values. The addition of insulation, thus lowering the U-values of the building components results in a thermal response factor > 4, thus in a heavyweight construction. It should be noted that in the above calculation position of the insulation is important and in this case it is assumed that additional insulation is added to the external part of the construction so that the high heat capacity elements of the construction are exposed to internal variations.

Energy profile/demand: Its energy profile as defined through simulations is 104700 kWh (cooling load) and 304300 kWh (heating load) for year 2007.

8.3. Energy efficient measures in order to alleviate the climate change

A combination of design parameters affect the indoor environment and energy consumption of buildings like the orientation, building geometry, physical properties of materials and building systems, (Ouedraogo et al., 2012) .

Previous analysis shows that increase of cooling energy demand and indoor overheating are the direct results of the climate change. In order to tackle the climate change, a number of energy efficient techniques are studied for each climatic period.

The energy efficient strategies that are studied for the demonstration hotel are based on the example given in CIBSE TM36 (CIBSE TM36, 2005) and are summarised in Table 58.

Table 58 Energy efficient strategies for the demonstration hotel to tackle climate change

Principle	**Type of Principle**	**Option**
switch off	Passive cooling	Reduce internal gains e.g. using **shading, using double low emission glazing**
switch off & absorb	Passive cooling	Increase the thermal response factor *(f_r)* i.e. **adding insulation in walls & roof**
reflect	Passive cooling	Increase the reflectance of external surfaces in the summer period i.e. **using cool materials, using double low emission glazing**
blow away	Passive cooling	Intelligent **night ventilation and day time control**
convection	Hybrid cooling	Interact in the cooling set point and thermal comfort i.e. using **ceiling fans** in the rooms

Five principles are used to tackle the energy increase and overheating of the hotel: 'switch off', 'absorb', 'reflect', 'blow away' and' convect'. The principle 'switch off' is realized with the control of solar gains in the interior of the building, with the use of external shading and the use of energy efficient glazing. The 'switch off & absorb' principle is approached by increasing the thermal response factor (> 4) of the building with the addition of external insulation in the non-insulated fabric. Energy efficient glazing summarizes both principles 'switch off' and reflect' by removing and 'reflecting' the undesirable solar gains. Apart from the glazing, the 'reflect' option is also illustrated by increasing the reflectance of the external surfaces and relieving indoor spaces from excessive peak temperatures. The 'blow away' principle is illustrated by an 'intelligent' ventilation system and the use of automated control in the daytime and nighttime ventilation according to the external temperature and the indoor temperature of each zone. In addition to the minimum airflow rates in each zone of the hotel as defined by the national legislation, extra fresh air is supplied in the areas of the hotel according to the external temperature and the internal temperature, both at day and night. The convection principle is illustrated with the use of ceiling fans by blowing the 'cool' air downwards to the occupied zone and extending the thermal comfort zone without the use of air conditioning.

For each of the above strategies, in order to achieve the maximum energy saving technique and the optimum solution, different scenarios are examined as shown in Table 60.

The reference building is described in paragraph 9.2.1. For each parametric analysis one variable is changed, while the others are kept the same. Table 59 describes the variables that in each simulation run are replaced by an energy measure. For example in the case of insulation, scenario EPBD, the uninsulated external walls and roof of the reference building (U_{roof}=3.05W/m^{2}K, Uwalls=2.20 W/m^{2}K and Uwallsconcr=3.40 W/m^{2}K, Table 59) are straightened with insulation so that a Uroof of 0.45 W/m^{2}K and a Uwalls of 0.5 W/m^{2}K is achieved (Table 60).

All other parameters (i.e. infiltration, shading, air flow rates, etc) are kept the same as described in paragraph 9.2.1 In the case of double glazing (switch off & reflect principle), all windows of the reference situation (single glazing and double, U=5.68 W/m^{2}K, U=2.95 W/m^{2}K, Table 59) are replaced by double glazing of U-value 2.95 W/m^{2}K and g=0.8 (Table 60). Again all other parameters (i.e. no insulation, infiltration, shading, air flow rates, etc) are kept the same as described in paragraph 9.2.1. Using the above methodology all energy saving techniques of Table 60 are simulated.

Table 59 Assumptions of reference building

Reference Building		
Switch off & Absorb	Insulation	Uroof=3.05W/m^{2}K, External wall-concrete frame=3.40 W/m^{2}K Uwalls=2.20 W/m^{2}K
Switch off &Reflect	Glazing	Common areas: single with aluminum frame: Ugl:5.68, Corridors to the rooms Ugl: 2.95 Rooms: single with wooden frame Ugl:5.68
Switch off	Shading	Shading factor for windows (southeast) of 1st and 2nd floor 0.43 Shading factor for windows (southeast) of 3rd and 4nd floor (cooling period) : 0.14 Shading factor for windows (northwest) of rooms with 2.85m height : 0.28 Shading factor for windows (northwest) of rooms with 3.75m height : 0.2
Reflect	Absorptance of materials	External walls and roof 0.6
Blow away	Day Ventilation	No intelligently controlled day ventilation, fixed airflows as defined by legislation Common area of hotel: 9 m^3/h/m^2 Room of hotel: 1.2 m^3/h/m^2 Office areas: 3 m^3/h/m^2
	Night ventilation	No intelligently controlled night ventilation
Convection	Ceiling fans	No ceiling fans in the rooms, cooling set point 26°C

Table 60 Scenario of energy efficient techniques for the upgrade of the building envelope as a response to climate change

Principle	**ENERGY EFFICIENT TECHNIQUES**	**DESCRIPTION**
	Insulation	
Switch off & Absorb	According to the current EPBD	Uroof=0.45W/m^{2}K, Uwalls=0.5 W/m^{2}K
	7 cm in external walls & roof	Uroof=0.45W/m^{2}K, Uwalls=0.34 W/m^{2}K
	10 cm in external walls & roof	Uroof=0.32W/m^{2}K, Uwalls=0.25 W/m^{2}K
	12 cm in external walls & roof	Uroof=0.27W/m^{2}K, Uwalls=0.21 W/m^{2}K
	Glazing	
Switch off &Reflect	Double glazing	Uopen=2.95 W/m^{2}K, g=0.8
	Double low e glazing	Uopen =1.8 W/m^{2}K, g=0.6
	Double low e glazing	Uopen =1.8 W/m^{2}K, g=0.45
	Double low e glazing with argon	Uopen =1.43 W/m^{2}K, g=0.6
	Double low e glazing	Uopen =1.00 W/m^{2}K, g=0.55
	Shading	
Switch off	Shading to openings of corridors (southern orientation)	Shading factor : 0.5
	Shading to openings of corridors (southern orientation)	Shading factor : 0.7
	Shading to openings of corridors (southern orientation)	Shading factor : 0.8
	Shading to openings of corridors (southern orientation) and rooms	Shading factor : 0.8 (corridors, rooms :0.5)
	Shading to openings of corridors (southern orientation) and rooms	Shading factor : 0.8 (corridors, rooms :0.7)
	Cool materials	
Reflect	External walls	Solar absorptance: 0.2
	External walls &roof	Solar absorptance: 0.2
	Ventilation	
Blow away	Daytime	Ventilation when the indoor temp of each zone is greater than 23°C and external temperature lower than 25°C, for the period may-sept
	Daytime	Ventilation when the indoor temp of each zone is greater than 23°C and external temperature lower than internal temperature in each zone, for the period may-sept
	Night time	Ventilation at a constant rate from 23:00 – 7:00, for the period may-sept
	Night time	Ventilation when the indoor temp of each zone is greater than 23°C, 23:00 – 7:00, for the period may -sept
	Night time	Ventilation when the outdoor temp is greater than 15°C, 23:00 – 7:00, for the period may-sept
	Ceiling fans	
convection	Hybrid cooling	cooling set point of bedrooms at 27°C (instead of 26°C), increase of 1°C assuming that the fans cover 60% of the thermal zone – TOTEE 20701-1

8.3.1. ‘Switch off & Absorb’ principle

The principle ‘switch off & absorb’ is represented by adding insulation. The reference building has no insulation in the building components and it is characterized as a low weight construction. The application of external insulation in the walls and roof increases the thermal resistance of the building components, lowers the U-values and increases the thermal response factor (>4).

An insulation material (extruded polystyrene) with thermal conductivity λ=0.030 W/mK and density ρ= 28 kg/m^3 is selected as this is a usual material for building refurbishment in Greece. Four scenarios are studied:

- Adequate thickness of insulation so that the required U-values are obtained as defined by the current national EPBD legislation: Insulation 4cm to the external walls and 7 cm to the roof (Uroof=0.45W/m^{2}K, Uwalls=0.5 W/m^{2}K), resulting in thermal response factor f_r= 5.45 >4.
- Thickness of insulation 7 cm to the external walls and roof, so that lower U-values are obtained (Uroof=0.45W/m^{2}K, Uwalls=0.34 W/m^{2}K) , f_r= 5.66.
- Thickness of insulation 10 cm to the external walls and roof (Uroof=0.32W/m^{2}K, Uwalls=0.25 W/m^{2}K), f_r= 5.88.
- Thickness of insulation 12 cm to the external walls and roof (Uroof=0.27W/m^{2}K, Uwalls=0.21 W/m^{2}K), f_r= 5.98.

It should be noted that the thickness of the insulation depends on the insulation material. Table 61 shows the thickness of insulation that is required for the external walls when using insulation materials with different thermal conductivity (λ) and density (ρ). The insulation materials used for this example are included in the library of the TRNSYS software.

Table 61 Thicness of different insulation materials in order to achieve the required Uwalls

Thermal conductivity & density of insulation material	**Uwalls**	0.5 W/m^{2}K	0.34 W/m^{2}K	0.25 W/m^{2}K	0.21 W/m^{2}K
λ=0.030 W/mK & ρ=28 kg/m^3 (extruded polystyrene XPS – low density)	Thickness (cm)	5	7	10	12
λ=0.034 W/mK & ρ=35 kg/m^3 (extruded polystyrene XPS– average density)		5	8	12	14.5
λ=0.039 W/mK & ρ=80 kg/m^3 (mineral wool-low density)		6	10	14	17
λ=0.050 W/mK & ρ=100 kg/m^3 (mineral wool – high density)		8	12.5	17.5	21

It should be noted that there exist novel insulation materials (for example vacuum insulation) which offer very low thermal conductivity and so the required thickness is reduced to achieve a similar U-value. However in this case ‘typical’ insulation material in the Greek market was considered such as extruded polystyrene and its performance was compared to this of higher density insulation material such as mineral wool.

8.3.2. ‘Switch off & Reflect’ principle

8.3.2.1. Glazing

Both principles ‘switch off’ and ‘reflect’ are illustrated by using energy efficient glazing that control the solar gains in the interior of the building and reflects successive heat in summer. Different glazing types are simulated:

- As currently the hotel is characterized by a large number of single glazing, all windows are replaced with typical double glazing (U=2.95 W/m^{2}K, g=0.8)
- Double low emissivity glazing with U=1.8 W/m^{2}K , g=0.6
- Double low emissivity glazing with U=1.8 W/m^{2}K, g=0.45
- Double low emissivity glazing, U=1.43 W/m^{2}K, g=0.6
- Double low emissivity glazing, U=1.00 W/m^{2}K, g=0.55

8.3.2.2. Shading

Shading is also a ‘switch off’ technique by adjusting the penetration of the solar radiation in the interior of buildings, consequently by modulating the thermal and visual comfort of users. Shading may have a substantial impact on the cooling demand of buildings. For the demonstration hotel the following shading solutions are considered:

- Shading to the openings of corridors with southern orientation, shading factor 0.5
- Shading to the openings of corridors with southern orientation, shading factor 0.7
- Shading to the openings of corridors with southern orientation, shading factor 0.8
- Shading to the openings of corridors with southern orientation (shading factor 0.8) and shading to the openings of rooms with north-western orientation (shading factor 0.5)
- Shading to the openings of corridors with southern orientation (shading factor 0.8) and shading to the openings of rooms with north-western orientation (shading factor 0.7)

8.3.3. 'Reflect' principle

The 'reflect' principle is applied with the use of cool materials that are characterised by high solar reflectance and infrared emittance (Santamouris et. al, 2011). They work by reflecting solar radiation and therefore rejecting solar heat gains at the opaque external surfaces of the building. Heat transfer to the internal space by conduction is therefore reduced providing lower indoor temperatures and reduced cooling energy demand, (Kolokotroni et al., 2012).

For the demonstration hotel the following two scenarios are considered:

- Application of cool materials in the external facades (solar absorptance: 0.2)
- Application of cool materials in the external facades and the roof (solar absorptance: 0.2)

8.3.4. 'Blow away' principle

The 'blow away' principle is applied by implementing day time and nighttime intelligently controlled ventilation. This is based on the fact that ventilation can provide passive cooling when the external temperature is lower than the target internal one. When the external temperature is higher than the internal one then the ventilation becomes a heat source.

In the reference case no mechanical ventilation is installed in the main areas of the hotel. However, within the frames of the simulations, for the reference building minimum airflow rates are assumed as defined by the national building regulations TOTEE 20701-1/2010 (section 9.2.1. table 2.3).

Common areas of the hotel: 9 $m^3/h/m^2$

Rooms of the hotel: 1.2 $m^3/h/m^2$

Office areas: 3 $m^3/h/m^2$

In addition to the above airflow rates, extra fresh air is simulated in order to investigate passive cooling relief and energy savings. These include automated control that links the supply of extra fresh air in the areas of the hotel according to the internal and/or external temperature. The control includes:

Daytime ventilation

- Extra fresh air when the indoor temperature of each zone is greater than 23°C and external temperature lower than 25°C (7.00-23.00), for the months May-September
- Extra fresh air when the indoor temperature of each zone is greater than 23°C and external temperature lower than internal temperature of each zone (7.00-23.00), for the months May-September

Night ventilation

- Fresh air at a constant rate (23:00 – 7:00), for the months May-September
- Fresh air when the indoor temperature of each zone is greater than 23°C, (23:00 – 7:00). for the months May-September
- Fresh air when the outdoor temperature is greater than 15°C, (23:00 –7:00), for the months May-September

Common areas: Automated control will be applied assuming mechanically controlled dampers connected to a BMS. In this case airflow rates of a total 5 ach will be achieved in these areas during daytime and night time ventilation.

Rooms: It is assumed that extra fresh air during the day and night is realized through openable windows. Based on an airflow analysis using the AIOLOS software (appendix 6), high ventilation rates can be achieved in the rooms both during the day and at night. The average airflow values are shown in the appendix 6. Based on the airflow results, 5.5 ach are assumed for daytime and 6 ach for night time, assuming 50% open the door balcony of the rooms. It is realized that these are average values for the periods based on hourly ventilation simulations; however as the required output is monthly or seasonal energy use such an average will give reasonable results.

8.3.5. ‘Convection’ principle

The ‘convection’ principle is illustrated by applying ceiling fans. Ceiling fans can increase the air velocity. According to the literature their use create ‘*a turbulent and variable quality air motion that contributes to more comfortable effect than a uniform air motion*’ and with their use ‘*an air speed of 1.0 m/s at 29°C can be equivalent to 24°C without the ceiling fan’* (Santamouris, 2007). Ceiling fans can decrease the use of air conditioning by setting the room thermostat at higher temperatures.

For the purposes of the simulations, the cooling set point of the rooms is set to 27°C (instead of 26°C), that is an increase of 1°C assuming that the fans cover 60% of the thermal zone – (based on the national legislation TOTEE 20701-1/2010). When a ceiling fan or another source of air movement is available under the control of occupants, then the comfort temperature can be increased by 2K, (CIBSE TM52, 2013).

8.4. Simulation results

8.4.1. Reference building (no energy measures)

- **Heating load**

Table 62 Heating load of the reference building for the present day and the years 2020, 2050 and 2080

Reference building – Heating load kWh/m^2/year		
	kWh/m^2/year	**Variation (%) compared to present day**
Present day	61	
2020	52	-15
2050	43	-30
2080	33	-46

- **Cooling load**

Table 63 Cooling load of the reference building for the present day and the years 2020, 2050 and 2080

Reference building – Cooling load kWh/m^2/year		
	kWh/m^2/year	**Variation (%) compared to present day**
Present day	41	
2020	47	+15
2050	55	+34
2080	67	+63

8.4.2. ‘Switch off & Absorb’ principle – insulation

- **Heating load**

Table 64 Impact of insulation on the heating load (kWh/m^2/year) of the building for the present day and the years 2020, 2050 and 2080

Heating load kWh/m^2/year				
	Present day	**2020**	**2050**	**2080**
Reference	61	52	43	33
EPBD	27	22	17	12
7cm	25	20	16	11
10cm	23	19	15	10
12 cm	23	18	14	10

Table 65 Variation (%) of the heating load compared to the reference building

Heating load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
EPBD	-56	-58	-60	-63
7cm	-59	-61	-63	-66
10cm	-62	-64	-66	-69
12 cm	-63	-65	-67	-70

Table 66 Variation in kWh/m^2/year of the heating load compared to the reference building

Heating load – Difference in kWh/m^2 /year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
EPBD	-34	-30	-26	-21
7cm	-36	-32	-27	-22
10cm	-38	-33	-28	-23
12 cm	-38	-34	-29	-23

- **Cooling load**

Table 67 Impact of insulation on the cooling load (kWh/m^2/year) of the building for the present day and the years 2020, 2050 and 2080

Cooling load kWh/m^2/year				
	Present day	**2020**	**2050**	**2080**
Reference	41	47	55	67
EPBD	43	47	54	63
7cm	43	48	54	64
10cm	43	48	55	64
12 cm	44	48	55	64

Table 68 Variation (%) of the cooling load compared to the reference building

Cooling load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
EPBD	4	1	-2	-5
7cm	5	2	-1	-4
10cm	6	3	-1	-4
12 cm	6	3	0	-4

Table 69 Variation in kWh/m^2/year of the cooling load compared to the reference building

Cooling load – Difference in kWh/m^2 /year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
EPBD	1	1	-1	-3
7cm	2	1	0	-3
10cm	2	1	0	-3
12 cm	2	1	0	-3

8.4.3. ‘Switch off & Reflect’ principle

8.4.3.1. Glazing

- **Heating load**

Table 70 Impact of different glazing types on the heating load of the building for the present day and the years 2020, 2050 and 2080

Heating load kWh/m^2/year				
	Present day	**2020**	**2050**	**2080**
Reference	61	52	43	33
Double Uopen=2.95 W/m^{2}K, g=0.8	57	49	40	31
Double low e Uopen =1.8 W/m^{2}K, g=0.6	56	48	40	30
Double low e Uopen =1.8 W/m^{2}K, g=0.45	56	48	40	30
Double low e with argon Uopen 1.43 g=0.6	54	46	38	29
Double low e Uopen 1.00 g=0.55	53	45	37	28

Table 71 Variation (%) of the heating load compared to the reference building

Heating load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Double Uopen=2.95 W/m^{2}K, g=0.8	-6	-6	-7	-7
Double low e Uopen =1.8 W/m^{2}K, g=0.6	-8	-9	-9	-9
Double low e Uopen =1.8 W/m^{2}K, g=0.45	-8	-8	-8	-9
Double low e with argon Uopen 1.43 g=0.6	-12	-12	-13	-13
Double low e Uopen 1.00 g=0.55	-13	-13	-14	-14

Table 72 Variation in KWh/m^2/year of the heating load compared to the reference building

Heating loads – Difference in kWh/m^2 /year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Double Uopen=2.95 W/m^{2}K, g=0.8	-4	-3	-3	-2
Double low e Uopen =1.8 W/m^{2}K, g=0.6	-5	-4	-4	-3
Double low e Uopen =1.8 W/m^{2}K, g=0.45	-5	-4	-4	-3
Double low e with argon Uopen 1.43 g=0.6	-7	-6	-6	-4
Double low e Uopen 1.00 g=0.55	-8	-7	-6	-5

- **Cooling load**

Table 73 Impact of different glazing types on the cooling load of the building for the present day and the years 2020, 2050 and 2080

Cooling load kWh/m²/year				
	Present day	**2020**	**2050**	**2080**
Reference	41	47	55	67
Double Uopen=2.95 W/m²K, g=0.8	41	47	55	67
Double low e Uopen =1.8 W/m²K, g=0.6	40	45	53	64
Double low e Uopen =1.8 W/m²K, g=0.45	38	43	51	62
Double low e with argon Uopen 1.43 g=0.6	40	46	53	64
Double low e Uopen 1.00 g=0.55	40	45	53	63

Table 74 Variation (%) of the cooling load compared to the reference building

Cooling load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Double Uopen=2.95 W/m²K, g=0.8	1	1	0	0
Double low e Uopen =1.8 W/m²K, g=0.6	-4	-4	-4	-4
Double low e Uopen =1.8 W/m²K, g=0.45	-8	-8	-8	-8
Double low e with argon Uopen 1.43 g=0.6	-2	-2	-3	-3
Double low e Uopen 1.00 g=0.55	-4	-4	-4	-5

Table 75 Variation in KWh/m^2/year of the cooling load compared to the reference building

Cooling load – Difference in kWh/m^2 /year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Double Uopen=2.95 W/m^{2}K, g=0.8	0	0	0	0
Double low e Uopen =1.8 W/m^{2}K, g=0.6	-2	-2	-2	-3
Double low e Uopen =1.8 W/m^{2}K, g=0.45	-3	-4	-4	-5
Double low e with argon Uopen 1.43 g=0.6	-1	-1	-2	-3
Double low e Uopen 1.00 g=0.55	-2	-2	-2	-4

8.4.3.2. Shading

- **Heating load**

Table 76 Impact of different shading solutions on the heating load of the building for the present day and the years 2020, 2050 and 2080

Heating load kWh/m^2/year				
	Present day	**2020**	**2050**	**2080**
Reference	61	52	43	33
corridors shad.fact 0.5	62	53	44	33
corridors shad.fact 0.7	62	53	45	34
coridors shad.fact 0.8	63	54	45	34
corridors shad.fact 0.8 & rooms 0.5	64	55	46	35
corridors shad.fact 0.8 & rooms 0.7	64	55	46	35

Table 77 Variation (%) of the heating load compared to the reference building

Heating load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Corridors shad.fact 0.5	1	1	1	1
Corridors shad.fact 0.7	2	3	3	3
coridors shad.fact 0.8	3	3	3	3
corridors shad.fact 0.8 & rooms 0.5	5	5	5	6
corridors shad.fact 0.8 & rooms 0.7	6	6	6	7

Table 78 Variation in KWh/m^2/year of the heating load compared to the reference building

Heating load – Difference in kWh/m^2/year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
corridors shad.fact 0.5	1	1	1	0
corridors shad.fact 0.7	1	1	1	1
coridors shad.fact 0.8	2	2	1	1
corridors shad.fact 0.8 & rooms 0.5	3	3	2	2
corridors shad.fact 0.8 & rooms 0.7	3	3	3	2

- **Cooling load**

Table 79 Impact of different shading solutions on the cooling load of the building for the present day and the years 2020, 2050 and 2080

Cooling load kWh/m²/year				
	Present day	**2020**	**2050**	**2080**
Reference	41	47	55	67
corridors shad.fact 0.5	41	46	54	66
corridors shad.fact 0.7	40	46	54	65
coridors shad.fact 0.8	40	46	53	65
corridors shad.fact 0.8 & rooms 0.5	38	43	51	63
corridors shad.fact 0.8 & rooms 0.7	37	42	50	61

Table 80 Variation (%) of the cooling load compared to the reference building

Cooling load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
corridors shad.fact 0.5	-1	-1	-1	-1
corridors shad.fact 0.7	-3	-2	-2	-2
coridors shad.fact 0.8	-3	-3	-3	-2
corridors shad.fact 0.8 & rooms 0.5	-8	-7	-6	-6
corridors shad.fact 0.8 & rooms 0.7	-11	-10	-9	-8

Table 81 Variation in KWh/m^2/year of the cooling load compared to the reference building

Cooling load – Difference in kWh/m²/year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
corridors shad.fact 0.5	0	-1	-1	-1
corridors shad.fact 0.7	-1	-1	-1	-2
coridors shad.fact 0.8	-1	-1	-2	-2
corridors shad.fact 0.8 & rooms 0.5	-3	-4	-4	-4
corridors shad.fact 0.8 & rooms 0.7	-4	-5	-5	-6

8.4.4. ‘Reflect’ principle - Cool materials

- **Heating load**

Table 82 Impact of cool materials on the heating load of the building for the present day and the years 2020, 2050 and 2080

Heating load kWh/m^2/year				
	Present day	**2020**	**2050**	**2080**
reference	61	52	43	33
walls 0.2	64	55	46	35
walls 0.2, roof 0.2	69	60	50	38

Table 83 Variation (%) of the heating load compared to the reference building

Heating load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
reference				
walls 0.2	6	6	7	7
walls 0.2, roof 0.2	14	15	16	17

Table 84 Variation in KWh/m^2/year of the heating load compared to the reference building

Heating load – Difference in kWh/m^2/year from reference building				
	Present day	**2020**	**2050**	**2080**
reference				
walls 0.2	4	3	3	2
walls 0.2, roof 0.2	8	8	7	6

- **Cooling load**

Table 85 Impact of cool materials on the cooling load of the building for the present day and the years 2020, 2050 and 2080

Cooling load kWh/m²/year				
	Present day	**2020**	**2050**	**2080**
reference	41	47	55	67
walls 0.2	36	42	50	61
walls 0.2, roof 0.2	29	34	41	52

Table 86 Variation (%) of the cooling load compared to the reference building

Cooling load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
reference				
walls 0.2	-11	-10	-9	-8
walls 0.2, roof 0.2	-30	-28	-25	-23

Table 87 Variation in KWh/m^2/year of the cooling load compared to the reference building

Cooling load – Difference in kWh/m²/year from reference building				
	Present day	**2020**	**2050**	**2080**
reference				
walls 0.2	-5	-5	-5	-6
walls 0.2, roof 0.2	-12	-13	-14	-15

8.4.5. ‘Blow away principle’ - Ventilation

- **Heating load**

Table 88 Impact of ventilation control on the heating load of the building for the present day and the years 2020, 2050 and 2080

Heating load kWh/m²/year				
	Present day	**2020**	**2050**	**2080**
Reference	61	52	43	33
Day time vent indoor temp > 23°C & outdoor temperature < 25°C	59	51	42	31
Day time vent indoor temp > 23°C & indoor temp >outdoor temp	59	51	42	31
Night vent at a constant rate , 5 ach from 23:00 – 7:00	109	96	82	66
Night Vent when indoor temp of each > 23°C, 23:00 – 7:00	58	49	41	31
Night Vent when the outdoor temp > 15°C, 23:00 – 7:00	63	54	45	34

Table 89 Variation (%) of the heating load compared to the reference building

Heating load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Day time vent indoor temp > 23°C & outdoor temperature < 25°C	-2	-3	-3	-4
Day time vent indoor temp > 23°C & indoor temp >outdoor temp	-2	-3	-3	-4
Night vent at a constant rate , 5 ach from 23:00 – 7:00	80	84	90	100
Night Vent when indoor temp of each > 23°C, 23:00 – 7:00	-4	-5	-6	-7
Night Vent when the outdoor temp > 15°C, 23:00 – 7:00	4	4	4	4

Table 90 Variation in KWh/m^2/year of the heating load compared to the reference building

Heating load – Difference in kWh/m^2/year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Day time vent indoor temp > 23°C & outdoor temperature < 25°C	-1	-1	-1	-1
Day time vent indoor temp > 23°C & indoor temp >outdoor temp	-1	-1	-1	-1
Night vent at a constant rate , 5 ach from 23:00 – 7:00	49	44	39	33
Night Vent when indoor temp of each > 23°C, 23:00 – 7:00	-3	-3	-3	-2
Night Vent when the outdoor temp > 15°C, 23:00 – 7:00	2	2	2	1

❖ Cooling load

Table 91 Impact of ventilation control on the cooling load of the building for the present day and the years 2020, 2050 and 2080

Cooling load kWh/m^2/year				
	Present day	**2020**	**2050**	**2080**
Reference	41	47	55	67
Day time vent indoor temp > 23°C & outdoor temperature < 25°C	35	41	49	62
Day time vent indoor temp > 23°C & indoor temp >outdoor temp	33	39	47	59
Night vent at a constant rate , 5 ach from 23:00 – 7:00	24	29	38	51
Night Vent when indoor temp of each > 23°C, 23:00 – 7:00	23	28	36	50
Night Vent when the outdoor temp > 15°C, 23:00 – 7:00	23	28	37	51

Table 92 Variation (%) of the cooling load compared to the reference building

Cooling load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Day time vent indoor temp > 23°C & outdoor temperature < 25°C	-15	-12	-10	-7
Day time vent indoor temp > 23°C & indoor temp >outdoor temp	-20	-17	-14	-11
Night vent at a constant rate , 5 ach from 23:00 – 7:00	-42	-37	-31	-23
Night Vent when indoor temp of each > 23°C, 23:00 – 7:00	-44	-40	-34	-25
Night Vent when the outdoor temp > 15°C, 23:00 – 7:00	-45	-40	-33	-23

Table 93 Variation in KWh/m^2/year of the cooling load compared to the reference building

Cooling loads – Difference in kWh/m^2/year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Day time vent indoor temp > 23°C & outdoor temperature < 25°C	-6	-6	-5	-5
Day time vent indoor temp > 23°C & indoor temp >outdoor temp	-8	-8	-8	-7
Night vent at a constant rate , 5 ach from 23:00 – 7:00	-17	-17	-17	-16
Night Vent when indoor temp of each > 23°C, 23:00 – 7:00	-18	-19	-18	-17
Night Vent when the outdoor temp > 15°C, 23:00 – 7:00	-18	-19	-18	-16

8.4.6. ‘Convection’ principle - Ceiling fans

- **Cooling load**

Table 94 Impact of ceiling fans on the cooling load of the building for the present day and the years 2020, 2050 and 2080

Cooling load kWh/m^2/year				
	Present day	**2020**	**2050**	**2080**
Reference	41	47	55	67
Ceiling fans at the rooms	32	38	45	56

Table 95 Variation (%) of the cooling load compared to the reference building

Cooling load – Variation % from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Ceiling fans at the rooms	-21	-20	-18	-16

Table 96 Variation in KWh/m^2/year of the cooling load compared to the reference building

Cooling load – Difference in kWh/m^2/year from reference building				
	Present day	**2020**	**2050**	**2080**
Reference				
Ceiling fans at the rooms	-9	-9	-10	-11

8.5. Discussion

Reference building: As expected, due to the climate change and the increase of the air temperature, the cooling load of the building increases. Compared to the present day, this is increased by 15% (in year 2020), 34% (in year 2050) and 63% (in year 2080). Heating load is decreased by 15% (in year 2020), 30% (in year 2050) and 46% (in year 2080).

For the year 2080 the increase of the cooling load is disproportionally higher compared to the decrease of the heating load meaning that after the year 2050 the increase of the outdoor temperature will have a significant penalty on the cooling demand of the building.

- ***Heating load***

The 'absorb' principle illustrated by adding insulation and thus lowering the U-values of the building components has the major impact among the techniques on the heating load. The highest energy savings are achieved when using 10cm in the external walls and roof. The simulations showed that beyond this width, there is no extra benefit for the building. Therefore, for the case of 10 cm, the energy savings are 38 kWh/m^2/year for the present climatic file (or 62%), 33 kWh/m^2/year for year 2020 (or 64%), 28 kWh/m^2/year for year 2050 (or 66%) and 23 kWh/m^2/year for year 2080 (or 69%).

The use of glazing that summarizes both the principles 'switch off' and 'reflect' results in significant reduction of heating load. The glazing configuration of U-value 1.00 W/m^{2}K and g=0.55 results in the highest energy savings of 13% in all climatic files, or 8 kWh/m^2/year in the present climatic file, 7 kWh/m^2/year in year 2020, 6 kWh/m^2/year in year 2050 and 5 kWh/m^2/year in year 2080. Also a U-value of 1.80 W/m^{2}K and g=0.6 results in an 11% reduction of heating load in all climatic files.

The 'blow away' principle illustrated by intelligent ventilation both in day and night has small impact on the heating load. Both controls of the *day time* ventilation minimize the heating load by 1 kWh/m^2/year in all climatic files (or 2-3%). Concerning the *night ventilation control*, the heating load decreases slightly by 4% in all climatic files in the case of night ventilation that performs at indoor temperature >23°C. When there is no any control in the function of night ventilation, then the heating load increases significantly. Therefore no control of night ventilation is not recommended.

As expected, both principles 'switch off' illustrated by the shading technique and 'reflect' illustrated by the application of cool materials have a negative impact on the heating load. In the case of shading the highest increase occurs when using shading coefficient 0.7 and 0.8 in the rooms and corridors respectively, and this is around 6% in all climatic files (or ~3kWh/m^2/year). The increase is higher when applying cool materials both in external walls and roof and this is around 15% in all periods.

- ***Cooling load***

Ventilation that epitomizes the ‘blow away’ principle has the major impact on the cooling load of the building. All controls results in significant energy savings. The highest ones are achieved when the night ventilation operates at internal zone temperatures above 23°C. In that case the energy savings are 18 kWh/m^2/year for the present climate file (or 44%), 19 kWh/m^2/year for year 2020 (or 40%), 18 kWh/m^2/year for year 2050 (or 34%) and 17 kWh/m^2/year for year 2080 (or 25%).Very similar results are noted when night ventilation operates at outdoor temperature above 15°C, however as aforementioned this technique has a negative effect on the heating load.

The ‘reflect’ principle with the use of cool materials has also major impact on the cooling load. The highest energy savings are achieved when using cool materials both in the external walls and roof, and in that case the cooling load decreases by 30% in the present year (or 12 kWh/m^2/year) and 23% in the year 2080 (or 15 kWh/m^2/year).

The adjustment of the cooling set point is the third technique in the rank resulting in high energy savings and it is illustrated by the use of ceiling fans or the ‘convection’ principle. In that case the cooling load decreases 9 kWh/m^2/year in the present climate file and 11 kWh/m^2/year in year 2080 (21% and 16% respectively).

Also, the principle ‘switch off’ with the use of shading plays an important role. The building takes best benefit when applying high shading factors of 0.8 in both the rooms of northwestern orientation and the corridors of southern orientation. In that case, in all climatic files the highest energy savings are approx. 10%, or approx. 5 kWh/m^2/year.

Finally and compared to the other techniques, the use of low emissivity glazing has a moderate impact. The best benefit is when using a glazing configuration of U-value 1.80 W/m^{2}K and g=0.45 that results in energy savings of 8% in all climatic files, or 3 kWh/m^2/year in the present climate file, 4 kWh/m^2/year in year 2020, 4 kWh/m^2/year in year 2050 and 5 kWh/m^2/year in year 2080.

As expected the ‘switch off & absorb’ principle illustrated by adding insulation has little effect on the cooling load. An insulation width greater than 10cm does not provide further modification to the cooling load. This is a 6% increase in the present climatic file (or + 2kWh/m^2/year), 3% increase in year 2020, whereas a slight reduction of cooling demand by 1% is noted for year 2050 and 4% reduction for year 2080.

For this type of building that is operating during the cooling period and taking into consideration the increase of the cooling load due to the climate change, it seems that the choice of an intelligent ventilation control, the application of cool materials and the adjustment of the cooling setpoint are the most suitable energy efficient techniques to mitigate the consequences of the climate change. Although the upgrade of the building envelope is mandatory, for that type of building that operates mainly during the cooling period, ,insulation could be the last technique to invest on as simulations show that it would reduce the cooling demand after the year 2050; on the other hand excessive width of insulation might aggravate the thermal comfort levels. Concerning the shading, although in other circumstances this technique would have a significant impact on the cooling demand, for the specific demonstration hotel has a medium impact because of the orientation of the large glazing surfaces that are facing northwest.

CHAPTER 9

Definition of Optimum Building for Patra (climatic zone B)

9 Definition of Optimum Building for Patra (climatic zone B)

9.1. Introduction

This chapter defines the 'optimum' building' for the present day, period 2020, 2050 and 2080 as a response to the climate change. The 'optimum' building is the one that comprises the most energy efficient techniques as these are defined by the simulation results in chapter 8. The investigated climate change adaptation methods focus on the upgrade of the building envelope by controlling the solar and heat gains and are based on the principles: 'blow away' (intelligently day and night ventilation), 'switch off' (shading), 'reflect' (cool materials), 'absorb and switch off' (insulation), 'switch off and reflect' (energy efficient glazing) and 'absorb' (thermal mass). Additionally the convection principle is assessed with the adjustment of the cooling set point (ceiling fans) for further reduction of the cooling demand.

The present chapter aims to:

- Calculate the energy profile (heating and cooling load, kWh/m^2/yr) of the optimum buildings in the present year, in year 2020, 2050 and 2080.
- Assess the impact factor of the most efficient mitigation strategies taking into consideration the operation of the hotel buildings in order to facilitate the building owners to understand the priorities when retrofitting their hotels planning on a short term or a long term future. Therefore different techniques are proposed for 'all year' and 'seasonally' operated buildings.

9.2. Methodology

The most energy efficient strategies as these are defined in chapter 8 are applied to the reference hotel building in order to identify the 'optimum' building for the present day, year 2020, year 2050 and year 2080. Simulations using TRNSYS are performed for the optimum buildings in order to calculate the heating and cooling loads (kWh/m^2/yr). The simulations are performed for the typical hotel building located in climatic zone B.

Simulation results of chapter 8 show that the most efficient mitigation strategies are not necessarily the same for all climatic periods; therefore for each climatic period one ‘optimum’ building is defined. Additionally, two modes of operation are simulated: ‘all year’ and ‘seasonally’ operated buildings. Therefore, 4 optimum buildings with all year operation are assigned, (optimum building for present day, optimum building for year 2020, for 2050 and for 2080-Table 97) and respectively 4 optimum buildings with ‘seasonal’ operation are assigned (optimum building for present day, optimum building for year 2020, for 2050 and for 2080,Table 101).

- ‘All year’ operated hotel

The selected principles and energy techniques are those that have the best benefit for the building for both the heating and cooling period.

- ‘Seasonally’ operated hotel

The selected principles and energy techniques are those that have the best benefit for the cooling period. In that case the building is operating during the months May to September. The simulations are carried out for the whole year but heating, cooling, ventilation and all internal gains (lighting, people) are operating only for the months May – September and for the rest of months (January – April and October to December) the systems and internal gains are set to 0.

Thermal mass: Increased thermal mass is applied to the ‘seasonally’ and ‘all year’ operated buildings to investigate further reduction of cooling load. This is realized by applying thicker walls with brickwork of increased density. The initial width of the external walls increases from 20cm to 50cm.

9.3. Building with all year operation

The optimum energy measures for an ‘all year’ operated building are those that provide the best benefit for both the cooling and heating period. Based on the simulation results of chapter 8, the heating load is reduced significantly with the use of a. insulation and then b. double low emissivity glazing. The ‘switch off & absorb’ principle illustrated by insulation has the major impact. This technique should be used for the ‘all year’ operated building that currently has no insulation although its use would have a small penalty on the cooling load for the present year and years 2020 and 2050. However, the simulations show that the cooling period is also favored by the insulation technique in year 2080. Concerning the glazing, a configuration of U-value 1.00W/m^{2}K and g=0.55 results in the highest energy savings for both the heating and cooling period. The 'blow away' principle illustrated by intelligent ventilation both in day and night has a major impact on the cooling load but also on the heating load. Among the controls of *night* ventilation the one that performs at indoor temperature >23°C results in the highest energy savings in both the heating and cooling period. Among the controls of *day* time ventilation the one that performs at indoor temperature of each zone >23°C and indoor temperature > outdoor temperature results on the highest energy savings for both the heating and cooling period.

Concerning the use of cool materials, these could be dropped, or alternatively applied only for year 2080 where, compared to the other climatic files, the smallest penalty on the heating load (2 kWh/m^2/yr increase) is calculated. Ceiling fans are also suggested for a building with all year operation as their use has a significant impact on the cooling load and no impact on the heating load. The 'switch off' principle illustrated by the shading technique has varying impact depending on the shading factor. In order to have the maximum benefit for the cooling period, different shading factors are selected for each climate period assuming in all cases a minimum 2 kWh/m^2/yr increase of heating load.

The selected energy techniques for an all year operated building and for each period are shown with hierarchy in Table 97 considering their impact on the cooling and heating load (kWk/m^2/yr). The optimum building for each period is the one that comprises the following:

- The optimum building for **the present day** comprises: Insulation in external walls and roof, double low e glazing, intelligently controlled night ventilation (operating at indoor temperature >23°C), intelligently controlled day ventilation, ceiling fans in the rooms and shading to the corridors with a shading factor 0.8.
- The optimum building for **year 2020** comprises: Insulation in external walls and roof, double low e glazing, intelligently controlled night ventilation (operating at indoor temperature >23°C), intelligently controlled day ventilation, ceiling fans in the rooms and shading to the corridors with a shading factor 0.8.
- The optimum building for **year 2050** comprises: Insulation in external walls and roof, double low e glazing, intelligently controlled night ventilation (operating at indoor temperature >23°C), intelligently controlled day ventilation, ceiling fans in the rooms, shading to the corridors with a shading factor 0.8 *and shading to the rooms with a shading factor 0.5*

- The optimum building for **year 2080** comprises: Insulation in external walls and roof, double low e glazing, intelligently controlled night ventilation (operating at indoor temperature >23°C), intelligently controlled day ventilation, ceiling fans in the rooms*, cool materials on external walls*, shading to the corridors with a shading factor 0.8 and shading to the rooms *with a shading factor 0.7*

The optimum building for present day and the optimum building for year 2020 comprise the same energy techniques. The optimum building for year 2050 comprises also the same techniques but includes more shading (higher shading factor). The optimum building for year 2080 includes even more shading and is also equipped with cool materials on the walls.

The energy measures for each period are shown in Table 97.

Table 97 Energy saving techniques for a building with all year operation

Energy saving techniques for a building with all year operation **.**							
	Principle	**Energy measure**	**Description**	**Present day**	**2020**	**2050**	**2080**
heating	1. Switch off & Absorb	Insulation	10 cm in external walls & roof, Uroof=0.32W/m^{2}K, Uwalls=0.25 W/m^{2}K	X	X	x	x
	2. Switch off &Reflect	Low e glazing	Double low e glazing Uopen= 1.06 W/m^{2}K, g=0.55	X	x	x	x
	3a. Blow away	Intelligently controlled **night** ventilation	Night ventilation when indoor temp of each zone > 23°C, 23:00 – 7:00	X	x	x	x
	3b. Blow away	Intelligently controlled **day** ventilation	Day ventilation when the indoor temp of each zone is greater than 23°C and external temperature lower than 25°C **or** day ventilation when the indoor temp of each zone is greater than 23°C and external temperature lower than internal temperature in each zone	X	x	x	x
cooling	4. Reflect	Cool materials	External walls 0.2 solar absorptance				x
	5. Convection	Ceiling fans in rooms	cooling set point of rooms at 27°C (instead of 26°C), increase of 1°C assuming that the fans cover 60% of the thermal zone – TOTEE 20701-1	X	x	x	x
	6a. Switch off	Shading	Corridors shad.fact 0.8	X	x		
	6b. Switch off	Shading	corridors shad.fact 0.8 & rooms 0.5			x	
	6c. Switch off	Shading	corridors shad.fact 0.8 & rooms 0.7				x

9.3.1. Simulation results for optimum building with all year operation

- Heating and cooling load

Table 98 Heating and cooling load (kWh/m^2/yr) of the optimum buildings for the different climatic periods

	Heating Load (kWh/m^2/yr)	Cooling Load (kWh/m^2/yr)
Present day	21	8
2020	16	11
2050	13	15
2080	9	22

- Heating load – variation from the reference building

Table 99 Heating load (kWh/m^2/yr) of the optimum buildings and their variation from the reference building

Heating load (kWh/m^2/yr)				
	Reference building	Optimum building	Variation % from reference building	Variation in kWh/m^2/yr
Present day	61	21	-66	-40
2020	52	16	-69	-36
2050	43	13	-70	-30
2080	33	9	-73	-24

- Cooling load – variation form the reference building

Table 100 Cooling load (kWh/m^2/yr) of the optimum buildings and their variation from the reference building

Cooling load (kWh/m^2/yr)				
	Reference building	Optimum building	Variation % from reference building	Variation in kWh/m^2/yr
Present day	41	8	-80	-33
2020	47	11	-77	-36
2050	55	15	-73	-40
2080	67	22	-67	-45

9.4. Building with seasonal operation

Concerning a hotel with seasonal operation (months May – September), the optimum energy measures are those that achieve the maximum reduction of the cooling load. Based on the simulation results of chapter 8, night ventilation that epitomizes the ‘blow away’ principle has the major impact on the cooling load of the building. The simulations show that slight different results are achieved according to the ventilation control. Therefore, for the present day climate file and year 2020 the maximum energy savings in the area of night ventilation occur when night ventilation performs at outdoor temperature greater than 15°C, whereas for the years 2050 and 2080 the maximum energy savings are achieved when night ventilation performs at indoor temperature > 23°C.

The ‘reflect’ principle with the use of cool materials is the second technique with a major impact on the cooling load. The ‘convection’ principle illustrated by the use of ceiling fans is the third optimum energy saving technique, and this is followed by the use of intelligently controlled day ventilation, the shading technique and the glazing with a U-value of 1.8 W/m^2K and g=0.45. The ‘switch off & absorb’ principle illustrated by the use of insulation favors the heating period and has a negative impact on the cooling period for the present day file, and the climate files 2020 and 2050. However, the simulation shows a positive impact of this technique on the cooling load for year 2080 and thus is selected to be applied for the optimum building for year 2080.

The selected energy techniques for each period are shown in Table 101. The energy techniques are shown with hierarchy considering their impact on the cooling load ($kWk/m^2/yr$). The optimum building for each period is the one that comprises the total energy saving techniques. Therefore:

- The optimum building for **the present day** comprises: Intelligently controlled night ventilation (operating at outdoor temperature >15°C), cool materials, ceiling fans, intelligently controlled day ventilation, shading and double low e glazing.
- The optimum building for **the year 2020** comprises: Intelligently controlled night ventilation (operating at outdoor temperature >15°C), cool materials, ceiling fans, intelligently controlled day ventilation, shading and double low e glazing.

- The optimum building for **the year 2050** comprises: Intelligently controlled night ventilation (*operating at indoor temperature >23°C*), cool materials, ceiling fans, intelligently controlled day ventilation, shading and double low e glazing.
- The optimum building for **the year 2080** comprises: Intelligently controlled night ventilation (*operating at indoor temperature >23°C*), cool materials, ceiling fans, intelligently controlled day ventilation, shading, double low e glazing *and insulation*.

The optimum building for the present day and year 2020 comprise the same energy techniques. The optimum building for year 2050 and year 2080 differ in the type of night ventilation control. Additionally, the optimum building for year 2080 is equipped with insulation.

Table 101 shows the energy techniques for the optimum buildings for each climatic period.

Table 101 Energy saving techniques for the optimum building with seasonal operation

<table>
<tr><th colspan="7">Energy saving techniques for the optimum building with seasonal operation. The energy savings are shown with hierarchy considering their impact (reduction) on the cooling load kWh/m^2/year</th></tr>
<tr><th>Principle</th><th>Energy measure</th><th>Description</th><th>Present day</th><th>2020</th><th>2050</th><th>2080</th></tr>
<tr><td>1a. Blow away</td><td>Intelligently controlled night ventilation</td><td>Night ventilation when indoor temp of each zone > 23°C, 23:00 – 7:00</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>1b. Blow away</td><td>Intelligently controlled night ventilation</td><td>Night ventilation when the outdoor temperature is greater than 15°C, 23:00 – 7:00</td><td>X</td><td>x</td><td></td><td></td></tr>
<tr><td>2. Reflect</td><td>Cool materials</td><td>External walls and roof 0.2 solar absorptance</td><td>X</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>3. Convection</td><td>Ceiling fans in rooms</td><td>cooling set point of rooms at 27°C (instead of 26°C), increase of 1°C assuming that the fans cover 60% of the thermal zone – TOTEE 20701-1</td><td>X</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>4. blow away</td><td>Intelligently controlled day ventilation</td><td>Day time vent indoor temp > 23C & indoor temp >outdoor temp</td><td>X</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>5. Switch off</td><td>Shading</td><td>Shading factor: corridors 0.8, rooms :0.7</td><td>X</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>6. Switch off &Reflect</td><td>Low e glazing</td><td>Double low e Uopen=1.8 W/m^2K, g=0.45</td><td>X</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>7. Switch off & Absorb</td><td>Insulation</td><td>10 cm in external walls & roof, Uroof=0.32W/m^2K, Uwalls=0.25 W/m^2K</td><td></td><td></td><td></td><td>x</td></tr>
</table>

9.4.1. Simulation results for optimum building with seasonal operation

9.4.1.1. Seasonal building operating the months May -September

Table 102 Heating and cooling load (kWh/m^2/yr) for the seasonal building when operating seasonally

Heating, cooling ventilation operating May - September	Heating load (kWh/m^2/yr)	Cooling load (kWh/m^2/yr)
Present day	1	6
2020	1	8
2050	1	13
2080	1	19

- Cooling load – Variation (%) from reference building

Table 103 Cooling load (kWh/m^2/yr) for the seasonal building when operating seasonally and variation from the reference building

Cooling load (kWh/m^2/yr)				
	Reference building	Optimum building	Variation % from reference building	Variation kWh/m^2/yr from reference building
Present day	41	6	-85	-35
2020	47	8	-83	-39
2050	55	13	-76	-42
2080	67	19	-72	-48

9.4.1.2. Seasonal building operating all year

Table 104 Heating and cooling load (kWh/m^2/yr) for the seasonal building when operating all year

Heating, cooling ventilation operating all year	Heating load (kWh/m^2/yr)	Cooling load (kWh/m^2/yr)
Present day	73	6
2020	64	8
2050	52	13
2080	12	19

9.5. Optimum building and increased thermal mass

The principle ‘absorb’ is investigated in the case of the optimum buildings in order to investigate further reduction of the cooling load. This is realized by applying increased thermal mass, thus by applying thicker walls to the building with brickwork of increased density.

9.5.1. Initial building construction for optimum building

The building construction is from brickwork of total width 20cm. Insulation is applied to the ‘all year’ operated buildings (present year, year 2020, 2050 and 2080) and the seasonally operated building of year 2080. The ‘seasonally’ operated optimum buildings of the present day, year 2020 and year 2050 do not have insulation. Therefore the thermal response factor is calculated for three types of buildings: 1. optimum building with no insulation, 2. optimum building with insulation –seasonally operated, and 3. optimum building with insulation – all year operated. The cases (2) and (3) differ in the type of glazing. The U-values are calculated by the software used for the simulations (TRNSYS). Based on these U-values, the admittance values are taken by the tables 3.49 – 3.53 of CIBSE Guide A. Also, the admittance values are calculated using the Dynamic Thermal Property Calculator (ver 1.0), developed by Arup and based on ISO 13786, (BS EN ISO 13786:2007). The calculated admittance values are very close to these of tables 3.49 – 3.53 of CIBSE Guide A.

The thermal response factors of the optimum buildings are:

- Optimum building with no thermal insulation (seasonally operated of present year and years 2020, 2050): f_r = **3.35 < 4**

Table 105 Building properties for the optimum building with no insulation

	Area (m^2)	U (W/m^2K)	AU (W/K)	Y (W/m^2K)	AY (W/K)
external wall	2864.00	2.20	6300.80	3.55	10167.20
internal partition	5289.32			3.76	19887.82
internal floor	3383.00			5.44	18403.52
roof	1580.00	3.06	4830.06	5.06	7994.80
glazing double low e	353.00	1.80	621.28	1.80	621.28
glazing double low e	295.00	1.80	519.20	1.80	519.20
ground floor	1580.00	3.09	4885.36	3.59	5672.20
sum	**15344.32**		**17156.70**		**63266.02**
			Σ(AU)		Σ(AY)

- Optimum building with thermal insulation (seasonally operated, year 2080): f_r = **6.75 > 4**

Table 106 Building properties for the optimum building with insulation – seasonally operated

	Area (m^2)	U (W/m^2K)	AU (W/K)	Y (W/m^2K)	AY (W/K)
external wall	2864.00	0.25	716.00	3.55	10167.20
internal partition	5289.32			3.76	19887.82
internal floor	3383.00			5.44	18403.52
roof	1580.00	0.32	505.60	5.06	7994.80
glazing double low e	353.00	1.80	621.28	1.80	621.28
glazing double low e	295.00	1.80	519.20	1.80	519.20
ground floor	1580.00	3.09	4885.36	3.59	5672.20
sum	**15344.32**		**7247.44**		**63266.02**
			Σ(AU)		Σ(AY)

- Optimum building with thermal insulation (all year operated): f_r **= 7.00 > 4**

Table 107 Building properties for the optimum building with insulation – all year operated

	Area (m^2)	U (W/m^2K)	AU (W/K)	Y (W/m^2K)	AY (W/K)
external wall	2864.00	0.25	716.00	3.55	10167.20
internal partition	5289.32			3.76	19887.82
internal floor	3383.00			5.44	18403.52
roof	1580.00	0.32	505.60	5.06	7994.80
glazing double low e	353.00	1.00	353.00	1.00	353.00
glazing double low e	295.00	1.00	295.00	1.00	295.00
ground floor	1580.00	3.09	4885.36	3.59	5672.20
sum	**15344.32**		**6754.96**		**62773.54**
			Σ(AU)		Σ(AY)

9.5.2. Optimum building construction with increased thermal mass

Thicker walls are applied to the building construction with brickwork of higher density. The total width of the external walls increases from 20cm to 50cm.

The thermal response factors of the optimum buildings with increased thermal mass are:

- Optimum building with no thermal insulation (seasonally operated, present year and years 2020, 2050, glazing): f_r **= 3.92 < 4**

Table 108 Building properties for the optimum building with no thermal insulation and increased thermal mass – seasonally operated

	Area (m^2)	U (W/m^2K)	AU (W/K)	Y (W/m^2K)	AY (W/K)
external wall	2864.00	1.20	3425.34	3.56	10167.20
internal partition	5289.32			3.76	19887.82
internal floor	3383.00			5.44	18403.52
Roof	1580.00	3.06	4830.06	5.06	7994.80
glazing double low e	353.00	1.80	621.28	1.80	621.28
glazing double low e	295.00	1.80	519.20	1.80	519.20
ground floor	1580.00	3.09	4885.36	3.59	5672.20
Sum	**15344.32**		**14281.24**		**63266.02**
			Σ(AU)		Σ(AY)

- Optimum building with thermal insulation (seasonally operated, year 2080): f_r = **6.80 > 4**

Table 109 Building properties for the optimum building with thermal insulation and increased thermal mass – seasonally operated

	Area (m^2)	U (W/m^2K)	AU (W/K)	Y (W/m^2K)	AY (W/K)
external wall	2864.00	0.23	658.72	3.56	10167.20
internal partition	5289.32			3.76	19887.82
internal floor	3383.00			5.44	18403.52
Roof	1580.00	0.32	505.60	5.06	7994.80
glazing double low e	353.00	1.80	621.28	1.80	621.28
glazing double low e	295.00	1.80	519.20	1.80	519.20
ground floor	1580.00	3.09	4885.36	3.59	5672.20
Sum	**15344.32**		**7190.16**		**63266.02**
			Σ(AU)		Σ(AY)

- Optimum building with thermal insulation (all year operated) : f_r **= 7.10 > 4**

Table 110 Building properties for the optimum building with thermal insulation and increased thermal mass – all year operated

	Area (m^2)	U (W/m^2K)	AU (W/K)	Y (W/m^2K)	AY (W/K)
external wall	2864.00	0.23	658.72	3.56	10167.20
internal partition	5289.32			3.76	19887.82
internal floor	3383.00			5.44	18403.52
roof	1580.00	0.32	505.60	5.06	7994.80
glazing double low e	353.00	1.00	353.00	1.00	353.00
glazing double low e	295.00	1.00	295.00	1.00	295.00
ground floor	1580.00	3.09	4885.36	3.59	5672.20
sum	**15344.32**		**6697.68**		**62773.54**
			Σ(AU)		Σ(AY)

9.6. Simulation results for increased thermal mass

9.6.1. Optimum building ‘all year ‘ operated

Table 111 Cooling and heating load (kWh/m^2/yr) for the ‘all year’ operated building with increased thermal mass

	Heating load (kWh/m^2/yr)	Cooling load (kWh/m^2/yr)
Present day	21	8
2020	16	11
2050	13	15
2080	9	22

9.6.2. Optimum building ‘seasonally ‘ operated

Table 112 Cooling and heating load (kWh/m^2/yr) for the ‘seasonally’ operated building with increased thermal mass

	Heating load (kWh/m^2/yr)	Cooling load (kWh/m^2/yr)
Present day	1	5
2020	1	8
2050	1	12
2080	1	19

9.7. Discussion

As a response to the climate change, the most energy efficient adaptation methods are applied to the reference building in an effort to identify the 'optimum' buildings for the present year, year 2020, year 2050 and year 2080. The climate change adaptation methods focus on the building envelope and are described by the following principles: 'blow away (intelligently controlled night and day ventilation), 'switch off; (shading), reflect (cool materials) 'reflect and switch off' (double low e glazing), 'switch off & absorb' (insulation), and 'absorb' (thermal mass).

Hotels are distinguished in 'all year' operated and 'seasonally' operated buildings. Therefore, the adaptation methods are applied in two modes of buildings: a. all year operated, and b. seasonally operated (operating the months May-September). The aim of this distinction is to investigate whether the building owners can focus on specific adaptation methods according to the operation of their building and understand which investments have a long term benefit.

For an 'all year' operated building the mitigation strategies focus on both the heating and cooling period in order to reduce heat transfer during winter and switch off the solar gains during summer, whereas for a seasonally operated building, the mitigation strategies focus on the cooling period in order to remove excessive solar gains.

A different hierarchy is noted in the selection of the mitigation strategies for an 'all year' operated and 'seasonally' operated building.

All year operated building: For an 'all year operated' building, the principle '**switch off & absorb'** (insulation) is the one with the most savings in the heating period whereas the '**blow away**' principle (intelligently controlled night ventilation) results in the highest savings in the cooling period. Then the third principle to be considered in an investment is the '**reflect and switch off'** illustrated by the use of energy efficient glazing that lowers the energy demand for both the cooling and heating period. The technique of intelligently controlled day ventilation is the fourth principle in the hierarchy that reduces the cooling load significantly but has a much lower impact on the heating load. The shading technique ('**switch off**' principle) is also playing an important role for the reduction of cooling load. However, for the specific building, this technique does not result in huge energy savings because of the northern orientation of the large area of the openings. Finally, the '**reflect**' principle illustrated by the use of cool materials results in reduction of the cooling load but this is offset by a respectively high increase of the heating load. The use of cool materials starts to be of clear benefit for the building after year 2080 where the difference between the decrease of the cooling load and the increase of the heating load becomes small. Therefore the use of cool materials is recommended for the optimum building of year 2080.

Cooling load: The implementation of the above principles results in significant reduction of the cooling load of the reference building in the different climatic periods: 80% or 33 kWh/m^2/yr in present year, 77% or 36 kWh/m^2/yr in year 2020, 73% or 40 kWh/m^2/yr in year 2050 and 67% or 45 kWh/m^2/yr in year 2080 (Table 100). Furthermore, the analysis of each principle (in chapter 8) shows that in order to tackle the climate change, the optimum building for year 2080 should incorporate more shading compared to the other optimum buildings and also should be equipped with cool materials. However, because of the air temperature increase the optimum building of year 2080 still presents the highest cooling load compared to the optimum buildings of the other climatic periods. Therefore for year 2080, with the application of conventional energy efficient strategies, 175% (or 14 kWh/m^2/yr) more cooling will be required compared to the present day.

Heating load: The implementation of the principles ‘switch off and absorb’ (insulation), and ‘switch off and reflect’ (double low e glazing) in conjunction with the climate change (increase of air temperature) result in high reduction of the heating load of the reference building in the different climatic periods: 66% or 40 kWh/m^2/yr in present day, 69% or 36 kWh/m^2/yr in year 2020, 70% or 30 kWh/m^2/yr in year 2050 and 73% or 24 kWh/m^2/yr in year 2080 (Table 99). As expected the climate change favours the building in terms of heating, therefore the optimum building of year 2080 will require 57% (or 12 kWh/m^2/yr) less heating compared to the current situation.

Seasonally operated building: For a seasonally operated building, the most important principle to be implemented is the ‘**blow away’**, represented by the use of intelligently controlled night ventilation that results in significant energy savings for the cooling period. Then, the ‘**reflect principle’** with the use of cool materials is the second technique in the hierarchy, followed by the ‘**convection**’ principle (ceiling fans), the ‘**blow away’** technique (intelligently controlled day ventilation), the ‘switch off’ principle (shading) and the ‘**reflect & switch off’** principle (glazing) that presents the least energy saving. For a seasonally operated building the ‘*absorb & switch off’* principle (insulation) is recommended only for the optimum building projected in year 2080.

Cooling load: The implementation of the above principles results in significant reduction of the cooling load of the reference building in the different climatic periods: 85% or 35 kWh/m^2/yr in the present year, 83% or 39 kWh/m^2/yr in year 2020, 76% or 42 kWh/m^2/yr in year 2050 and 72% or 48 kWh/m^2/yr in year 2080.

Although the significant reduction of the cooling load of the reference building in each climatic period, the optimum building of year 2080 will require 217% (or 13 kWh/m^2/yr) more cooling from the current situation.

Increased thermal mass

The increase of thermal mass by using thicker walls and thus lowering the thermal response factor did not have an impact on the energy demand of the building, this could be interpreted because the building is already equipped with a number of energy efficient techniques and their impact on the building energy use offset this of the increased thermal mass. However this needs further investigation.

As already revealed in the literature (Wan et al., 2011; Wan et al., 2012; Xu et al., 2012; Ouedraogo et al., 2012; Giannakidis et al., 2011; Kolokotroni et al., 2012), the present study shows that due to the climate change the cooling load of buildings is expected to rise and the heating load to decline in areas with hot summer periods. Taking into consideration that currently cooling is provided mainly by electricity, there will be a huge increase of the fuel's demand. The consequences of its increased use are already known (peak demand in summer months, power generation capacity, increased cost, sick syndrome buildings and indoor air quality) and indicate the need to develop other alternatives for cooling supply and generation especially in areas with hot summer. Additionally, as more cooling will be needed than heating, primary energy will change according to the energy demand.

9.8. Conclusions

The most energy efficient mitigation strategies are applied to the reference building in order to assign the 'optimum buildings' of the present year, year 2020, 2050 and 2080. Two modes of buildings are considered: 'all year' and 'seasonally' operated. The simulations are performed for a typical hotel building located in climatic zone B.

With the implementation of conventional climate change adaptation methods, a significant energy reduction of the reference building is achieved in all climatic periods. However, the simulation results show an increasing trend for the cooling demand and a decreasing trend for the heating demand of buildings. Specifically:

- ❖ Optimum building with 'all year' operation

Cooling: The optimum building of year 2080 will require 175% (or 14 kWh/m^2/yr) more cooling compared to the present day optimum building.

Heating: The optimum building of year 2080 will require 57% (or 12 kWh/m^2/yr) less heating compared to the present day optimum building.

- ❖ Optimum building with 'seasonal' operation

The optimum building of year 2080 will require 217% (or 13 kWh/m^2/yr) more cooling compared to the present day optimum building.

- ❖ Energy efficient measures for 'optimum' buildings
- The 'blow away' principle (intelligently night ventilation) is the first to be considered as an investment in both 'seasonally' and 'all year' operated buildings for the reduction of the cooling load. The simulations show that, in the long term future, control based on indoor temperatures becomes more efficient than control based on outdoor temperatures. This could be attributed to the increase of the air temperature.
- The 'absorb & switch off' principle (insulation) is the first to be considered for an 'all year' operated building for the reduction of heat transfer but is not the first technique to invest on for a 'seasonally' operated building as in this case it is recommended for investments projected in the long term future.
- The 'reflect' principle illustrated by the use of cool materials should be considered for a 'seasonally' operated building but should not be included between the first investments for an 'all year' operated building because of its penalty on the heating load. In this case, this technique should be considered for long term investments, i.e. for year 2080.
- The 'reflect & switch off' principle (energy efficient glazing) is of high importance for an 'all year' operated building because its use results in energy savings for both heating and cooling period. However for a 'seasonally' operated building this is the mitigation strategy with the least impact on the cooling demand. For the

demonstration hotel building this can be attributed to the large area of openings facing north. Additionally, the technical characteristics (U-value, factor g) of the glazing play a crucial role on the savings, and for a cooling period the priority is to lower solar gains, whereas for an 'all year' operated building the priority is to reduce heat loss during winter and reduce heat gains during summer. Therefore different glazing should be suggested for the 'all year' and 'seasonally' operated building.

- The 'switch off' technique (shading) plays an important role in the reduction of cooling demand for a 'seasonally' operated building. For 'all year' operated buildings, appropriate shading should be selected that would result in the highest savings of cooling and the least penalty on the heating demand. The results show that buildings in the long term future would require more shading.
- The 'convection' principle illustrated by the use of ceiling fans and thus adjusting the cooling set point is recommended for 'seasonally' and 'all year' operated buildings as it results in significant reduction of the cooling load with no impact on the heating demand.
- Thermal mass does not have an impact on the energy demand of buildings that are already well equipped with a number of mitigation strategies, but this should be further investigated.

The next chapter investigates the effectiveness of the 'optimum' building in climatic zones A and C of Greece.

CHAPTER 10

Effectiveness of Optimum Building in Climatic Zones A and C of Greece

10 Effectiveness of Optimum Building in Climatic zones A and C of Greece

10.1. Introduction

The aim of this chapter is to assess the effectiveness of the most energy efficient strategies (as these are defined for the optimum buildings in climatic zone B), for buildings in climatic zones A and C of Greece. This work is aimed to propose energy efficient strategies for existing buildings and therefore there is limited flexibility in architectural design. The main objective of this work is to identify the optimal refurbishment strategy given the constraints of the existing case-study building when exposed to different climatic conditions in Greece; for this reason obvious energy advantages due to building orientation have not been explored. This chapter presents the simulation results for all climatic zones (A, B,C) of Greece in order to have comparable results. Additionally, an effort is made to find out if a correlation exists between the modification of the energy demand of the buildings and the climate change in means of heating and cooling degree days.

10.2. Methodology

The effectiveness of the mitigation strategies is assessed for the area of Iraklio of Crete island (35.3N, 25.18E, climatic zone A,) and Thessaloniki (40.3 N, 22.58 E climatic zone C). The above locations are selected because out of 90 hotels (hotel sample), 32% are located in climatic zone A (and of these 23 hotels in the island of Crete) and 46% in zone C (and of these 38 hotels in the greater area of Thessaloniki), (see Figure 49). For the purposes of this research the demonstration hotel is 'transposed' to the above mentioned locations, Iraklio and Thessaloniki.

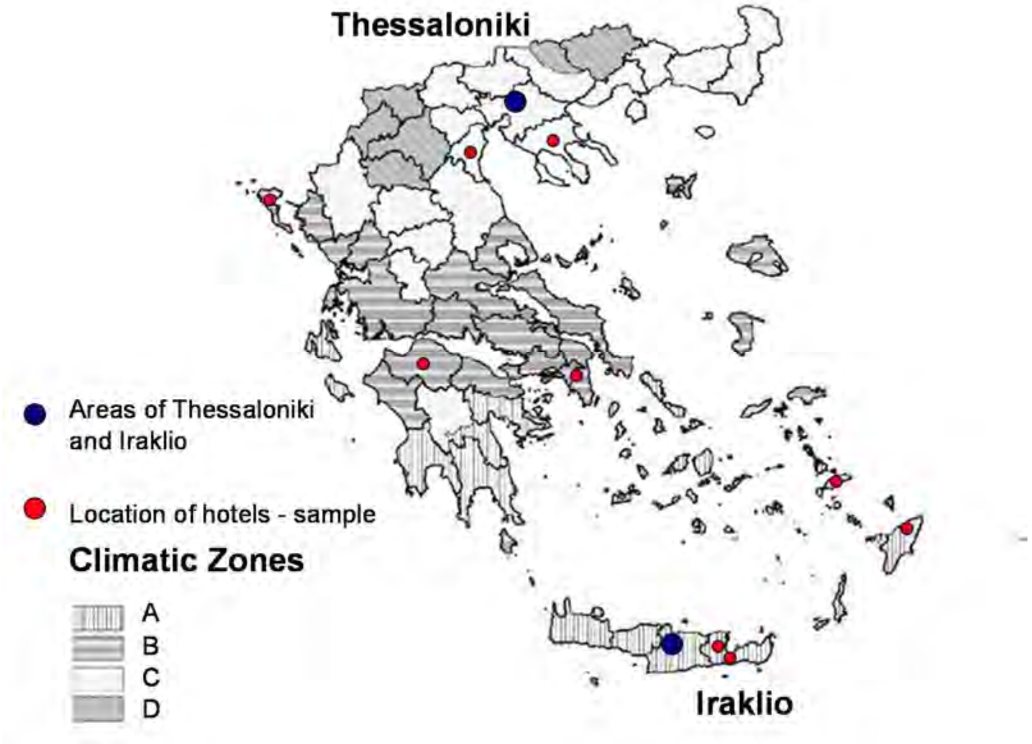


Figure 49 Map of Greece showing location of Thessaloniki and Iraklio

The study is structured in two parts:

Climatic analysis: The future files for the above locations (Iraklio and Thessaloniki) are generated. The same methodology is used as the one that was followed for the area of Patra: the climatic files for Thessaloniki and Iraklio, to be used for the simulations, are provided by METEONORM. The TMY2 METEONORM files are used as the baseline climates and converted to an EPW format using the EnergyPlus Weather Converter tool. Then, the future files are generated using the CCWorldWeather Generator tool, developed by Southampton University, for the climatic periods 2020, 2050 and 2080. The parameters below are 'morphed' using the CCWorldWeather Generator tool:

- dry bulb temperature (℃)
- relative humidity (%)
- global radiation (kJ)
- diffuse radiation (kJ)
- wind speed (m/s)

Prior to any simulations, the climatic files are analysed and compared. Statistical techniques and graphical methods are used to study the weather characteristics of Patra, Thessaloniki and Iraklio. Additionally the degree day method is used for their comparison.

Simulations: Hourly simulations are carried out using the TRNSYS software in order to calculate the heating and cooling loads (kWh/m^2/yr) of the 'optimum' buildings, 'all year' and 'seasonally operated', located in the above areas and for the present day, year 2020, 2050 and 2080. An effort is made that the interpretation of the results is done in accordance with the climate change in means of heating and cooling degree days.

Architectural considerations

As already mentioned in section 7.3.2, a great variety of climate subtypes are met in the several regions of Greece. A totally different building design approach is required for the three climatic zones A, B and C taking into account the different latitude and the regional weather characteristics like maximum temperatures, solar radiation, precipitation and wind velocities. However, the transposition of the demonstration hotel from climatic zone B to climatic zones A and C does not consider the building form, the orientation and other architectural parameters of the building design. This is explained because the study focuses on the energy profile of an 'existing' (demonstration) hotel and how this can be improved with a number of energy efficient techniques through refurbishment.

The building form and the architectural features play a significant role in the energy performance of buildings. There is a debate whether 'green' buildings can be expressive and of high aesthetic quality and in many cases the energy efficiency of buildings is achieved through a number of engineering equipment such as solar collectors, high performance building systems, heat exchangers, etc. that are applied when the building design is completed (Riekstiņš, 2011) However, the building form and orientation determine the passive use of solar and wind energy; for example in a cold climate an architects' aim would be a design that maximizes the solar gains, and in a moderate - hot climate a design that reduces the solar gains and enhances passive natural ventilation techniques (Oikonomou et al., 2011; .Riekstiņš, 2011). Characteristically Cody (2012) mentions that 'two approaches can be followed to achieve desired internal conditions and energy performance; 'the conventional approach of sealing off the external environment as much as possible and employing mechanical systems to provide the desired internal conditions or alternatively deployment of building form, construction and skin to capture and utilize the natural external environmental flows and allow the creation of the desired internal conditions', (Cody, 2012). The interaction of the building form with its environment is a main characteristic of the bioclimatic architecture and neglecting the climate as a design consideration is one of the main reasons for failures in building performance (Albuquerque, 2007). However in many cases it is observed that bioclimatic concept is not integrated in the design process and architects concentrate on other parameters that may conflict with energy issues: for example architects can face the dilemma between attractive, well-lighted spaces and spaces that do not use much energy, the dilemma between glazed buildings and the provision of acceptable indoor comfort while using less energy, or architects often design a building form that does not enhance natural ventilation or daylight or does not have the optimum orientation for the exploitation of the solar energy. Additionally, a building shape with minimised heat losses requires a ratio as small as possible between its outer surface and the total constructed volume but because of aesthetic and construction issues this shape is not achieved in most projects (Pacheco et al., 2012).

It is evident that the building design of the demonstration hotel is not compatible with the principles of a bioclimatic and energy efficient architecture: all rooms face towards the sea despite the view's north orientation, the building form consists of a long rectangular shape, the north facing common areas have extended glazing areas and the openings of the circulation areas (corridors) facing south are not shaded It could be argued that the north orientation of the common areas and the extended glazing facing north enhances the passive cooling of these areas since the hotel is operating during the summer period; but in general, the building design of the demonstration hotel does not take into consideration optimum orientation, energy issues, comfort and heat exchange with the environment. It focuses on "architectural" parameters like the view, and this can be explained because its construction dates back in the 1970s thus in a period when the need for energy efficient building design was not compulsory.

The current study takes as default the building layout of the demonstration hotel, although this is not an optimum one in terms of orientation and form. In another circumstances and following a low energy design process, the building should be carefully sited in the different climatic zones and its building elements and form should be selected optimally in order to control, collect and store the sun's energy; resulting in another building design in climatic zones A, B and C.

10.3. Analysis and comparison of climatic files

Statistical techniques and graphical methods are used to study the weather characteristics of Patra, Thessaloniki and Iraklio. Also the degree day method is used.

10.3.1. Climatic characteristics of Thessaloniki

The characteristics of Thessaloniki for each weather variable (maximum, minimum, average values etc) for present day climate file (as provided by METEONORM) and for the years 2020, 2050 and 2080, (as generated using the CCWorldWeather Generator tool) are shown in Table 113.

Table 113 Characteristics of weather variables for the area of Thessaloniki for 4 periods: present day, year 2020, year 2050 and year 2080

Weather variables for the area of Thessaloniki				
Temperature (°C)				
	Present day	**2020**	**2050**	**2080**
Maximum	36.7	37.5	38.25	39.4
Minimum	-6.6	-5.9	-5.27	-4.3
Average	14.6	15.3	16.05	17.1
Median	14.5	15.2	15.94	17.0
Mode	21.1	4.7	5.35	6.4
Variance	83.9	84.1	84.32	84.8
standard deviation	9.2	9.2	9.18	9.2
Global Radiation (kJ)				
	Present day	**2020**	**2050**	**2080**
Maximum	3509.0	3475	3404	3334
Minimum	0.0	0	0	0
Average	574.4	565	558	544
Median	0.0	0	0	0
Mode	0.0	0	0	0
Variance	719914.4	703642	690831	669283
standard deviation	848.5	839	831	818
Diffuse Radiation (kJ)				
	Present day	**2020**	**2050**	**2080**
Maximum	1732.0	1729	1688	1661
Minimum	0.0	0	0	0
Average	308.2	303	299	291
Median	0.0	0	0	0
Mode	0.0	0	0	0
Variance	174312.4	170221	166455	160607
standard deviation	417.5	413	408	401
Relative Humidity (%)				
	Present day	**2020**	**2050**	**2080**
Maximum	100.0	100	100	100
Minimum	31.0	31	31	32
Average	70.1	70	71	71
Median	71.0	71	72	72
Mode	80.0	100	100	100
Variance	256.5	255	254	250
standard deviation	16.0	16	16	16
Wind speed (m/s)				
	Present day	**2020**	**2050**	**2080**
Maximum	14.8	15.0	15.0	15.5
Minimum	0.0	0.0	0.0	0.0
Average	1.9	1.9	1.9	1.9
Median	1.3	1.3	1.3	1.4
Mode	0.3	0.0	0.0	0.0
Variance	3.6	3.6	3.5	3.6
standard deviation	1.9	1.9	1.9	1.9

10.3.2. Climatic characteristics of Iraklio

The characteristics of Iraklio for each weather variable (maximum, minimum, average values etc) for the present day climate file (as provided by METEONORM) and for the year 2020, 2050 and 2080 (as generated using the CCWorldWeather Generator tool) are shown in Table 114.

Table 114 Characteristics of weather variables for the area of Iraklio for 4 periods: present day, year 2020, year 2050 and year 2080

Weather variables for the area of Iraklio				
Temperature (°C)				
	Present day	**2020**	**2050**	**2080**
Maximum	35.9	36.6	37.3	38.3
Minimum	3.8	4.5	5.3	6.4
Average	18.7	19.3	20.1	21.2
Median	18.6	19.3	20.0	21.1
Mode	13.5	27.1	27.9	28.9
Variance	40.1	39.7	39.5	39.2
standard deviation	6.3	6.3	6.3	6.3
Global Radiation (kJ)				
	Present day	**2020**	**2050**	**2080**
Maximum	3468.0	3453	3494	3497
Minimum	0.0	0	0	0
Average	732.9	728	725	729
Median	0.0	0	0	0
Mode	0.0	0	0	0
Variance	1043192.6	1029548	1025729	1041022
standard deviation	1021.4	1015	1013	1020
Diffuse Radiation (kJ)				
	Present day	**2020**	**2050**	**2080**
Maximum	1779.0	1775	1798	1800
Minimum	0.0	0	0	0
Average	305.0	303	302	303
Median	0.0	0	0	0
Mode	0.0	0	0	0
Variance	153744.7	151705	150602	151727
standard deviation	392.1	389	388	390
Relative Humidity (%)				
	Present day	**2020**	**2050**	**2080**
Maximum	97.0	98	99	100
Minimum	37.0	37	38	38
Average	63.5	64	65	65
Median	64.0	64	65	66
Mode	69.0	62	62	62
Variance	128.6	128	130	133
standard deviation	11.3	11	11	12
Wind speed (m/s)				
	Present day	**2020**	**2050**	**2080**
Maximum	17.1	17.7	18.8	21.1
Minimum	0.0	0.0	0.0	0.0
Average	3.5	3.6	3.7	4.0
Median	3.0	3.0	3.1	3.4
Mode	2.6	4.1	4.3	4.7
Variance	6.7	7.0	7.6	9.0
standard deviation	2.6	2.6	2.8	3.0

10.3.3. Climatic characteristics of Patra

The characteristics of Patra for each weather variable (maximum, minimum, average values etc) for the present day climate file (as provided by METEONORM) and for year 2020, year 2050 and year 2080 (as generated using the CCWorldWeather Generator tool) are shown in Table 115.

Table 115 Characteristics of weather variables for the area of Iraklio for 4 periods: present day, year 2020, year 2050 and year 2080

Weather variables for the area of Patra

Temperature (°C)

	Present day	2020	2050	2080
Maximum	36.5	37.22	37.98	38.99
Minimum	-0.2	0.58	1.42	2.53
Average	17.8	18.49	19.25	20.26
Median	17.5	17.93	18.68	19.69
Mode	11.6	10.89	11.70	12.73
Variance	49.9	49.24	48.90	48.51
standard deviation	7.1	7.02	6.99	6.96

Global Radiation (kJ)

	Present day	2020	2050	2080
Maximum	3394.80	3365.05	3375.20	3440.60
Minimum	0.00	0.00	0.00	0.00
Average	628.03	622.24	618.99	617.03
Median	0.00	0.00	0.00	0.00
Mode	0.00	0.00	0.00	0.00
Variance	844126.89	832880.28	830773.19	837667.97
standard deviation	918.76	912.62	911.47	915.24

Diffuse Radiation (kJ)

	Present day	2020	2050	2080
Maximum	1774.80	1760.88	1748.83	1806.34
Minimum	0.00	0.00	0.00	0.00
Average	318.79	315.54	313.37	311.39
Median	0.00	0.00	0.00	0.00
Mode	0.00	0.00	0.00	0.00
Variance	176986.49	174225.65	172724.83	172276.44
standard deviation	420.70	417.40	415.60	415.06

Relative Humidity (%)

	Present day	2020	2050	2080
Maximum	100.00	100.00	100.00	100.00
Minimum	35.00	35.76	36.41	37.56
Average	65.61	66.32	66.95	67.78
Median	66.00	67.13	67.79	68.73
Mode	71.00	76.05	77.50	79.40
Variance	135.12	136.50	139.30	143.92
standard deviation	11.62	11.68	11.80	12.00

Wind speed (m/s)

	Present day	2020	2050	2080
Maximum	14.90	15.21	16.50	18.22
Minimum	0.00	0.00	0.00	0.00
Average	2.74	2.79	2.91	3.09
Median	2.20	2.25	2.33	2.50
Mode	1.60	0.00	0.00	0.00
Variance	4.85	5.04	5.52	6.37
Standard deviation	2.20	2.25	2.35	2.52

10.4. Heating and Cooling Degree Days

The heating and cooling degree days and the night time cooling degree days are calculated for the areas of Patra, Thessaloniki and Iraklio, using equation 4 and equation 5 (CIBSE TM1, 41) as these are described in section 6.8.2.1.

As default by the Technical Chamber of Greece, the base temperature for heating degree days is 18°C and 26 °C for cooling degree days (Technical Chamber of Greece, 20701-3/ 2010). According to CIBSE TM 41, the base temperature for degree days is the external temperature at which the plant (taking into consideration the balance between the heat gains and heat losses) will not need to run. Therefore, for the calculation of the night-time cooling degree days the base temperature is assumed to be 20°C as this is close to the mean night temperature for most areas in Greece during summer and at which the cooling plant will not need to operate.

The cooling and heating degree days for Patra, Thessalonik and Iraklio are presented in Table 116 and the night time cooling degree days are presented in Table 117.

Table 116 Cooling and heating mean degree hours for Patra, Iraklio and Thessaloniki, for present climatic file and years 2020, 2050 and 2080

Heating (base temp 18 °C) and Cooling (base temp 26°C) Degree Days				**Variation % from present**			**Variation in degree days**		
	Patra	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**
Present									
CCD	169	141	122						
HDD	1121	2123	871						
2020									
CCD	200	177	159	**19**	**25**	**31**	**32**	**36**	**38**
HDD	990	1961	753	-12	-8	-13	-130	-162	-118
2050									
CCD	250	**218**	**212**	**48**	**54**	**75**	**82**	**77**	**91**
HDD	851	1812	631	-24	-15	-28	-269	-311	-240
2080									
CCD	330	**289**	**302**	**96**	**104**	**149**	**161**	**147**	**181**
HDD	681	1607	478	-39	-24	-45	-440	-517	-393

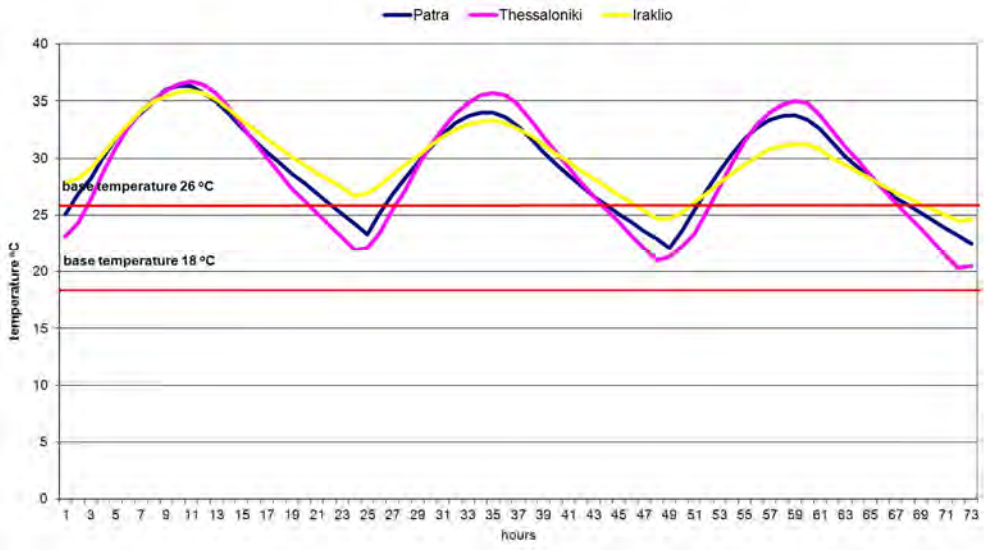
- **Nighttime cooling degree days base 20°C**

Table 117 Nighttime cooling degree days for Patra, Iraklio and Thessaloniki, for present climatic file and years 2020, 2050 and 2080

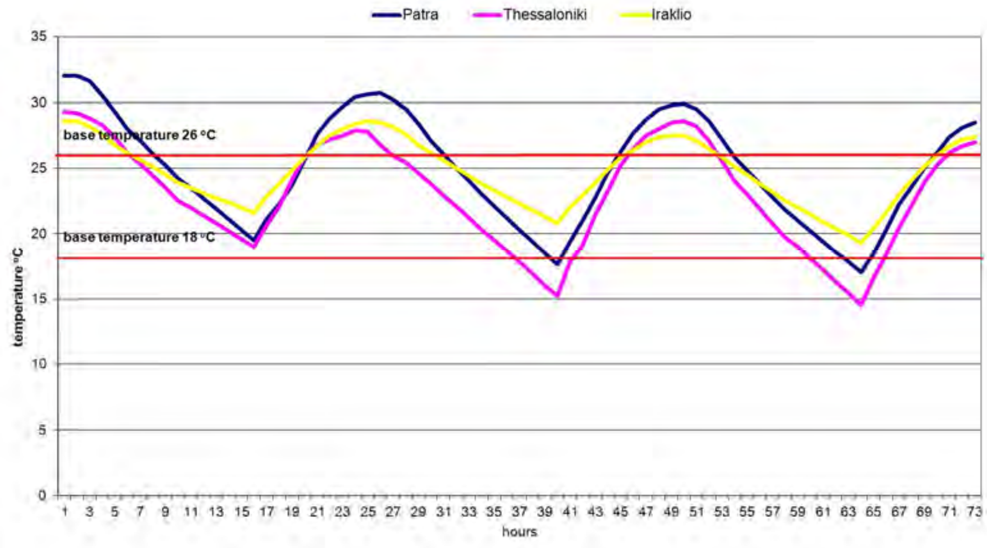
Night Cooling (base temp 20°C) Degree Days				**Variation % from present**			**Variation in degree days**		
	Patra	**Thes.**	**Iraklio**	**Patra**	**Thes.**	**Iraklio**	**Patra**	**Thes.**	**Iraklio**
Present									
CCD	101	64	143						
2020									
CCD	126	85	172	25	33	20	25	21	29
2050									
CCD	157	109	211	55	70	48	56	45	68
2080									
CCD	206	149	273	104	133	91	105	85	130

The degree days analysis (Table 116, Graph 27 - Graph 34) shows that Patra presents the maximum number of cooling degree days and Thessaloniki the maximum number of heating degree days. Also, it is noted an increase of cooling through the years and a decrease in heating; furthermore with reference to the present year, the decrease in heating degree days is almost double than the increase of the cooling degree days.

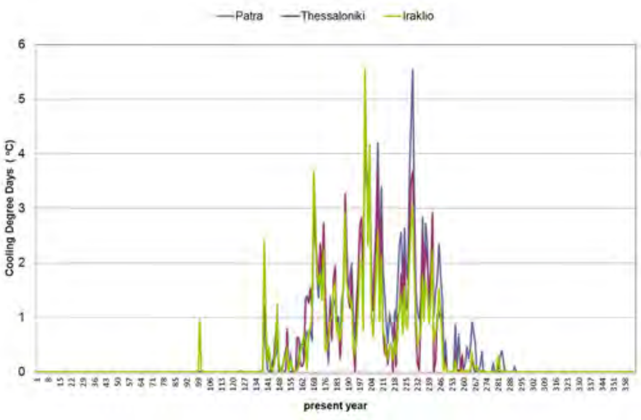
Iraklio presents higher nighttime cooling degree days than the other two locations (Table 117) that may affect the cooling energy demand of the buildings. Additionally, Graph 25 and Graph 26 show that for typical summer days in July and August the diurnal difference is higher in Patra and Thessalloniki than in Iraklio, which also might affect the energy demand of buildings.



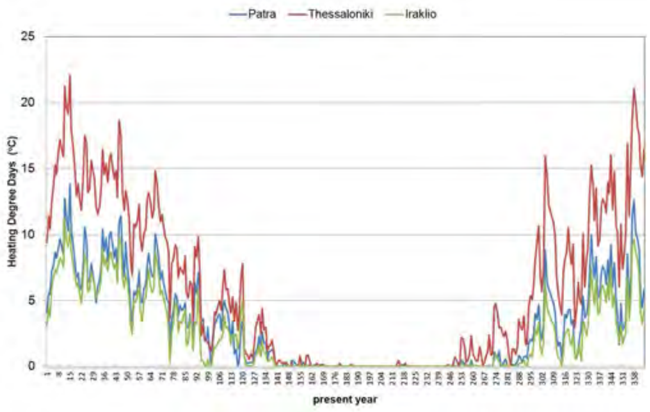
Graph 25 Hourly temperatures (℃) for 3 days in July



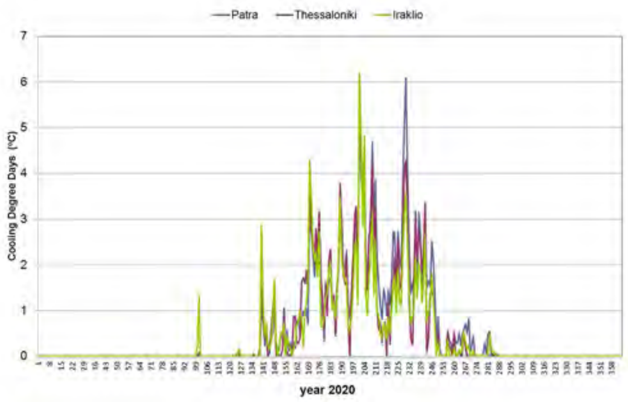
Graph 26 Hourly temperatures (℃) for 3 days in August



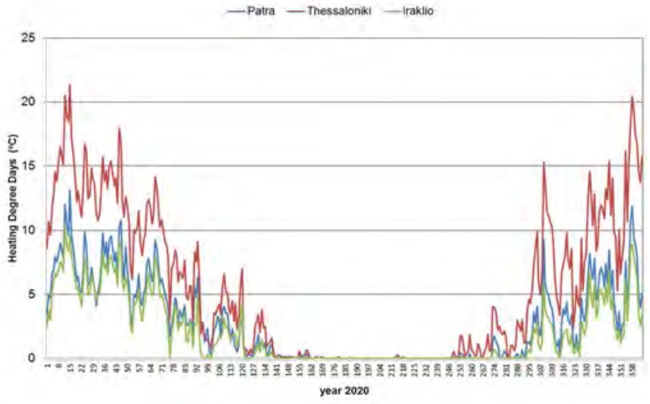
Graph 27 Mean CDD for Patra, Thessaloniki and Iraklio for present



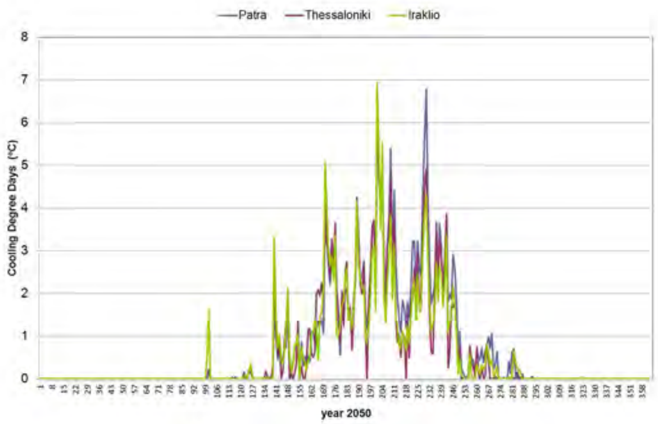
Graph 28 Mean HDD for Patra, Thessaloniki and Iraklio for present



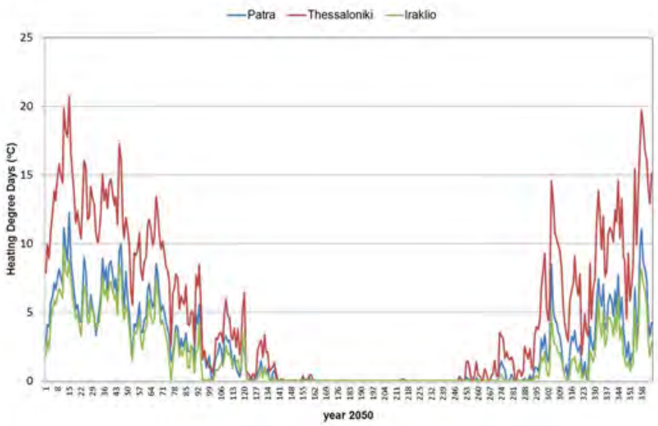
Graph 29 Mean CDD for Patra, Thessaloniki and Iraklio for 2020



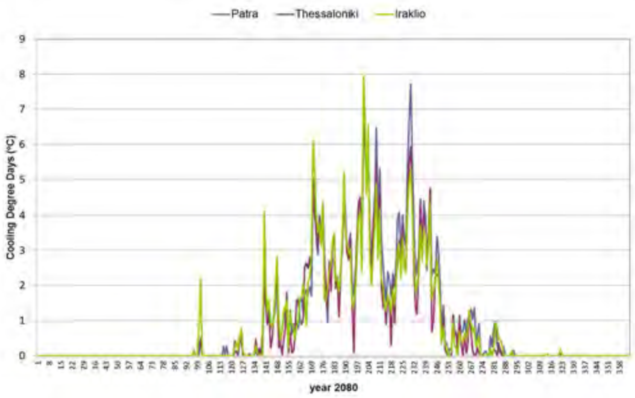
Graph 30 Mean HDD for Patra, Thessaloniki and Iraklio for 2020



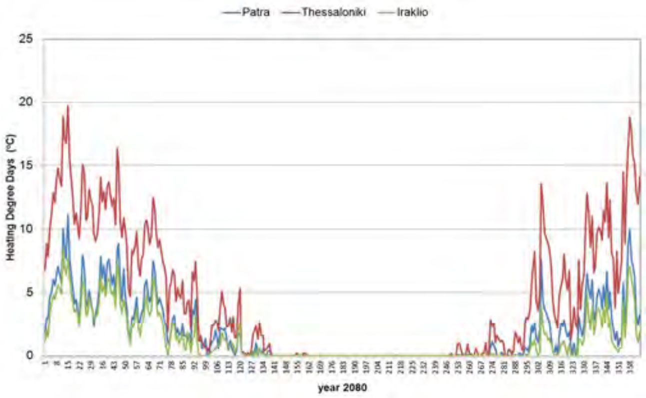
Graph 31 Mean CDD for Patra, Thessaloniki and Iraklio for 2050



Graph 32 Mean HDD for Patra, Thessaloniki and Iraklio for 2050



Graph 33 Mean CDD for Patra, Thessaloniki and Iraklio for 2080



Graph 34 Mean HDD for Patra, Thessaloniki and Iraklio for 2080

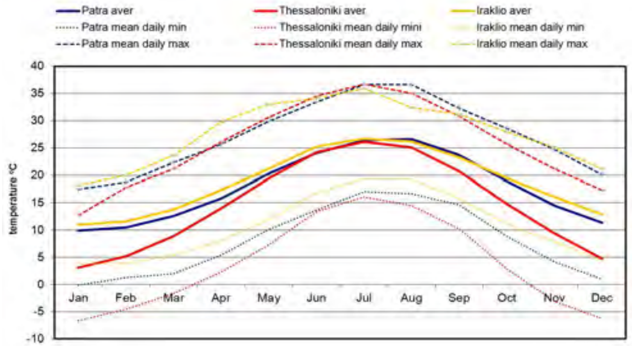
10.5. Comparison of weather variables

The weather analysis shows an increase of all weather variables (DBT, RH, and wind speed) between the present climatic file and year 2080. In detail, comparing the present climatic file with year 2080 it is noted:

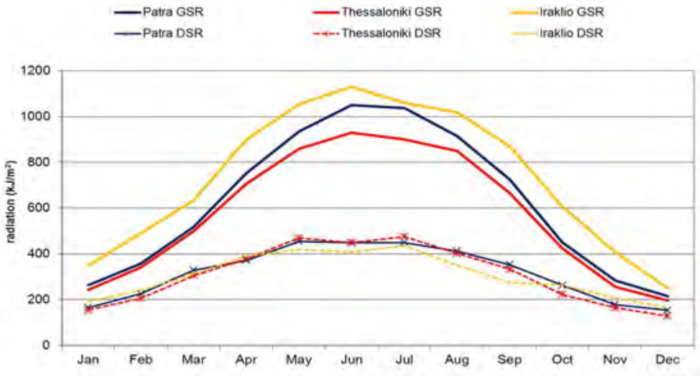
- An increase of the maximum temperatures by 2.7°C in Thessaloniki, 2.4 °C in Iraklio and 2.5 °C in Patra. Thessaloniki presents the highest maximum temperatures in all climatic periods, Patra is the second one with almost identical maximum temperatures to these of Thessaloniki and Iraklio presents slightly lower maximum temperatures compared to the other two locations, (Graph 35, Graph 39, Graph 43, Graph 47)
- Increase of the average and median temperatures by 2.5°C in Thessaloniki, 2.5 °C in Iraklio and 2.5 °C in Patra. Iraklio is and remains the hottest area with the highest average and median temperatures in all climatic periods, then comes Patra with average temperatures-median 0.5-1°C lower than these of Iraklio and the lowest average – median temperatures by far are noted in Thessaloniki. On the other hand, Thessaloniki is and remains the coldest area with the lower temperatures ranging from -6.6 °C in present and -4.3°C in year 2080, (Graph 35, Graph 39, Graph 43, Graph 470
- Increase of the average and median relative humidity by 1% in Thessaloniki, 1.5% in Iraklio and 2.2% in Patra. The highest relative humidity is noted in Thessaloniki, with an average around 70% throughout the years, and the lowest relative humidity is noted in Iraklio, ranging from 63.5% in present file to 65% in 2080, (Graph 38, Graph 42, Graph 46, Graph 50).
- Increase of the maximum wind speed by 0.7m/s in Thessaloniki, 4m/s in Iraklio and 3.3m/s in Patra. The windiest area is Iraklio with average wind speeds around 3.5m/s in present day and 4m/s in 2080. The less windy area is Thessaloniki with average wind speeds of 1.9m/s through all climatic periods, (Graph 37, Graph 41, Graph 45, Graph 49).
- Iraklio receives the highest maximum global solar radiation on horizontal plane, Thessaloniki and Patra areas receive lower solar radiation and almost the same amount. In terms of average values, Iraklio receive the highest ones around 730 kJ through all years, Patra around 620 kJ and Thessaloniki around 565 kJ, (Graph 36, Graph 40, Graph 44, Graph 48).

- Average values of diffuse radiation are almost identical in all areas, around 300 kJ in Thessaloniki and Iraklio and 315 kJ in Patra, (Graph 36, Graph 40, Graph 44, Graph 48).

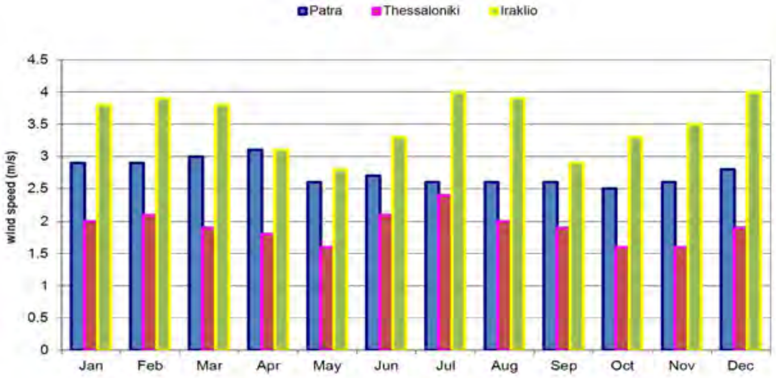
❖ Present climate file



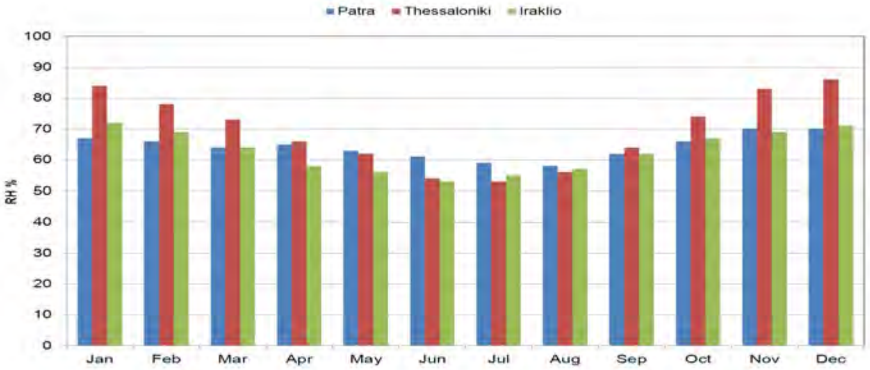
Graph 35 Monthly average , maximum and minimum temperature (°C) for present



Graph 36 Global solar radiation (GSR) and diffuse solar radiation (DSR) (kJ/m^2) for present

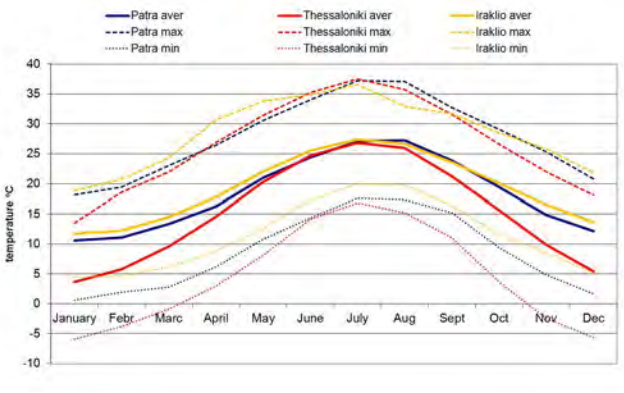


Graph 37 Monthly mean wind speed (m/s) for present

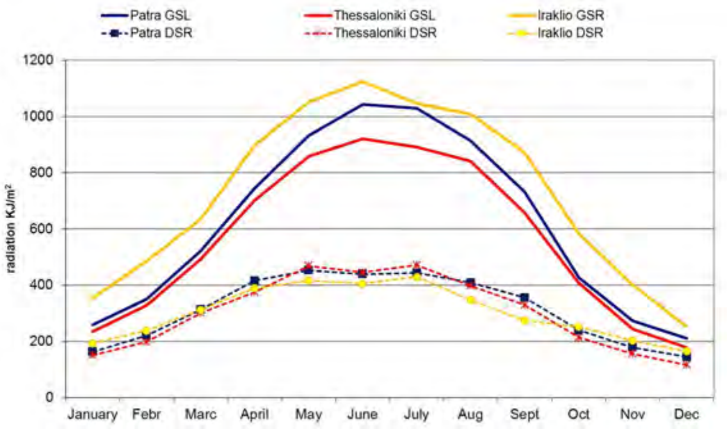


Graph 38 Monthly mean RH (%)for present

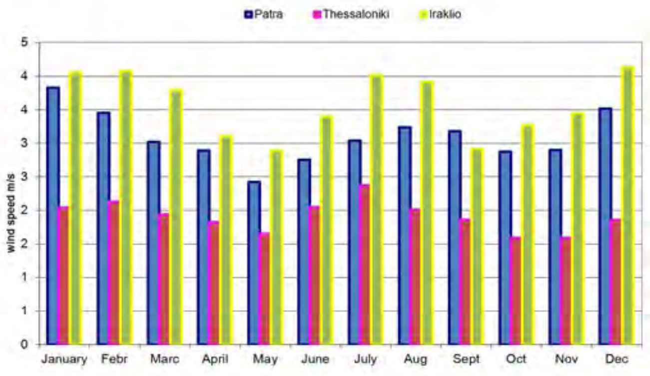
❖ Year 2020



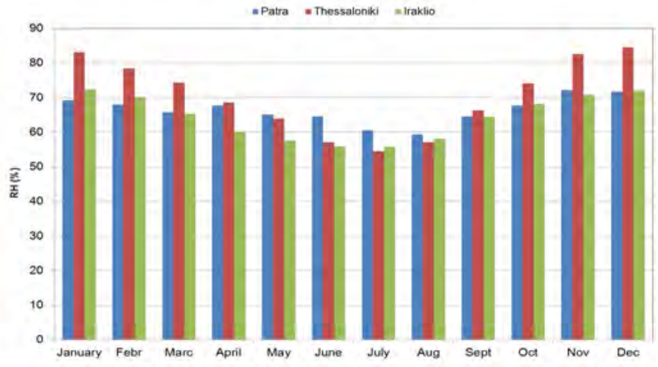
Graph 39 Monthly average , maximum and minimum temperature (°C) for year 2020



Graph 40 Global solar radiation (GSR) and diffuse solar radiation (DSR) (kJ/m^2) for year 2020

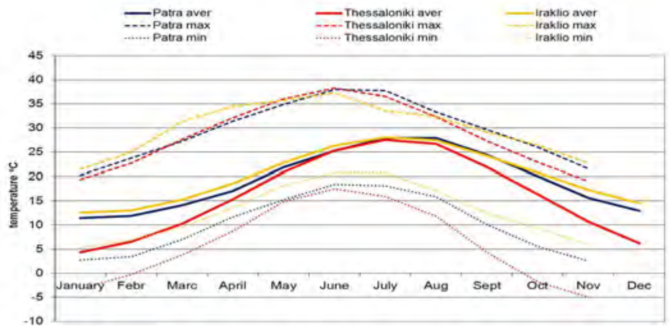


Graph 41 Monthly mean wind speed (m/s) for year 2020

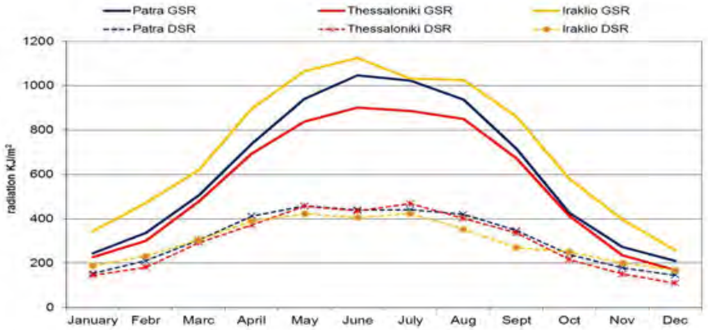


Graph 42 Monthly mean RH(%) for year 2020

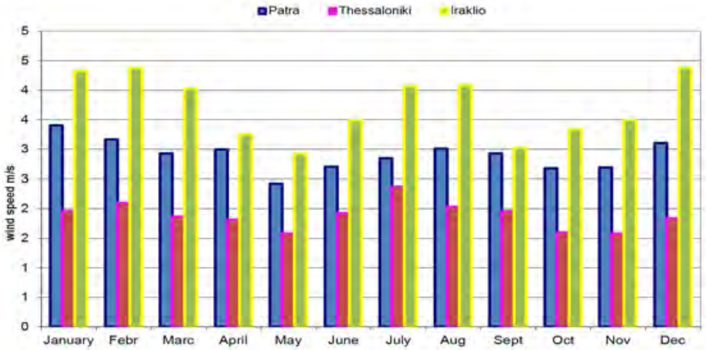
Year 2050



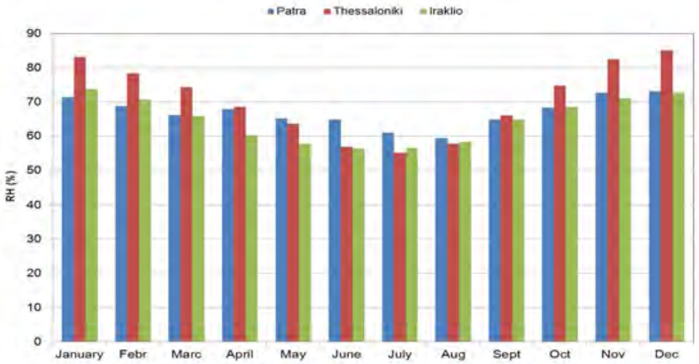
Graph 43 Monthly average , maximum and minimum temperature (°C) for year 2050



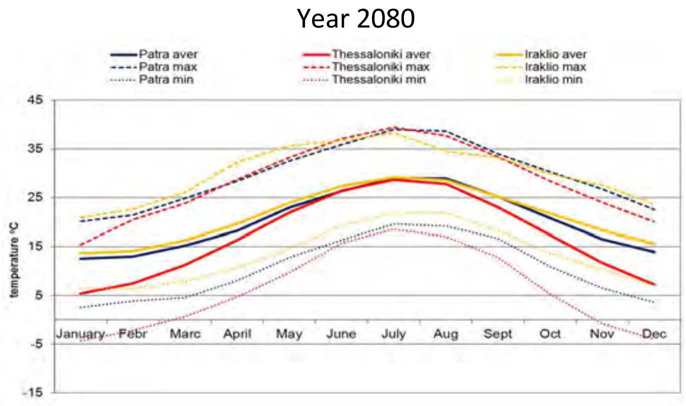
Graph 44 Global solar radiation (GSR) and diffuse solar radiation (DSR) (kJ/m^2) for year 2050



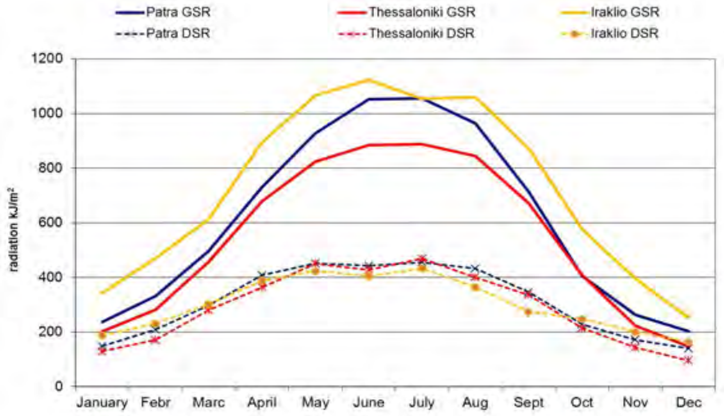
Graph 45 Monthly mean wind speed (m/s) for year 2050



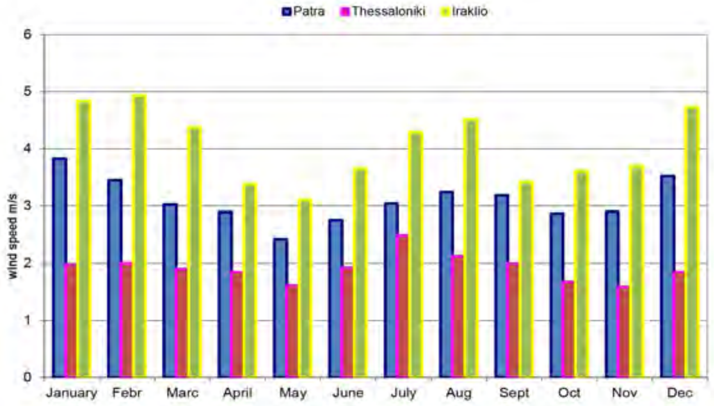
Graph 46 Monthly mean RH (%) for year 2050



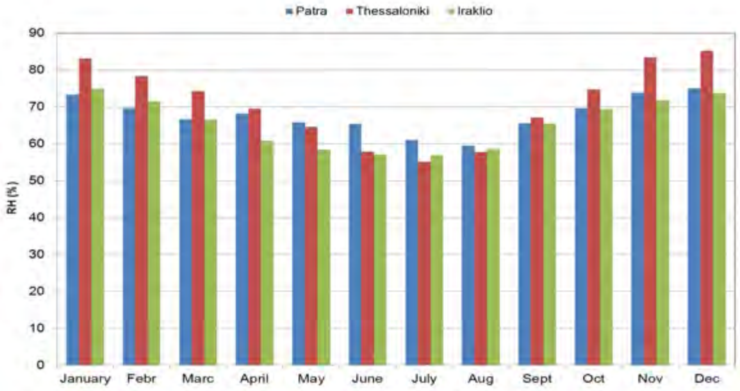
Graph 47 Monthly average , maximum and minimum temperature (°C) for year 2080



Graph 48 Global solar radiation (GSR) and diffuse solar radiation (DSR) (kJ/m^2) for year 2080



Graph 49 Monthly mean wind speed (m/s) for year 2080



Graph 50 Monthly mean RH (%) for year 2080

The future climate files of Iraklio, Patra and Thessaloniki are generated using the morphing method'. As mentioned in previous chapter, 'Morphing involves shifting and stretching the climatic variables in the present–day weather time series to produce new weather time series that encapsulate the average climate change while preserving the physically realistic weather sequences of the source data' (Belcher et al., 2005). One of the characteristics of this methodology, sometimes referred as the 'main disadvantage', is that the future climates rely on the variability and character of the present – day files. This is also evident in the Graph 35 - Graph 50, where it can be seen that the weather variables of the future files are described by curves of the same geometry with this of the present file but shifted accordingly and resulting in increased values for all-weather variables (temperature, RH, wind speed).

Additionally to the above, literature reveals measurements of the weather modification. Measurements of external air temperature showed the hottest summer in Europe in 2003 and even more extreme maximum temperatures in Greece, up to 44.8°C, during the summer of 2007. Simulations of future regional climates indicate that in end of 21st century, summer of Mediterranean areas will experience daily maximum temperature similar to these of summer 2007, (Roshan et al., 2012; Founda and Giannakopoulos, 2009) .As already noted in many studies, (Lam et al., 2005; Wan et al., 2011; Bhandari et al., 2012), the different weather variables have an impact on the building design, the building operation and consequently its energy profile. Dry bulb temperature influences the heat losses / gains through the building envelope and affects the thermal response of the building construction. External temperature and relative humidity are key factors for air-conditioned buildings; furthermore the sizing of the cooling system is based on the amount of solar radiation. Wind speeds have an impact on the cooling potential of different passive techniques, i.e. natural day and night ventilation. Wind data also may influence the building infiltration.

From the above analysis, it should be expected that among the 3 areas, cooling demand will be higher in Iraklio that combines both the highest average day time and nighttime temperatures and solar radiation whereas the cooling demand will be lower in Thessaloniki. On the other hand it should be expected higher heating demand in Thessaloniki and lower in Iraklio. In all areas, an increase of the air temperature and relative humidity is forecast which in terms of energy demand would signify an increasing trend of the cooling demand in all areas and simultaneously a decreasing trend of the heating demand in all areas.

10.6. Simulation results

10.6.1. ‘All year’ operated building

Table 118 - Table 121 and Graph 51 and Graph 52 present the simulation results for the ‘all year’ optimum building.

❖ Heating load (kWh/m^2/yr)

Table 118 Heating load (kWh/m^2/yr) for the ‘all year‘ operated building

‘All year’ operated building Heating load kWh/m^2/yr			
	Patra	**Thessaloniki**	**Iraklio**
PRESENT DAY			
Reference	61	136	42
Optimum	21	58	12
2020			
Reference	52	125	34
Optimum	16	53	9
2050			
Reference	43	116	27
optimum	13	48	7
2080			
Reference	33	103	19
optimum	9	41	4

Table 119 Variation of heating load for the ‘all year‘ operated building

‘All year’ operated building- Heating load						
	Variation (%) from reference building			Variation kWh/m^2/yr from reference building		
	Patra	Thessaloniki	Iraklio	Patra	Thessaloniki	Iraklio
Present day	66	57	70	40	78	29
2020	68	58	73	36	73	25
2050	71	69	76	31	68	21
2080	74	60	81	24	62	15

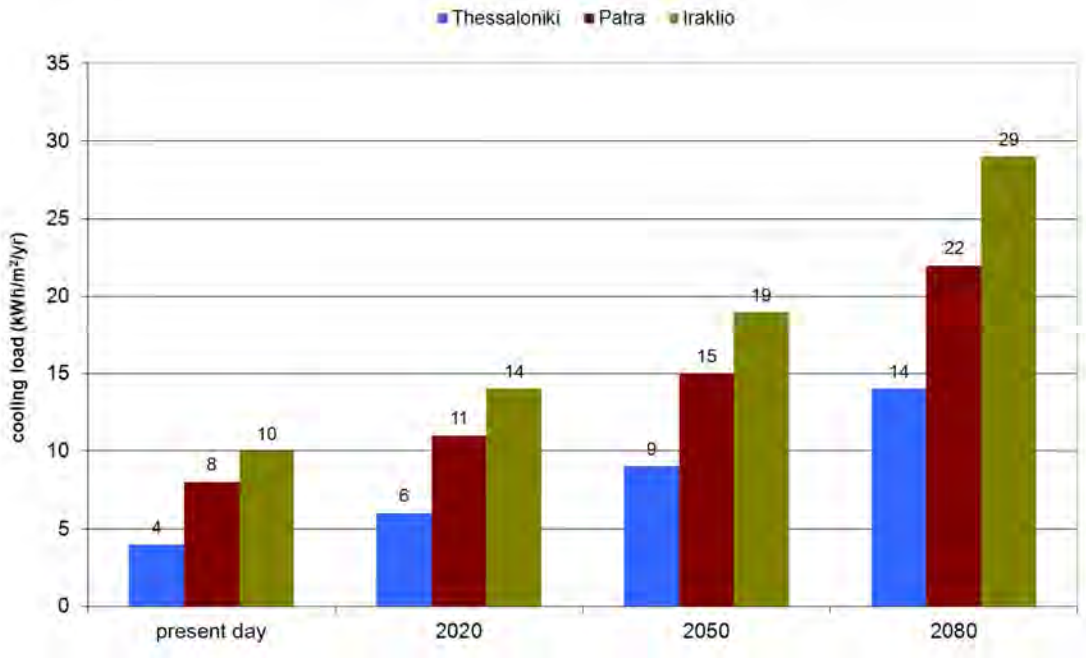
- Cooling load (kWh/m^2/yr)

Table 120 Cooling load (kWh/m^2/yr) for the ‘all year‘ operated building

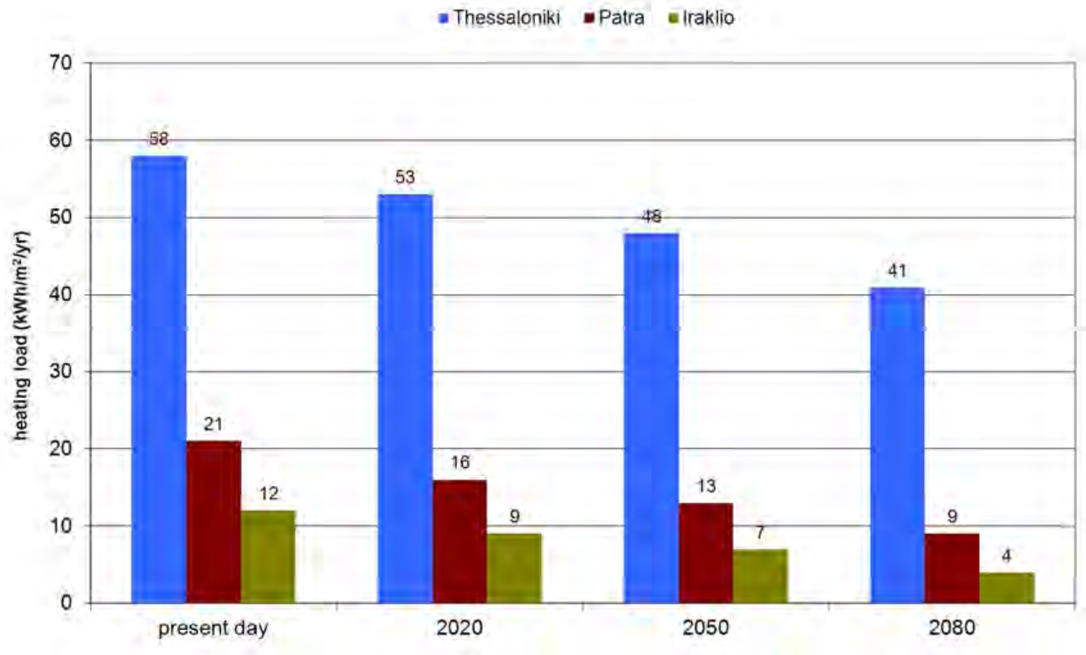
‘All year’ operated building			
Cooling load kWh/m^2/yr			
	Patra	**Thessaloniki**	**Iraklio**
PRESENT DAY			
Reference	41	31	44
Optimum	8	4	10
2020			
Reference	47	37	50
Optimum	11	6	14
2050			
Reference	55	43	59
Optimum	15	9	19
2080			
Reference	67	53	72
Optimum	22	14	29

Table 121 Variation of cooling load for the ‘all year‘ operated building

‘All year’ operated building **– Cooling load**						
	Variation (%) from reference building			**Variation kWh/m^2/yr from reference building**		
	Patra	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**
Present day	80	87	78	33	27	34
2020	76	83	73	36	31	37
2050	72	79	67	40	34	40
2080	66	73	60	44	39	43



Graph 51 Cooling load (kWh/m^2/yr) for optimum 'all year' operated building



Graph 52 Heating load (kWh/m^2/yr) for optimum 'all year' operated building

10.6.2. 'Seasonally' operated building

Table 122 Heating load (kWh/m^2/yr)

'Seasonally' operated building			
Heating load kWh/m^2/yr			
	Patra	**Thessaloniki**	**Iraklio**
PRESENT DAY			
Reference	61	136	42
Optimum	1	2	1
2020			
Reference	52	125	34
Optimum	1	2	1
2050			
Reference	43	116	27
Optimum	1	2	0
2080			
Reference	33	103	19
Optimum	1	2	0

Table 123 Variation of heating loads

'Seasonally' operated building **– Heating load**						
	Variation (%) from reference building			**Variation kWh/m^2/yr from reference building**		
	Patra	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**
Present day	98	98	98	60	133	41
2020	98	98	98	51	124	34
2050	98	98	98	42	114	27
2080	98	98	98	32	101	18

- Cooling load (kWh/m^2/yr)

Table 124 Cooling load (kWh/m^2/yr) for the 'seasonally' operated building

'Seasonally' operated building Cooling load kWh/m^2/yr			
	Patra	**Thessaloniki**	**Iraklio**
PRESENT DAY			
Reference	41	31	44
Optimum	6	3	6
2020			
Reference	47	37	50
Optimum	8	5	9
2050			
Reference	55	43	59
Optimum	13	8	15
2080			
Reference	67	53	72
Optimum	19	13	24

Table 125 Variation of cooling load for the 'seasonally' operated building

'Seasonally' operated building - Cooling load						
	Variation (%) from reference building			**Variation kWh/m^2/yr from reference building**		
	Patra	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**
Present day	86	92	86	35	29	38
2020	82	87	82	38	33	41
2050	76	82	75	42	36	44
2080	72	77	67	48	41	49

10.6.3. ‘Seasonally’ building operating all year

Table 126 and Table 127 present the simulation results for the seasonally ‘optimum’ building operating all year.

- Heating load (kWh/m^2/yr)

Table 126 Heating load (kWh/m^2/yr) for the ‘seasonal building‘ operating all year

Seasonal building operating all year			
Heating load kWh/m^2/yr			
PRESENT DAY			
	Patra	**Thessaloniki**	**Iraklio**
Reference	61	136	42
Optimum	73	145	56
2020			
Reference	52	125	34
Optimum	64	134	48
2050			
Reference	43	116	27
Optimum	52	123	37
2080			
Reference	33	103	19
Optimum	12	46	7

- Cooling load (kWh/m^2/yr)

Table 127 Cooling load (kWh/m^2/yr) for the ‘seasonal building‘operating all year

Seasonal building operating all year			
Cooling load kWh/m^2/yr			
	Patra	**Thessaloniki**	**Iraklio**
PRESENT DAY			
Reference	41	31	44
Optimum	6	3	6
2020			
Reference	47	37	50
Optimum	8	5	9
2050			
Reference	55	43	59
Optimum	13	8	15
2080			
Reference	67	53	72
Optimum	19	13	24

10.7. Discussion

The effectiveness of the most efficient strategies as these were defined for the optimum buildings of climatic zone B is assessed for climatic zones A and C of Greece.

The weather analysis of the three climatic zones showed that in all areas there will be an increase in the cooling degree days and a decrease in the heating degree days (Table 116), signifying an increase in the cooling energy demand and decrease in the heating energy demand respectively. Iraklio (zone A) has the maximum number of night cooling degree days, the highest values of solar radiation and wind speed at present and in the future and presents the smallest diurnal differences. On the other hand, Thessaloniki (zone C) presents the maximum number of heating degree days along with the lowest values of solar radiation. Patra has the maximum cooling degree days and large diurnal differences. Also in all areas, relative humidity is increasing with the years. Thessaloniki is the most humid city during the winter and spring months apart from the months May –August when Patra is the most humid area.

The simulations show that optimum buildings in Iraklio present the highest cooling energy demand, whereas optimum buildings in Thessaloniki present the highest heating energy demand. Also, an increasing tendency of the cooling load and a decreasing tendency of the heating load are observed in all areas through the years.

The implementation of the most energy efficient techniques in all climatic zones results in significant reduction of the cooling and heating loads of the reference building in the different climatic periods. In details:

10.7.1. All year operated building

- **Cooling load**

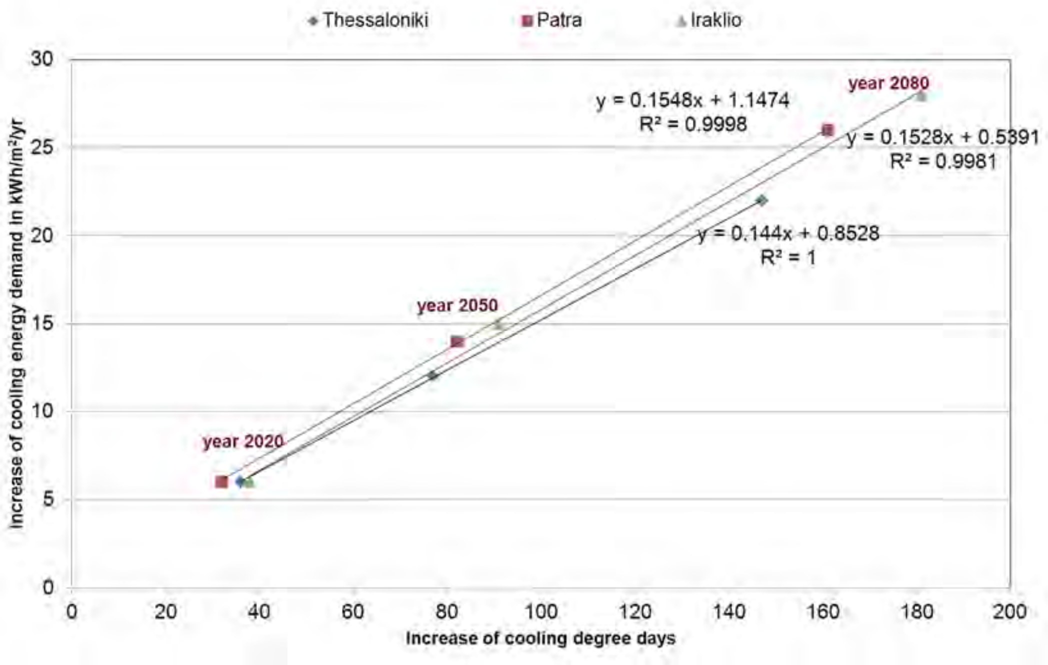
Reference building: Due to the climate change, the cooling load of the ***reference*** building is expected to increase through the years:

Patra: 15% (or 6 kWh/m^2/yr) with a parallel 19% increase of CDD (or 32 CDD) in year 2020, 34% (or 14 kWh/m^2/yr) with a 48% increase of CCD (82 CCD) in year 2050, and 63% (or 26 kWh/m^2/yr) with a 96% increase of CCD (161 CDD) in year 2080.

Thessaloniki: 19% (or 6 kWh/m^2/yr) with a parallel 25% increase of CDD (or 36 CDD) in year 2020, 39% (or 12 kWh/m^2/yr) with a 54% increase of CCD (77 CCD) in year 2050, and 71% (or 22 kWh/m^2/yr) with a 104% increase of CCD (147 CDD) in year 2080.

Iraklio: 14% (or 6 kWh/m^2/yr) with a parallel 31% increase of CDD (or 38 CDD) in year 2020, 34% (or 15 kWh/m^2/yr) with a 75% increase of CCD (91 CCD) in year 2050, and 64% (or 28 kWh/m^2/yr) with a 149% increase of CCD (181 CDD) in year 2080.

As it is shown in Graph 53 a linear correlation can be noted between the increase of the cooling degree days and the increase of the cooling energy demand of the reference building through the years.



Graph 53 Linear relation between the increase of CDD and the increase of the cooling energy demand

Optimum building: The reduction of the cooling load of the ***optimum*** building compared to the reference building due to the implementation of the most energy efficient technique in each period is:

Patra: 80% or 33 kWh/m^2/yr in present year, 76% or 36 kWh/m^2/yr in year 2020, 72% or 40 kWh/m^2/yr in year 2050 and 66% or 44 kWh/m^2/yr in year 2080.

Thessaloniki: 87% or 27 kWh/m^2/yr in present year, 83% or 31 kWh/m^2/yr in year 2020, 79% or 34 kWh/m^2/yr in year 2050 and 73% or 39 kWh/m^2/yr in year 2080.

Iraklio: 78% or 34 kWh/m^2/yr in present year, 73% or 37 kWh/m^2/yr in year 2020, 67% or 40 kWh/m^2/yr in year 2050 and 60% or 43 kWh/m^2/yr in year 2080.

- **Heating load**

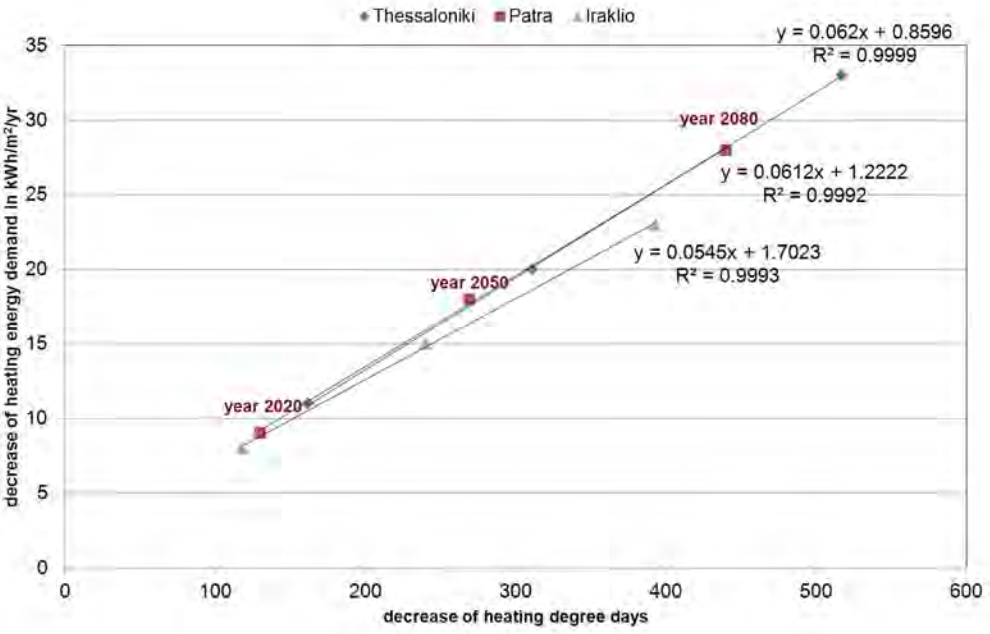
Due to the climate change, the heating load of the ***reference*** building is expected to decrease:

Patra: 15% (or 9 kWh/m^2/yr) with a parallel 12% decrease of HDD (or 130 HDD) in year 2020, 30% (or 18 kWh/m^2/yr) with a 24% decrease of HDD (269 HDD) in year 2050, and 46% (or 28 kWh/m^2/yr) with a 39% decrease of HDD (440 HDD) in year 2080.

Thessaloniki: 8% (or 11 kWh/m^2/yr) with a parallel 8% decrease of HDD (or 162 HDD) in year 2020, 15% (or 20 kWh/m^2/yr) with a 15% decrease of HDD (311 HDD) in year 2050, and 24% (or 33 kWh/m^2/yr) with a 24% decrease of HDD (517 HDD) in year 2080.

Iraklio: 19% (or 8 kWh/m^2/yr) with a parallel 13% decrease of HDD (or 118 HDD) in year 2020, 36% (or 15 kWh/m^2/yr) with a 28% decrease of HDD (240 HDD) in year 2050, and 55% (or 23 kWh/m^2/yr) with a 45% decrease of HDD (393 HDD) in year 2080.

As it is shown in Graph 54 a linear correlation can be noted between the decrease of the heating degree days and the decrease of the heating energy demand of the reference building through the years.



Graph 54 Graph showing the relation between the decrease of HDD and the decrease of the heating energy demand

Optimum building: The reduction of the heating load of the ***optimum*** building compared to the reference building is:

Patra: 66% or 40 kWh/m^2/yr in present year, 68% or 36 kWh/m^2/yr in year 2020, 71% or 31 kWh/m^2/yr in year 2050 and 74% or 24 kWh/m^2/yr in year 2080.

Thessaloniki: 57% or 78 kWh/m^2/yr in present year, 58% or 73 kWh/m^2/yr in year 2020, 59% or 68 kWh/m^2/yr in year 2050 and 60% or 62 kWh/m^2/yr in year 2080.

Iraklio: 70% or 29 kWh/m^2/yr in present year, 73% or 25 kWh/m^2/yr in year 2020, 76% or 21 kWh/m^2/yr in year 2050 and 81% or 15 kWh/m^2/yr in year 2080.

10.7.2. Seasonally operated building

- **Cooling load**

Optimum building: The reduction of the cooling load of the ***optimum*** building compared to the reference building is:

Patra: 86% or 35 kWh/m^2/yr in present year, 82% or 38 kWh/m^2/yr in year 2020, 76% or 42 kWh/m^2/yr in year 2050 and 72% or 48 kWh/m^2/yr in year 2080.

Thessaloniki: 92% or 29 kWh/m^2/yr in present year, 87% or 33 kWh/m^2/yr in year 2020, 82% or 36 kWh/m^2/yr in year 2050 and 77% or 41 kWh/m^2/yr in year 2080.

Iraklio: 86% or 38kWh/m^2/yr in present year, 82% or 41 kWh/m^2/yr in year 2020, 75% or 44 kWh/m^2/yr in year 2050 and 67% or 49 kWh/m^2/yr in year 2080.

10.7.3. Comparison of optimum buildings in the 3 climatic areas

The simulation results show the highest cooling energy demand in the southernmost part of Greece (Iraklio) and the lowest one in the northern area (Thessaloniki).

Concerning the heating energy demand, the highest values are observed in the northern part of Greece (Thessaloniki) and the lowest ones in the southern area (Iraklio).

From the climatic analysis, it seems that Patra (climatic zone B) presents the highest maximum temperatures and cooling degree days, large diurnal differences and small night time temperatures. As a result, during the year, Patra is cooler than Iraklio, and presents the mildest climatic characteristics, compared to Thessaloniki and Iraklio. As the most energy efficient techniques were selected for the optimum buildings of that climatic zone, it seems that in terms of cooling the techniques are performing very well for buildings in Thessaloniki (that is cooler area than Patra) but not so well for buildings in Iraklio that in overall is warmer area than Patra. Therefore, the optimum buildings in Thessaloniki present nearly zero cooling load, ranging from 4 kWh/m^2/yr in present to 14 kWh/m^2/yr in year 2080 (Table 120). However in areas as Iraklio with higher night time temperatures and solar radiation than Patra, optimum buildings present quite high energy demand for cooling, ranging for the 'all year' operated building from 10 kWh/m^2/yr (present) to 29 kWh/m^2/yr (year 2080) and for the 'seasonally' operated building from 6 kWh/m^2/yr (present) to 24 kWh/m^2/yr (year 2080), (Table 124). For this area and especially for the long term future (2080) more drastic climate change solutions are required; the development of a design strategy based on the principles 'switch off', 'reflect' and 'blow away' would help for the removal of solar gains and excessive heat gains. This strategy could include even more shading, different type of glazing (reflecting), cool materials of better performance and probably exploitation of the wind patterns of the area with another strategy/control of daytime and nighttime ventilation.

In terms of heating load, the optimum buildings in areas colder than Patra with more HDD, i.e.Thessaloniki, are not well equipped with the specific mitigation strategies and require high energy demand that ranges between 58 kWh/m^2/yr in present to 41 kWh/m^2/yr in year 2080. The selected energy techniques are not coping with the climate of this area, more efficient strategies are in need to tackle the climate change. A design strategy based on the 'switch off and absorb' principle would provide higher level of insulations, combined with a more appropriate glazing that would prevent heat losses, the minimization of shading and the avoidance of cool materials. On the hand, the optimum buildings of areas with less HDD than Patra, i.e. Iraklio, would present almost zero heating energy demand in 2080.

The climatic analysis of the forecast future years shows that the decrease in heating degree days is almost double than the increase of the cooling degree days. This results in increase of the cooling demand and decrease of the heating demand in the future. Taking into consideration that cooling mainly relies on electricity; this signifies a modification on the use of the primary energy and a shift towards electrical power. Other alternatives like renewable energy source should be considered for the generation of electrical energy.

The simulations are performed taking into consideration current conventional mitigation measures, thus passive cooling techniques that focus on the upgrade of the building envelope and deal with the control of heat transfer (switch off and absorb principle), solar control (switch off and reflect principle), heat gain (thermal storage capacity, absorb principle), heat dissipation (blow away principle) and the adjustment of the cooling set point (convection principle). With the implementation of the above climate change adaptation methods a significant reduction of the building energy demand is achieved in both the cooling and heating season but still the building presents rather high cooling in the long term future. This may indicate the inefficiency of the conventional mitigation methods to cope with the climate change and the necessity to develop further the technical characteristics of the current technologies to cope with severe climatic characteristics, in the long term future.

10.8. Conclusions

The main findings of this chapter can be summarized below:

- The forecast future years as these were generated using the CCWorldWeather Generator tool, developed by Southampton University; show that there is a significant increase of the CDD and significant decrease of HDD in all climatic zones through the years.
- Iraklio (climatic zone A) presents the maximum number of night cooling degree days, Thessaloniki (climatic zone C) the maximum number of heating degree days and Patra (climatic zone B) presents the highest cooling degree days.

- A linear correlation can be noted between the modification (decrease/increase) in heating and cooling degree days and the energy demand of the buildings.

- The number of CDD and HDD is an indication for the estimation of the energy demand of buildings, however other parameters like nighttime temperatures and diurnal difference should be considered.

- The optimum buildings in Iraklio present the highest cooling energy demand; this can be attributed to the highest nighttime temperatures. The maximum cooling degree days are calculated in Patra, however buildings in Patra present lower cooling load than buildings in Iraklio; this can be attributed to the lower nighttime temperatures in Patra that would enhance night cooling potential and affect the cooling of internal surfaces and air. Furthemore, Patra presents larger diurnal difference than Iraklio.

- Optimum buildings in Thessaloniki present the highest heating energy demand.

- In terms of cooling, the optimum buildings are not performing well in areas with increased night CDD and higher average temperatures than these of Patra and would require extra mitigation strategies to tackle the increased solar and heat gains based on the principles 'switch off', 'reflect' and 'blow away'. On the other hand, in areas with lower CDD than Patra, optimum building would require nearly zero cooling in the long-term future.

- In terms of heating, the optimum buildings are not performing well in areas with increased HDD than these of Patra and would require extra mitigation strategies based on the 'switch off and absorb' principle to cope with the heat losses through the building envelope. On the other hand, in areas with lower HDD than Patra, optimum building would require nearly zero heating in the long-term future.

- There will be an increase in the electricity demand in the long term future due to the increase of the cooling energy demand.

- The current mitigation strategies focusing on the building envelope are not efficient to cope with the climate change in the long term future, especially in areas with severe climatic conditions. Their performance and their characteristics should be further developed and these should be combined with the use of energy efficient plant.

CHAPTER 11

Conclusions and Further Research

11 Conclusions and Further Research

The study has investigated the energy performance of hotel buildings and climate change mitigation strategies for an optimum building envelope design. The study has proceeded in two parts:

First, the energy and environmental performance of 90 Greek hotels is collected through questionnaires and on site visits and statistically analysed. The reported energy consumption is classified using the k-means algorithm within the MATLAB environment. Well separate clusters derive from the classification and reference values for typical and best practice buildings are identified.

In the second part, a typical hotel building, as derived from the classification, is used as reference to assess the impact of the climate change on the building's energy demand. Then, climate change mitigation strategies are investigated for an optimum building envelope design for the current year, and years 2020, 2050 and 2080. The adaptation strategies are assessed for two modes of operation: 'all year' operated building and 'seasonally' operated building. The efficiency of the proposed strategies is assessed for the 3 climatic regions of Greece. The whole assessment is performed via hourly simulations using the TRNSYS software.

The main findings of this work fall into two broad categories:

- The purposes of the classification and the necessity of benchmarks and
- The definition of the most energy efficient mitigation strategies through simulation results aiming at the reduction of the building energy demand (heating and cooling load kWh/m^2/yr) in order to tackle the climate change.

11.1. Main results

Energy and environmental performance of 90 Greek hotels

- 40% of the hotels were constructed before 1979 when the national thermal insulation code was put into force. Only 9% is build after 2000. Thus, only 14% are fully insulated (roof, external wall & ground floor).

- Concerning the glazing, out of 50 hotels 44% have double glazing and only 8% have double reflective windows.
- For heating and cooling all hotels rely on the use of conventional energy sources, thus fossil fuels. For heating, 37% use electricity, 26% use natural gas for space heating, 7% liquid gas (LPG), 22% oil, 8% use both natural gas and oil. Cooling relies 100% on the use of electricity. Concerning domestic hot water, less than the half of the sample use solar collectors.
- Out of 50 hotels, only in 14% there is a Building Management System that is connected to the central cooling system. In 52% there is not a BMS.
- Energy measures have been applied in 52% of the hotels. These include the use of control cards in the rooms in order to switch off/on the lights (48%) the use of low energy luminaires (6), the use of air conditioners with inverter (6%) the use of low flush toilets (4%) and the use of thermostats (6%)
- The normalized average energy consumption (per size and climate) is shown in Table 128.

Table 128 Average energy consumption electricity and oil (kWh/m^2/yr) for the 90 hotels

Average energy consumption	**Electricity** (kWh/m^2/year)		**Oil** (kWh/m^2/year)
All sample included - 90 hotels	182	All sample included - 30 hotels	61
Annual operation (49 hotels)	202	Annual operation (12 hotels)	87
Seasonal operation (41 hotels)	159	Seasonal operation (18 hotels)	43

- Using the cumulative frequency distribution, the **electricity** consumption of a typical hotel building (50% of the sample) is approx. 140 kWh/m^2/year and of a best practice (25% of the sample) is 58 kWh/m^2/year.
- Using the cumulative frequency distribution, the **oil** consumption of a typical hotel building (50% of the sample) is approx. 28 kWh/m^2/year and of a best practice (25% of the sample) is 11 kWh/m^2/year.

Classification of hotels

The classification of the hotels using the k-means algorithm controlled with the silhouette plot is performed for the whole sample (90 hotels) and then for the 'all year' (49 hotels) and seasonally operated hotels (41 hotels). The results of the classification in terms of electricity consumption are shown in Table 129 –Table 131.

Table 129 Clustering of the electrical consumption of 49 hotels (year 2007)

Clusters for the Normalized Electricity consumption (2007) of 90 Hotels					
Values (kWh/m^2)	**1**	**2**	**3**	**4**	**5**
Number of hotels	29	23	26	9	3
Minimum	7	86	174	315	623
Maximum	86	174	315	623	1260
Centroid	39	129	234	378	945

Table 130 Clustering of the electrical consumption of 49 hotels (year 2007)

Clusters for the Normalized Electricity consumption (2007) of 49 Hotels with annual operation					
Values (kWh/m^2)	**1**	**2**	**3**	**4**	**5**
Number of hotels	13	16	10	8	2
Minimum	14	85	174	282	664
Maximum	85	174	282	664	1260
Centroid	38	132	225	369	1045

Table 131 Clustering of the electrical consumption of 41 hotels (year 2007)

Clusters for the Normalized Electricity consumption (2007) of 41 Hotels with seasonal operation				
Values (kWh/m^2)	**1**	**2**	**3**	**4**
Number of hotels	15	8	17	1
Minimum	7	76	175	586
Maximum	76	175	586	746
Centroid	37	117	252	746

As already mentioned in section 5.4, a characteristic of the k-means algorithm is that the clustering results are strongly influenced by the initial conditions. Therefore, the clustering results would have been different if the sample of the hotels was bigger and if the hotels were clustered based on the operational energy consumption of a different year.

Therefore, the above clusters could be used as benchmarks if:

- The sample is representative of the hotel stock, thus represents at least 10% of the hotel stock
- The average energy consumption that is used for the clustering covers at least a 5-year period for every hotel.

The hotels are clustered based on their operational energy consumption and in accordance with their size and guest facilities. Usually, 'small' hotels with fewer rooms and facilities belong in cluster 1, therefore it is unusual that a five star 'large' hotel and a two star 'small' hotel belong in the same cluster. Therefore, each hotel should be compared to the 'typical' hotel of the same cluster in order to assess its energy efficiency and be as 'good' or even 'better' than the typical hotel.

Impact of the climate change on the reference building using real monitored data

Using real monitored data for the period 1970 – 2010 for the area of Athens, the simulation results show an increase of the cooling load of the reference hotel by 33% and a decrease in the heating demand by 22% in 2010 compared to 1970.

Impact of the climate change on the reference building using generated future files

Future files were generated for the period 2020, 2050 and 2080 using the CCWorldWeather Generator tool developed by Southampton University (Southampton University,2010; Jentsch et al., 2008). The simulation results indicate an increase of the cooling load of the reference building by 15% in year 2020, 34% in year 2050 and 63% in year 2080. On the other hand heating load is expected to decrease by 14% in year 2020, 29% in year 2050 and 46% in year 2080.

Mitigation strategies for an optimum building envelope design for the reference building

The following climate change mitigation strategies (Table 132) are examined for the reference building based on the methodology described in CIBSE TM36 (Hacker et al., 2005).

Table 132 Climate change mitigation strategies for the reference hotel

Principle	Type of Principle	Techniques
Switch off	Passive cooling	shading, double low emission glazing
Absorb & switch off	Passive cooling	adding insulation in walls & roof
Reflect	Passive cooling	cool materials & double low e glazing
Blow away	Passive cooling	Intelligent night and day time control
Convection	Hybrid cooling	using ceiling fans

It is found that different strategies can be applied to all year and seasonally operated buildings for the most energy efficient performance. These include:

- All year operation.

The selected principles and energy techniques are those that have the best benefit for the building for both the heating and cooling period. In all climatic periods, the all year operated optimum buildings comprise: Insulation (10cm) in external walls and roof, double low e glazing (U=1.8 W/m^{2}K, g=0.45), intelligently controlled night ventilation, intelligently controlled day ventilation, ceiling fans in the rooms, and shading to the corridors. The building of year 2050 would need more shading and the building of year 2080 would need additional shading and cool materials.

The implementation of the above principles results in significant reduction of both the cooling and heating loads of the reference building in all climatic periods.

- Seasonal operation.

In that case the building is operating during the months May to September. The simulations are carried out for the whole year but heating, cooling, ventilation and all internal gains (lighting, people) are operating only for the months May – September whereas for the months January – April and October to December the systems and internal gains are set to 0. In all climatic periods, the 'optimum' buildings comprise: Intelligently controlled night ventilation, cool materials, ceiling fans, intelligently controlled day ventilation, shading and double low e glazing. Only the building of year 2080 would need insulation.

The implementation of the above principles results in significant reduction of the cooling load of the reference building in all climatic periods.

Effectiveness of the proposed measures in hotels located in different climatic regions in Greece

The simulation results and the reduction of the energy demand of the optimum building compared to the reference building in each period are shown in Table 133 (for all year operated building) and Table 134 (for 'seasonally' operated building).

Table 133 Heating and cooling load (kWh/m^2/yr) for the optimum building with all year operation for the 3 climatic zones of Greece

OPTIMUM BUILDINGS – ALL YEAR OPERATED							
		HEATING LOAD kWh/m^2/yr			**COOLING LOAD kWh/m^2/yr**		
		Patra	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**
Present day	Ref	61	136	42	41	31	44
	Opt	21	58	12	8	4	10
2020	Ref	52	125	34	47	37	50
	Opt	16	53	9	11	6	14
2050	Ref	43	116	27	47	37	50
	Opt	13	48	7	11	6	14
2080	Ref	33	103	19	67	53	72
	Opt	9	41	4	22	14	29

Table 134 Heating and cooling load (kWh/m^2/yr) for the optimum building with seasonal operation for the 3 climatic zones of Greece

OPTIMUM BUILDINGS – SEASONALLY OPERATED							
		HEATING LOAD kWh/m^2/yr			**COOLING LOAD kWh/m^2/yr**		
		Patra	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**
Present day	Ref	61	136	42	41	31	44
	Opt	1	2	1	6	3	6
2020	Ref	52	125	34	47	37	50
	Opt	1	2	1	8	5	9
2050	Ref	43	116	27	55	43	59
	Opt	1	2	0	13	8	15
2080	Ref	33	103	19	67	53	72
	Opt	1	2	0	19	13	24

11.2. Conclusions

From the analysis of the hotel stock it is obvious that there is enormous potential for energy savings through the rehabilitation of hotel buildings a. by upgrading the building envelope that currently in most of the cases does not comply with the EPBD legislation; additionally the research showed that a very few cases of the energy rehabilitations so far implemented has focused on the building envelope, b. the upgrade of the building systems that are rather old and c. the implementation and use of renewable energies since almost all of the hotels rely on the use of conventional fuel sources. Additionally, the use of solar collectors is rather low taking into consideration the high solar radiation in Greece.

Electricity is the main fuel used in the hotel sector. The average electricity consumption of the hotels is rather high enforcing the necessity for energy rehabilitation. Additionally, the classification results and in particular the average values of each cluster also identify high energy consuming typical buildings for each cluster. Also it should be noted that the characteristic values (maximum, minimum, centroid) of each cluster differ a lot (i.e centroid values for electricity 39 kWh/m^2/year for cluster 1 and 945 kWh/m^2/year for cluster 5, Table 128) intensifying the fact that the hotels' energy consumption varies widely from hotel to hotel depending on location, size and guest facilities. For that reason, a classification scheme based on clusters is useful for a better understanding of the energy performance of a large group of buildings with diverse size, operation and energy use.

The climate change and in particular the increase of the air temperature has a significant impact on the energy demand of the reference hotel building, an increase of the cooling load and a decrease of the heating load. Between the three climatic regions, the optimum buildings require more cooling in climatic zone A and extra mitigation strategies are in need based on the principles 'switch off', 'reflect' and 'blow away' to cope with the increased solar gains. In terms of heating, the optimum buildings in climatic zone C require extra mitigation strategies based on the 'switch off and absorb' principle to cope with the heat losses through the building envelope. Additionally, it was found that different strategies can be applied to all year and seasonally operated buildings for the most energy efficient performance. Therefore, for an all year operated building, extra shading and cool materials are required in time, whereas for a seasonally operated building insulation is required for the long term future, i.e. after year 2080.

The simulation results show that the cooling load of the optimum buildings is rather high in 2050 and 2080, meaning that the current technologies are not efficient enough to cope with the climate change in the long term future. Additionally, in terms of heating, optimum buildings are not very efficient in areas with severe climatic conditions. Therefore, for a better result the energy efficient building envelope design should be combined with the use of energy efficient plant.

11.3. Further research

The following are proposed as further research:

- A more complete classification scheme would require a higher number of sample that would shift accordingly the boundaries and centroid of each cluster. The practice showed that the collection of data was performed more effectively via site visits rather than through the internet. Additionally it would be very helpful the collaboration of a professional chamber, i.e. the Hellenic Chamber of Hotels, which did not respond within the frames of this research although it was addressed.

- Further research is required to identify whether a relation exists between the energy consumption of the hotels and their occupancy pattern. So far, information on this field derived from the literature is contradictory and it seems that external temperature has the major impact on the electricity consumption of hotels. Detailed data is required on the occupancy of different hotels and for a period consisting of at least three years.
- Adaptive comfort of customers especially in the rooms would consist of another field for further investigation. As already mentioned, the room is the area that is most influenced by the users' behaviour, and it would be interesting to investigate the relation of the energy consumption of the hotel in conjunction with the indoor environment in the rooms and the adaptive behaviour of the users in using ceiling fans, opening windows, switching on / off local cooling systems. This can be performed with measurements of energy consumption, indoor temperatures and comfort surveys.
- Further investigation is required on the impact of the thermal mass on the building energy consumption. This can be applied by investigating the impact of the thermal mass on the reference building, thus on buildings that are not equipped with energy measures.
- The impact of the climate change was investigated on a typical building of cluster 1. It would be interesting to investigate the impact of the climate change on typical buildings also of other clusters, and especially of clusters 4 and 5 that comprise buildings with very high energy consumption. In this case the energy savings relying only on a building envelope design will be very small and solutions on HVAC systems and renewable energy sources would be essential.

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Appendix 1 - Questionnaire for the hotel energy survey

QUESTIONNAIRE FOR THE ENERGY AND ENVIRONMENTAL ASSESSMENT OF HOTELS

1. GENERAL INFORMATION

Hotel name: ___
City/address: ___
Hotel category: ___
Year of construction: ___

The hotel owner occupies ___% of the building, since ______

Contact person
Name: ____________________ Tel/email: __________________

Building area/volume
Number of Floors (including ground floor):
Total Heated Floor Area [m^2]:
Total Heated Air Volume [m^3]:
Total Air-conditioned Floor Area [m^2]:
Total Air-conditioned Air Volume [m^3]:
Total Underground Parking Area [m^2]:

Building Function (List all primary spaces and their function, along with the occupied space or as a percentage of the total floor area of the whole building)

Space	**Floor Area [m^2]**	**Space**	**Floor Area [m^2]**
Common areas		**Rooms**	
Reception		Rooms	
Living area-lounge			
Dining room-restaurant			
Kitchen			
Laundry			
Cafeteria/bar			
Shops			
Conference Rooms			
Swimming pool			
Other (specify)			
Total building area			

Number of rooms: ___
Less than 100 ( ) 100 to 300 ( ) 300 to 500 ( )
Other:

Permanent Number of Employees:
Less than 5 ( ) 5 to 20 ( ) 20 to 50 ( ) 50 to 100 ( )

Other:

Hotel Operation: From month _____ to ____

Hotel occupancy/completeness (%):

January:	July:
February:	August:
March:	September:
April:	October:
May:	November:
June:	December:

Building renovations

Major Renovations or Additions: Did any renovation take place the last years? ________

Description of Renovation: ___________

Year: ___________

Cost: ___________

Are the architectural drawings of the building available?

Yes ( ) No ( )

2. INFORMATION ON ENERGY CONSUMPTION

Cost of energy (euros) the last 2 years

Year	**Fuel/ Cost (euros)**				
	Electricity	Gas	Diesel	Oil	Other
200..					
200..					

Source of Data: Utility [ ] Bills [ ] Other: ___

Annual Energy Consumption the last 2 years

Year	**Fuel/ Cost (kWh or lt)**				
	Electricity	Gas	Diesel	Oil	Other
200..					
200..					

Source of Data: Utility [ ] Bills [ ] Other: ___

3. BUILDING ENERGY MANAGEMENT

Is the thermal and electrical energy consumption of the building recorded?

Yes ( ) No ( )

If yes, what is the frequency of the recording? ___________

Do you have a written energy plan (excluding audits) for controlling energy costs in your building?

Yes ( ) No ( ) Don't know ( ) Plan to ( )

Who is responsible for the building services (heating/cooling)? ___________

Who is responsible for the maintenance of the building services? ___________

Financial sources which have been used in the past to purchase energy-saving capital equipment or for any planned energy investment (internal funds, loans, grants, goverrment support)**:** ___

Have there been any activities towards the clients' awareness regarding energy issues aiming at energy conservation? Yes ( ) No ( )

If yes, what activities have been taken? __________

Have there been applied measures of energy conservation? If yes, what are these and when these were applied?

Measure for energy conservation	Date of application
1.	
2.	
3.	

Which sector does it need improvement aiming at energy conservation?

Building insulation ( )
Heating system ( )
Cooling system ( )
Air-conditioning system/Ventilation ( )
Installation of hot water ( )
Lighting ( )
Building Management System ( )
Clients/hotels residents' awareness ( )

Specific problems of your building: __________

4. BUILDING DESCRIPTION

Building Shape / Orientation (provide a simple sketch / layout, showing the building orientation)

Does the building site or its surroundings contain obstructions that reduce outdoor air movement for natural ventilation? Yes ( ) No ( )

Nearby buildings (if any) are generally:
Taller ( ) Not as tall ( ) About same height ( )

Does the building or its surrounding contain objects that block sunlight from reaching the building?
Yes ( ) No ( )

ROOF

Flat Roof ( )   Tilted Roof ( )
Insulated ( )   Type of Insulation:

Roof area: _______ m^2

Problems to the roof construction due to:
Internal moisture ( )
Air penetration under the thermal insulation ( )
Physical corruption of thermal insulation ( )

FLOOR

Is the ground floor insulated?
Yes ( )   No ( )   Type of Insulation: _______

Are the floors insulated?
Yes ( )   No ( )   Type of Insulation: _______

Describe the layers of the ground floor construction (from inside to outside):

____

Problems to the floor construction due to:
Internal moisture ( )
Air penetration under the thermal insulation ( )
Physical corruption of thermal insulation ( )

Does the building have a basement?
Yes ( )   No ( )   **Function of the basement:** _______

The basement is:
Only heated ( )   Air conditioned ( )   No heating or cooling ( )

If the basement is conditioned, please specify:
Floor area: _______ [m^2]
Ceiling height: _______[m]
Is the basement floor insulated?
Yes ( )   No ( )   Type of Insulation: _______

EXTERNAL WALL

Concrete Blocks ( )   Double Concrete Blocks ( )   Concrete ( )
Brick ( )   Stone ( )   Other ( )

Are the external walls insulated? _____
Type of insulation: _____

Describe the layers of the external wall construction (from inside to outside):

____

Problems to the external wall construction due to:
Internal moisture ( )
Air penetration under the thermal insulation ( )
Physical corruption of thermal insulation ( )

WINDOWS - GLAZING

Glass Type

Single Glazed ( )   Double Glazed ( )   Other( )

Window airtightness: _____

Good ( )   Fair ( )   Bad ( )

SHADING DEVICES

TYPE	ORIENTATION	Area that is shaded	MAJOR DIMENSIONS (width, height, extension etc)
Overhangs			
Side fins			
Shutters			
Curtains			
Other			

5. HEATING SYSTEM

Type of System	Units (number)	Fuel	Daily Hours of Operation	Months of Operation
Common areas				
Central heating (boiler)				
Local fan coil units				
Local Electric Heater				
Other				
Rooms				
Central heating (boiler)				
Local fan coil units				
Local Electric Heater				
Other				

Condition of the heating system

Is the boiler insulated?   Yes ( )   No ( )

What is the condition of the insulation?   Good ( )   Fair ( )   Bad ( )

Is temperature control available?   Yes ( )   No ( )

Specify set temperature (C): __________

Set temperature is set by :

Space occupants ( )   Building manager( )   Other: __________

Operating Schedule

Days of Week	Time Heating is Turned On	Time Heating is Turned Off

System Maintenance
Most recent maintenance date: ___
Objective: ___

Does the building have any passive solar heating systems?
Yes ( ) No ( )

If yes, describe the system (atrium, greenhouse, heat storage, etc): ___
Location of the system: ___

6. COOLING SYSTEM

Type of System	Units (number)	Fuel	Daily Hours of Operation	Months of Operation
Common areas				
Central cooling				
Local A/C split units				
Ceiling fans				
Other				
Rooms				
Central cooling				
Local A/C split units				
Ceiling fans				
Other				

Is temperature control available? Yes ( ) No ( )

Specify set temperature (C): ___

Set temperature is set by:
Space occupants ( ) Building manager ( ) Other: ___

Provision for temperature setup
Specify set temperature (C): ___

Operating Schedule

Days of Week	Time A/C Turned On	Time A/C Turned Off

System Maintenance
Most recent maintenance date: ____
Objective: ________________________

Does the building have any passive cooling systems?
Yes ( ) No ( )

If yes, describe the system (underground cooling, etc): ___
Location of the system: ___

7. LIGHTING INSTALLATION

TYPE OF AREA	TYPE OF LIGHTS[1]	NUMBER OF LUMINAIRES	WATTS	CONTROL[2]
Common areas				
Reception				
Living area-lounge				
Dining room-restaurant				
Kitchen				
Laundry				
Cafeteria/bar				
Shops				
Conference Rooms				
Swimming pool				
Other				
Rooms				

[1] **(Use the following codes)**

SI: Standard Incandescent
F: Fluorescent
H: Halogen
Other:___________________

[2] **(Use the following codes)**

M: Manual, occupancy sensor
A: Automated, scheduled automatic control

Condition of the lighting installation
Good ( ) Fair ( ) Bad ( )

System Maintenance
Most recent maintenance date: ___
Objective: ___

8. HOT WATER SYSTEM

Type of System	Number of units	Volume (lt)	Power (kW)	Daily Hours of Operation	Months of Operation
Solar collector*					
Electric heater					
Natural gas					
District heating					
Other					

* For Solar Collector instead of power enter collector surface area (m^2)

9. ELECTRICAL APPLIANCES

List the electrical appliances (other than lighting, air conditioning, heating, and domestic hot water)

Type of System	**Units (number)**	**Power (kW)**	**Daily Hours of Operation**
Computers			
Copying machines			
Elevators			
Escalators			
Washers			
Dryers			
Cookers			
Other			

THANK YOU FOR YOUR COOPERATION

Appendix 2 - Pictures of the hotel

1. Year 2007 - Before the renovation

Figure 1 Southeast orientation (circulation areas to the rooms)

Figure 2 Southeast orientation Entrance and circulation areas

Figure 3 Northwest orientation (rooms)

Figure 4 Northwest orientation

Figure 5 Entrance

Figure 6 Lounge

Figure 7 Restaurant

Figure 8 Room

Figure 9 Reception

Figure 10 Lounge and bar

2. Year 2008 - After the renovation

Figure 11 Northwest orientation (rooms)

Figure 12 Northwest orientation - lounge

Figure 13 Lighting installation in the restaurant area

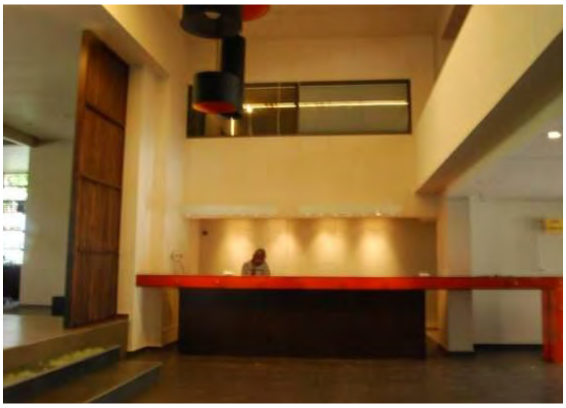

Figure 14 Lighting installation in the reception area

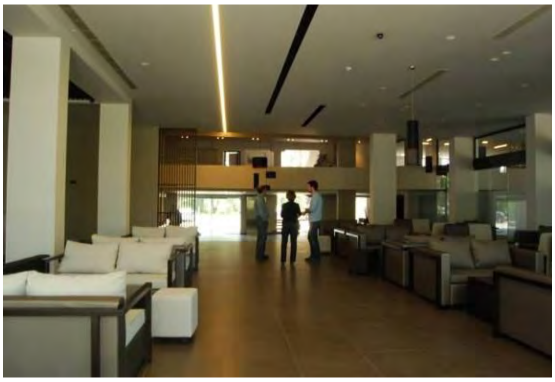

Figure 15 Lighting installation in the lounge area

Figure 16 Lounge area

Appendix 3 - Layout - architectural drawings

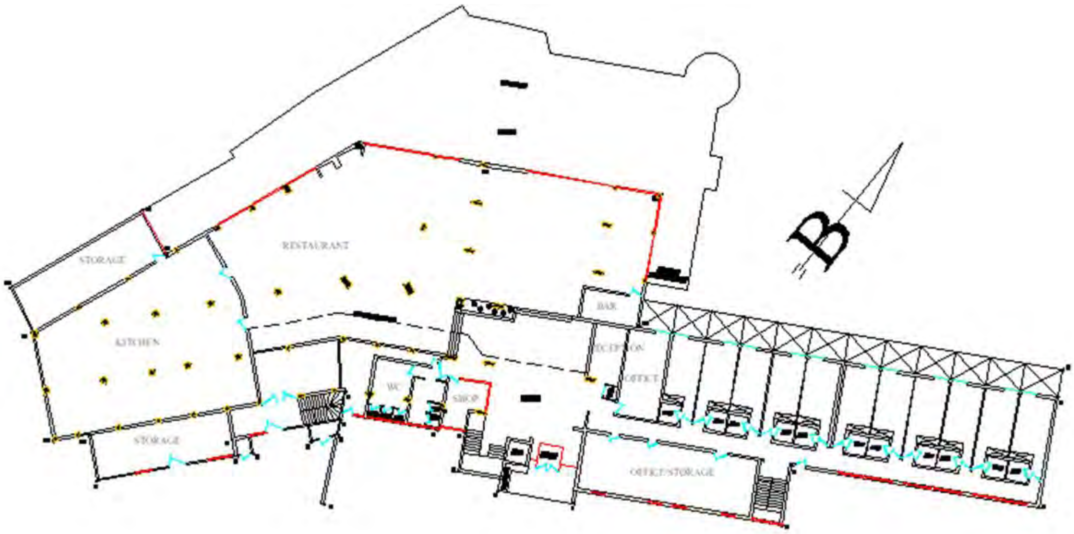

Figure 1 Ground floor

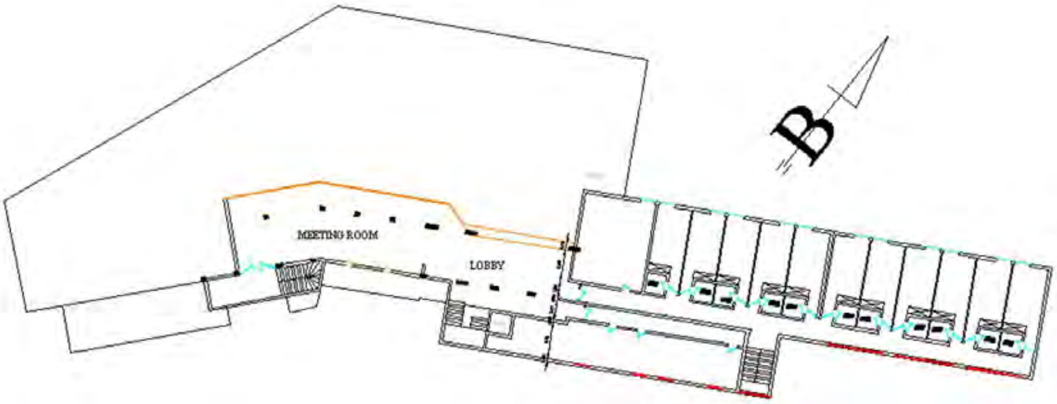

Figure 2 Mezzanine – a floor

Figure 3 B floor

Figure 4 C floor

Figure 5 D floor

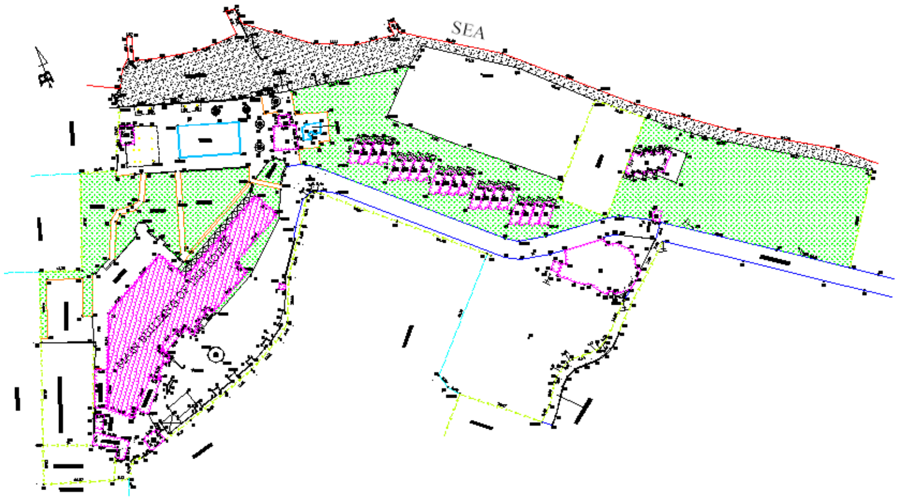

Figure 6 Existing building with the surrounding area

Appendix 4 - Thermal zones of the hotel for the simulations

Figure 1 Thermal zones - Ground floor

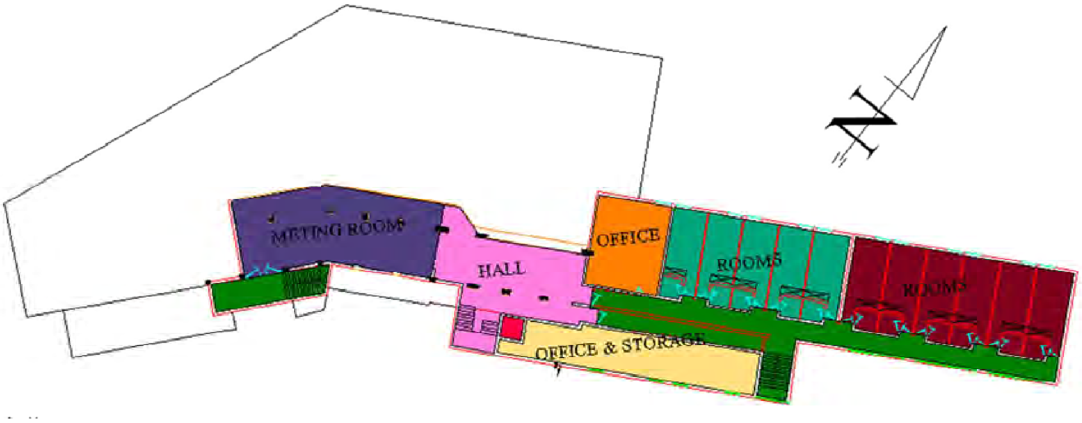

Figure 2 Thermal zones – Mezzanine A floor

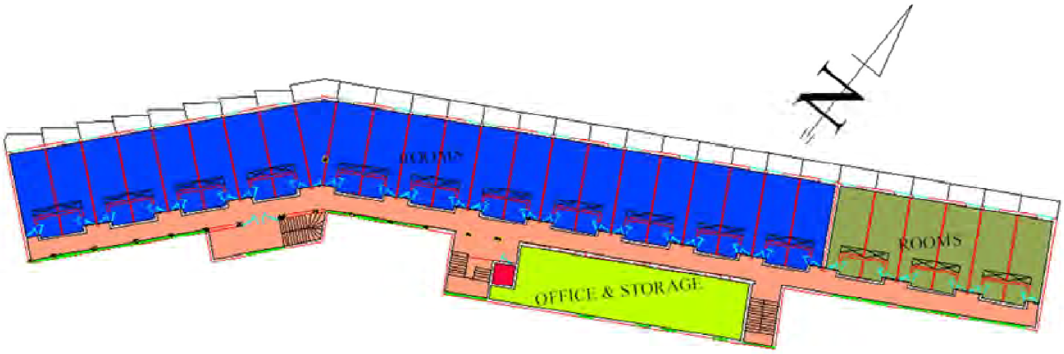

Figure 3 Thermal zones -B floor

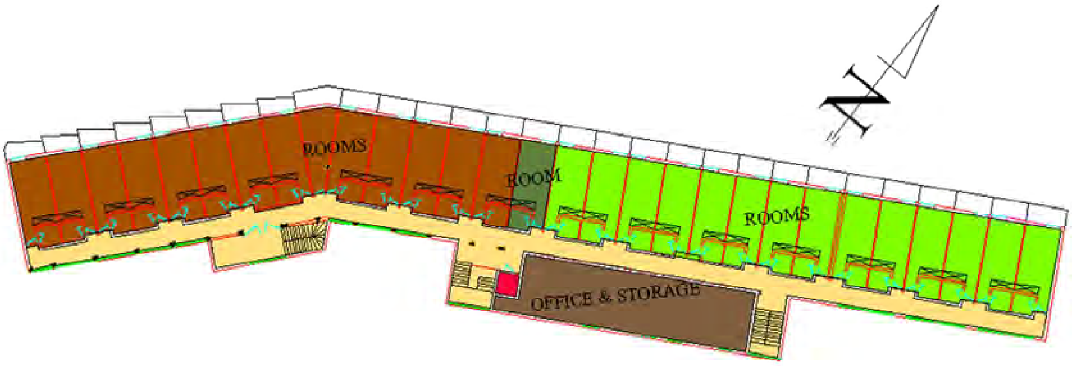

Figure 4 Thermal zones - C floor

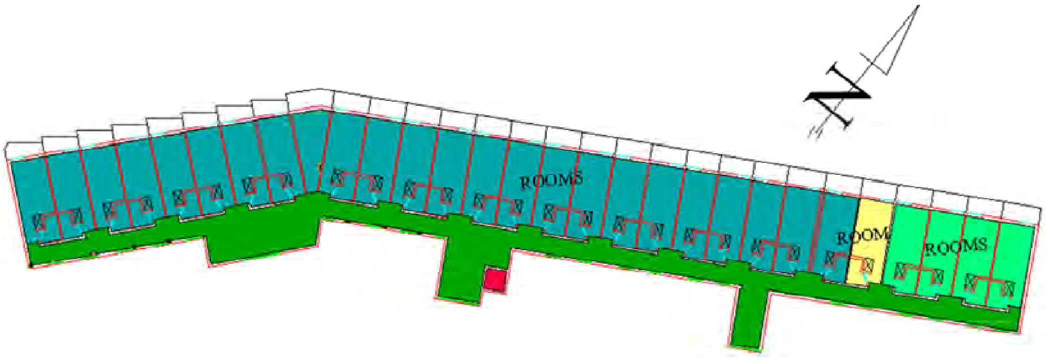

Figure 5 Thermal zones - D floor

Appendix 5 - Electricity bills for years 2007 - 2011

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΜΕΙΟΝ ΑΞΙΑ ΡΕΥΜ.ΕΝΑΝΤΙ	0,00
ΠΑΓΙΑ ΧΡΕΩΣΗ	11,76
ΩΧΒ 20880Χ0,09821€/ΩΧΒ=	2050,62
ΧΒ 453,6Χ2,10560€/ΧΒ=	955,10
ΜΕΙΟΝ ΑΞΙΑ ΡΕΥΜ.ΕΝΑΝΤΙ	-2190,08
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	0,12
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,50
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,41

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	826,61
ΦΠΑ 833,66 x 9% =	75,02
ΣΥΝΟΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	901,63

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
24650	24522	10240	0	10240
81768	81507	20880	0	20880
	23/10/2006			

ΤΙΜ.	ΣΙ KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	453,6

ΜΕΝΗ ΜΕΤΡΗΣΗ: 23/03/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,56	x	31/365	=	1107,23
Δ.Φ.	5390	x	0,20	x	31/365	=	91,52

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ

4000 x 146,00 x 0,80 x

ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ

0,00035 x 31/365 = 13,88

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.212,63

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ

50,88 x 126/365 = 17,56

ΜΕΙΟΝ ΕΝΑΝΤΙ ΕΡΤ -8,08

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 9,48

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40

20880 x 0,00030 = 6,26

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.228,37
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*2.130,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 14/03/2007

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής 10 12 - 4

Τέλη

Χρονολογικό Σήμαντρ

057 059152 01/03

Η-Αριθμός

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ 3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ 3020 18 ΧΙ 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ 23/10/2006 ΕΩΣ 26/02/2007

3 93207420 01 6 2203
2130,00 3
(2853)
00001427Α

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

Αρ. Λογ/κής Απόδοσης 33

Αριθμός Λογαριασμού (για μεταβίβαση)

ΗΜ/ΝΙΑ ΛΗΞΗΣ ΠΛΗΡΩΜΗΣ 14/03/2007

ΠΟΣΟ ΠΛΗΡΩΜΗΣ *2.130,00 €

Α 4 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Παρακαλούμε κόψτε εδώ

3431000/18Η

>393207420012203б< 2130003> 10124< 25> H

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,61
ΩΧΒ 4320Χ0,09821€/ΩΧΒ=	424,27
ΧΒ 16,8Χ2,10560€/ΧΒ=	35,37
ΠΟΣΟ ΣΤΡΟΓΓ. ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,41
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,31

ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	462,35
460,08 x 9% =	41,41
ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	503,76

Ξ ΕΙΣ ΜΕΤΡΗΤΗ

ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
24650	3200	0	3200
81768	4320	0	4320

KVA | ΣΥΝΤ. KWH 80 | ΧΡ. ΖΗΤ. 16,8 KW

ΕΗ: 25/04/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ. ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,56	x	28/365	=	1000,29
Δ.Φ.	5390	x	0,20	x	28/365	=	82,68

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ. ΗΜΕΡΩΝ
0,00035 x 28/365 = 12,54

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.095,51

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 28/365 = 3,90

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 3,90

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40

4320 x 0,00030 = 1,30
ΔΙΑΦΟΡΑ ΑΠΕ = -3,47

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.097,24
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*1.601,00 €

Α. ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ. ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 17/04/2007

Π α ρ α κ α λ ο ύ μ ε κ ό φ τ ε ε δ ώ

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΤΗΛΕΦ.
ΑΙΓΙΟΥ 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 ΧΙ 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
26/02/2007 ΕΩΣ 26/03/2007
3 93207420 01 7 2504
1601,00 4
00007533A (15065)

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής | Τέλη | Χρονολογικό Σήμαντ

10 12 - 4

086 150734 30/03 | Η-Αριθμός

Αρ. Λογ/κής Απόδοσ

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

55

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβαση)
17/04/2007	*1.601,00 €	

Α Ο ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η

>3932074200125047<

1601004>

10124< 25>

0861507340010133000

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,80
ΩΧΒ 22160Χ0,09821€/ΩΧΒ=	2176,33
ΧΒ 96,0Χ2,10560€/ΧΒ=	202,14
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	0,16
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,31
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,45

ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	2.382,19
ΙΑ 2387,92 x 9% =	214,91
ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	2.597,10

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
24803	24690	9040	0	9040
82099	81822	22160	0	22160

	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Σ		80	96,0

ΜΕΤΡΗΤΗ: 24/05/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,56	x	30/365	=	1072,02
Δ.Φ.	5390	x	0,20	x	30/365	=	88,61

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ

4000 x 146,00 x 0,80 x

ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ

0,00035 x 30/365 = 13,44

● **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.174,07

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ

50,88 x 30/365 = 4,18

● **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,18

● ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40

22160 x 0,00030 = 6,65

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.184,90
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*3.782,00 €

Α. ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ. ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 15/05/2007

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαντρο
10 12 - 4		

116 055562

30/04

Η-Αριθμός

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ: 3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ: 3020 18 Χ1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ: 26/03/2007 ΕΩΣ 25/04/2007

3 93207420 01 9 2305
3782,00 0
00002227Α (4453)

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
64

Αρ. Λογ/κής Απόδοσης

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβαση)
15/05/2007	*3.782,00 €	

Α 4 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

>3932074200123059< 3782000> 10124< 25>

Η

Παρακαλούμε κόψτε εδώ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,80
ΩΧΒ 17760Χ0,09821€/ΩΧΒ=	1744,21
ΧΒ 56,0Χ2,10560€/ΧΒ=	117,91
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	8,38
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,45
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,25
[illegible] ΠΛΗΡΩΝΕΤΕ	1.873,10
ΦΠΑ 1870,25 x 9% =	168,32
[illegible]	2.041,42

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚΩΗ	ΣΥΝΟΛΟ
20	24913	24803	8800	0	8800
25	82321	82099	17760	0	17760

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. ΚΩΗ	ΧΡ. ΖΗΤ. KW
Γ22		80	56,0

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 22/06/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,56	x	30/365	=	1072,02
Δ.Φ.	5390	x	0,20	x	30/365	=	88,61

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 30/365 = 13,44

● **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.174,07

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 30/365 = 4,18

● **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,18

● ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
17760 x 0,00030 = 5,33

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.183,58
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	3.782,00
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*7.007,00 €

+ 3.925

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 13/06/2007

παρακαλούμε κόψτε εδώ ✂

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής
10 12 - 4

Τέλη

Χρονολογικό Σήμαντρο

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΑΙΓΙΟΥ
ΤΗΛΕΦ. 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
25/04/2007 ΕΩΣ 25/05/2007

3 93207420 01 1 2106
7007,00 8
(10153)
00005077Α

145 061184
31/05

Η-Αριθμός

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

Αρ. Λογ/σμός Απόδοσης
59

Αριθμός Λογαριασμού (για μεταβίβαση)

[illegible]	ΠΟΣΟ ΠΛΗΡΩΜΗΣ
13/06/2007	*7.007,00 €

Α 4 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

10124< 25>

7007/008

>3932074200121061<

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,89
ΩΧΒ 27840Χ0,09821€/ΩΧΒ=	2734,17
ΧΒ 99,2Χ2,10560€/ΧΒ=	208,88
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,25
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,13

ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	2.945,82
4 2954,29 x 9% =	265,88
ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	3.211,70

ΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
25075	24913	12960	0	12960
82669	82321	27840	0	27840

Σ. Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
	80	99,2

ΜΕΤΡΗΣΗ: 24/07/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860	x	4,56	x	31/365 =	1107,23
Δ.Φ.	5390	x	0,20	x	31/365 =	91,52

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 31/365 = 13,88

● ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.212,63

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 31/365 = 4,32

● ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,32

• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
27840 x 0,00030 = 8,35

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.225,30
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*4.437,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 11/07/2007

176060724001012300000

Π α ρ α κ α λ ο ύ μ ε κ ό ψ τ ε ε δ ώ

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ
ΔΕΗ ΑΙΓΙΟΥ
ΤΗΛΕΦ. 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ 3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ 3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ 25/05/2007 ΕΩΣ 25/06/2007

3 93207420 01 3 1907
4437,00 0
00004770A (9539)

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαντρ
10 12 - 4		

176 060724
21/06

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
61

Η-Αριθμός

Αρ. Λογ/κής Απόδοσης

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβαση)
11/07/2007	*4.437,00 €	

Α 4 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420011907 3< 4437000> 10124< 25>

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,71
ΩΧΒ 38960Χ0,09821€/ΩΧΒ=	3826,26
ΧΒ 100,5Χ2,10560€/ΧΒ=	211,61
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	7,41
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,13
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,20

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	4.048,06
ΦΠΑ 4052,27 x 9% =	364,70
ΓΕΝΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	4.412,76

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	25301	25075	18080	0	18080
25	83156	82669	38960	0	38960

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	100,5

ΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 24/08/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ. ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,56	x	29/365	=	1036,81
Δ.Φ.	5390	x	0,20	x	29/365	=	85,70

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 29/365 = 13,00

● **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.135,51

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 29/365 = 4,04

● **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,04

● ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
38960 x 0,00030 = 11,69

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.151,24
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*5.564,00 €

Α. ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ. ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 13/08/2007

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαντρ
10 12 - 4		

207 065439
31/07 Η-Αριθμός

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΤΗΛΕΦ.
ΑΙΓΙΟΥ 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
25/06/2007 ΕΩΣ 24/07/2007

3 93207420 01 5 2208
5564,00 0
00007590Α (15179)

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

Αρ. Λογ/κής Απόδοσης 75

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβαση)
13/08/2007	*5.564,00 €	

Παρακαλούμε κόψτε εδώ

Α 5 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420012208 5< 5564000> 10124< 25>

2070654390010138000000

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,88
ΩΧΒ 47520Χ0,10073€/ΩΧΒ=	4786,81
ΧΒ 124,0Χ2,15959€/ΧΒ=	267,79
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,20
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,24
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	5.057,04
ΦΠΑ 5071,74 x 9% =	456,45
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	5.513,49

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
0	25533	25301	18560	0	18560
5	83750	83156	47520	0	47520

23/8/2007

ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	124,0

ΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 21/09/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,56	x	30/365	=	1072,02
Δ.Φ.	5390	x	0,20	x	30/365	=	88,61

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 30/365 = 13,44

- ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.174,07

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 30/365 = 4,18

- ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,18
- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
47520 x 0,00030 = 14,26

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.192,51
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*6.706,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 12/09/2007

ΔΕΗ

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ 3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ 3020 18 ΧΙ 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ 24/07/2007 ΕΩΣ 23/08/2007

3 93207420 01 7 2009
6706,00 6
00004536A (9071)

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαντ
10 12 - 4		

239 054984
30/08 Η-Αριθμός

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

Αρ. Λογ/κής Απόδοση 775

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβαση)
12/09/2007	*6.706,00 €	

Παρακαλούμε κόψτε εδώ

Α 4 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

239054984001018300000

Η >393207420012009 7< 6706006> 10124< 25>

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,00
ΩΧΒ 33600Χ0,10165€/ΩΧΒ=	3415,44
ΧΒ 138,8Χ2,17930€/ΧΒ=	302,49
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,24
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,01
[illegible]	3.721,18
ΦΠΑ 3731,01 x 9% =	335,79
[illegible]	4.056,97

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚWH	ΣΥΝΟΛΟ
20	25755	25533	17760	0	17760
25	84170	83750	33600	0	33600

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. ΚWH	ΧΡ. ΖΗΤ. KW
Γ22		80	138,8

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²	ΕΥΡΩ/Μ²	ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860 x	4,56 x	31/365 =	1107,23
Δ.Φ.	5390 x	0,20 x	31/365 =	91,52

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 31/365 = 13,88

• ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.212,63

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 31/365 = 4,32

• ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,32

• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
33600 x 0,00030 = 10,08

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.227,03
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*5.284,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 10/10/2007

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,80
ΩΧΒ 8240Χ0,10165€/ΩΧΒ=	837,60
ΧΒ 30,9Χ2,17930€/ΧΒ=	67,34
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	2,35
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,01
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,04
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	910,06
ΦΠΑ 910,21 x 9% =	81,92
ΣΥΝΟΛΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	991,98

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	25856	25835	1680	0	1680
25	84453	84350	8240	0	8240

ΩΛ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
22		80	30,9

ΟΜΕΝΗ ΜΕΤΡΗΣΗ: 20/12/2007

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²	ΕΥΡΩ/Μ²	ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860 x	4,56 x	29/365 =	1036,81
Δ.Φ.	5390 x	0,20 x	29/365 =	85,70

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ²	ΤΙΜΗ ΖΩΝΗΣ	ΠΑΛΑΙΟΤΗΤΑ	
4000 x	146,00 x	0,80 x	

ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 29/365 = 13,00

- ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.135,51

Ε.Ρ.Τ

ΚΤΗΣΙΑ ΧΡΕΩΣΗ	ΣΥΝΤ. ΗΜΕΡΩΝ	
50,88 x	29/365 =	4,04

- ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,04

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
8240 x 0,00030 = 2,47

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.142,02
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*2.134,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 11/12/2007

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
23/10/2007 ΕΩΣ 21/11/2007
3 93207420 01 3 1912
2134,00 5
(2943)
00001472Α

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής
10 12 - 4
Τέλη
Χρονολογικό Σήμαντρ.

326 057251
27/11
Η-Αριθμός

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

507

Αρ. Λογ/κής Απόδοσης

ΛΗΞΗ ΠΡ. ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβαση)
11/12/2007	*2.134,00 €	

Α 4 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Παρακαλούμε κόψτε εδώ ✂

>393207420011912< 2134005> 10124< 25>

3260572510010150000000

ΑΠΟ:LONG. BEACH ΑΡ. ΦΑΞ : 01 ΑΠΡ 2009 16:33 P2

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,91
ΩΧΒ 10720Χ0,10564€/ΩΧΒ=	1132,53
ΧΒ 30,9Χ2,26504€/ΧΒ=	69,99
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	0,98
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,04

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	1.206,45
ΦΠΑ 1208,65 x 9% =	108,78
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	1.315,23

ΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
0	25881	25856	2000	0	2000
5	84587	84453	10720	0	10720
	20/12/2007				

ΩΔ. ΤΙΜ.	ΣΙ. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	30,9

ΟΜΕΝΗ ΜΕΤΡΗΣΗ: 23/01/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	M^2	ΕΥΡΩ/M^2	ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860 x	4,56 x	29/365 =	1036,81
Δ.Φ.	5390 x	0,20 x	29/365 =	85,70

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

M^2 ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 29/365 = 13,00

● **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.135,51

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 29/365 = 4,04

● **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,04

• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
10720 x 0,00030 = 3,22

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.142,77
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*2.458,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 11/01/2008

ΔΕΗ

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής
10 12 - 4

Τέλη

Χρονολογικό Σήμαντ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ 3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ 3020 18 Χ1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ 21/11/2007 ΕΩΣ 20/12/2007

3 93207420 01 2 2101
2458,00 8
(575)
0000028 8Δ

355 057536
20/12

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

Η-Αριθμός

Αρ. Λογ/κής Απόδοση

21

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ
11/01/2008	*2.458,00 €

Αριθμός Λογαριασμού (για μεταβίβαση)

Α 5 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Π α ρ α κ α λ ο ύ μ ε κ ό ψ τ ε ε δ ώ

>393207420012101 2< 2458008> 10124< 25>

355057536001310000

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,38
ΩΧΒ 15280Χ0,10775€/ΩΧΒ=	1646,42
ΧΒ 44,0Χ2,31010€/ΧΒ=	101,64
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,23

/01/2008

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	1.751,67
1756,02 x 9% =	158,04
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	1.909,71

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚΩΗ	ΣΥΝΟΛΟ
20	25904	25881	1840	0	1840
25	84778	84587	15280	0	15280

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. ΚΩΗ	ΧΡ. ΖΗΤ. KW
Γ22		80	44,0

21/02/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²	ΕΥΡΩ/Μ²	ΣΥΝΤ. ΗΜΕΡΩΝ	
Δ.Τ.	2860 x	4,80 x	33/365 =	1241,01
Δ.Φ.	5390 x	0,21 x	33/365 =	102,32

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 33/365 = 14,78

• ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:	1.358,11

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 33/365 = 4,60

• ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:	4,60
• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40 15280 x 0,00030 =	4,58
ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.367,29
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*3.277,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 13/02/2008

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,17
ΩΧΒ 14320Χ0,10775€/ΩΧΒ=	1542,98
ΧΒ 41,3Χ2,31010€/ΧΒ=	95,41
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	7.55
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,23
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,12
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	1.648,76
ΦΠΑ 1645,86 x 9% =	148,13
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	1.796,89

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚΩΗ	ΣΥΝΟΛΟ
20	25921	25904	1360	0	1360
25	84957	84778	14320	0	14320

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. ΚΩΗ	ΧΡ. ΖΗΤ. KW
122		80	41,3

ΟΜΕΝΗ ΜΕΤΡΗΣΗ: 21/03/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,80	x	31/365	=	1165,51
Δ.Φ.	5390	x	0,21	x	31/365	=	96,10

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 31/365 = 13,88

- ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.275,49

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 31/365 = 4,32

- ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,32

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
14320 x 0,00030 = 4,30

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.284,11
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	3.277,00
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*6.358,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 13/03/2008

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ ☐☐☐☐☐☐☐☐☐☐

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογισμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαντρ
10 12 - 4		

056 067964

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ ΤΗΛΕΦ.
ΑΙΓΙΟΥ 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
22/01/2008 ΕΩΣ 22/02/2008
3 93207420 01 8 2103
6358,00 6
00003568A (7135)

29/02

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

310

Η-Αριθμός

Αρ. Λογ/κής Απόδοσ

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβασ
13/03/2008	*6.358,00 €	

Παρακαλούμε κόψτε εδώ

Δ 6 ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

3 081

>393207420012103 8< 6358006> 10124< 25>

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΙΑΓΙΑ ΧΡΕΩΣΗ	3,07
ΩΧΒ 10000Χ0,10775€/ΩΧΒ=	1077,50
ΚΒ 32,0Χ2,31010€/ΧΒ=	73,92
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,12
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,12

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	1.154,73
ΦΠΑ 1157,49 x 9% =	104,17
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	1.258,90

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚΩΡ	ΣΥΝΟΛΟ
20	25936	25921	1200	0	1200
25	85082	84957	10000	0	10000

ΚΩΔ. ΤΙΜ. Γ22	ΕΙ. KVA	ΣΥΝΤ. ΚΩΡ 80	ΧΡ. ΙΣΧ. 32,0 KW

ΟΜΕΝΗ ΜΕΤΡΗΣΗ: 21/04/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ. ΗΜΕΡΩΝ	
Δ.Τ.	2860	x	4,80	x	30/365 =	1128,44
Δ.Φ.	5390	x	0,21	x	30/365 =	93,04

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 30/365 = 13,44

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.234,92

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 30/365 = 4,18

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,18

- **ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40**
10000 x 0,00030 = 3,00

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.242,10
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	3.081,00
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*5.582,00 €

Α. ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ. ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 14/04/2008

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ
☐☐☐☐☐☐☐☐☐☐

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής: 10 12 - 4
Τέλη
Χρονολογικό Σήμ

087 003493
01/04

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ	ΤΗΛΕΦ.
ΑΙΓΙΟΥ	2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
22/02/2008 έως 23/03/2008

3 93207420 01 4 2204
5582,00 2
00002976Δ (5951)

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
17

Η-Αριθμός
Αρ. Λογ/κής Από
Αριθμός Λογαριασμού (για μεταβ

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ
14/04/2008	*5.582,00 €

ΠΑΡΑΚΑΛΟΥΜΕ ΚΟΨΤΕ ΕΔΩ

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420012204< 5582002> 10124< 25>

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	2,97
ΩΧΒ 12480Χ0,10775€/ΩΧΒ=	1344,72
ΧΒ 201,1Χ2,31010€/ΧΒ=	464,56
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,12
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,28
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	1.812,41
ΦΠΑ 1815,99 x 9% =	163,44
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	1.975,85

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚWH	ΣΥΝΟΛΟ
20	25957	25936	1680	0	1680
25	85238	85082	12480	0	12480

ΚΩΔ. ΤΙΜ. 122	Σ.Ι. KVA	ΣΥΝΤ. ΚWH 80	ΧΡ. ΖΗΤ. 201,1 KW

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 23/05/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²	ΕΥΡΩ/Μ²	ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860 x	4,80 x	29/365 =	1091,38
Δ.Φ.	5390 x	0,21 x	29/365 =	89,99

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 29/365 = 13,00

- ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.194,37

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 29/365 = 4,04

- ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,04

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
  12480 x 0,00030 = 3,74

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.202,15
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*3.178,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 14/05/2008

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ ☐☐☐☐☐☐☐☐☐☐

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαντρο
10 12 - 4		

113 003965
30/04

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ

ΔΕΗ	ΤΗΛΕΦ.
ΑΙΓΙΟΥ	2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
23/03/2008 ΕΩΣ 21/04/2008

3 93207420 01 1 2205
3178,00 1
00003660Δ (7319)

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

17

Η-Αριθμός

Αρ. Λογ/κής Απόδοσης

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβαση)
14/05/2008	*3.178,00 €	

παρακαλούμε κόψτε εδώ ✂

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >3932074200122051< 3178001> 10124< 25>

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,48
ΩΧΒ 32880Χ0,10775€/ΩΧΒ=	3542,82
ΧΒ 159,7Χ2,31010€/ΧΒ=	368,92
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	1,30
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,28
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,28
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	3.915,96
ΦΠΑ 3925,08 x 9% =	353,26
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	4.269,22

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚWΗ	ΣΥΝΟΛΟ
20	26121	25957	13120	0	13120
25	85649	85238	32880	0	32880

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	159,7

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 25/06/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860	x	4,80	x	34/365 =	1279,45
Δ.Φ.	5390	x	0,21	x	34/365 =	105,49

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 34/365 = 15,24

- ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.400,18

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 34/365 = 4,74

- ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,74

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
32880 x 0,00030 = 9,86

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.414,78
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*5.684,00 €

Α. ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ. ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗ ΙΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 11/06/2008

Παρακαλούμε κόψτε εδώ ✂

ΔΕΗ

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ
☐☐☐☐☐☐☐☐☐☐

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής: 10 12 - 4
Τέλη:
Χρονολογικό Σήμαντρ

147 004059

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ
ΔΕΗ ΑΙΓΙΟΥ
ΤΗΛΕΦ. 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ: 3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ: 3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ: 21/04/2008 ΕΩΣ 25/05/2008
3 93207420 01 3 2006
5684,00 6
00003826A (7651)

28/05
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
16

Η-Αριθμός
Αρ. Λογ/κής Απόδοσ
Αριθμός Λογαριασμού (για μεταφορ

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ
11/06/2008	*5.684,00 €

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420012006З< 5684006> 10124< 25>

1470040590010

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,17
ΩΧΒ 33920Χ0,10775€/ΩΧΒ=	3654,88
ΧΒ 112,8Χ2,31010€/ΧΒ=	260,58
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	1,40
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,28
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,10
ΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	3.920,41
ΦΠΑ 3928,81 x 9% =	353,60
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	4.274,01

ΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚWH	ΣΥΝΟΛΟ
20	26300	26121	14320	0	14320
25	86073	85649	33920	0	33920

ΚΩΔ. ΤΙΜ	ΣΙ. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	112,8

ΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 24/07/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860	x	4,80	x	31/365 =	1165,51
Δ.Φ.	5390	x	0,21	x	31/365 =	96,10

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 31/365 = 13,88

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.275,49

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 31/365 = 4,32

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,32

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
  33920 x 0,00030 = 10,18

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.289,99
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*5.564,00 €

Α. ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ. ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 14/07/2008

Παρακαλούμε κόψτε εδώ

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής: 10 12 - 4
Τέλη
Χρονολογικό Σήμαντρ

178 004293
01/07 Η-Αριθμός
Αρ. Λογικής Απόδοσ
35
Αριθμός Λογαριασμού για μεταβίβασ

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ
ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ 3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ 3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ 25/05/2008 ΕΠΣ 25/06/2008
3 93207420 01 7 2207
5564,00 0
00003745Α (7489)

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ 14/07/2008
ΠΟΣΟ ΠΛΗΡΩΜΗΣ *5.564,00 €

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420012207< 5564000> 10124< 25>

1780042930010

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,12
ΩΧΒ 55840Χ0,11372€/ΩΧΒ=	6350,68
ΧΒ 147,1Χ2,43834€/ΧΒ=	358,68
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	15,48
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,10
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,35

ΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	6.728,21
ΦΠΑ 6729,23 x 9% =	605,63
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	7.333,84

ΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
:0	26603	26300	24240	0	24240
'5	86771	86073	55840	0	55840

.ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ KW
122		80	147,1

ΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 26/08/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860	x	4,80	x	29/365 =	1091,38
Δ.Φ.	5390	x	0,21	x	29/365 =	89,99

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 145,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 29/365 = 13,00

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.194,37

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 29/365 = 4,04

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,04

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
  55840 x 0,00030 = 16,75

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.215,16
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	5.564,00
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*14.113,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

ΕΙΔΟΠΟΙΗΣΗ ΔΙΑΚΟΠΗΣ

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 12/08/2008

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαντ
10 12 - 4		

207 004714
28/07 Η-Αριθμός

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ
ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9

Παρακαλούμε κ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,06
ΩΧΒ 38640Χ0,11529€/ΩΧΒ=	4454,81
ΧΒ 136,4Χ2,47180€/ΧΒ=	337,15
ΠΟ[illegible] ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,45
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,15

ΓΙΑ Τ[illegible]ΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	4.795,62
ΦΠΑ 4806,61 x 9% =	432,59
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	5.228,21

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. ΚWΗ	ΣΥΝΟΛΟ
20	27187	26964	17840	0	17840
25	88164	87681	38640	0	38640

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ ΖΗΤ. KW
Γ22		80	136,4

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 21/10/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ. ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,80	x	28/365	=	1052,94
Δ.Φ.	5390	x	0,21	x	28/365	=	86,82

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 28/365 = 12,54

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.152,30

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 28/365 = 3,90

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 3,90

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
38640 x 0,00030 = 11,59

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.167,79
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*6.396,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη **ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ:** 10/10/2008

25/08/2008 έως 21/09/2008

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,06
ΩΧΒ 25120Χ0,11529€/ΩΧΒ=	2896,08
ΧΒ 98,9Χ2,47180€/ΧΒ=	244,46
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	19,34
Π Ο ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,15
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,13

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	3.162,66
ΦΓ 3151,14 x 9% =	283,60
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	3.446,26

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	27302	27187	9200	0	9200
25	88478	88164	25120	0	25120

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	98,9

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 20/11/

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²	ΕΥΡΩ/Μ²	ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860 x	4,80 x	28/365 =	1052,94
Δ.Φ.	5390 x	0,21 x	28/365 =	86,82

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 28/365 = 12,54

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.152,30

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 28/365 = 3,90

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 3,90

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
25120 x 0,00030 = 7,54

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.163,74
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*4.610,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 10/11/2008

11

21/09/2008 ως 21/10/2008

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,39
ΩΧΒ 19520Χ0,11529€/ΩΧΒ=	2250,46
ΧΒ 94,2Χ2,47180€/ΧΒ=	232,84
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	9,22
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,13
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,04

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	2.496,00
ΦΠΑ 2492,55 x 9% =	224,33
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	2.720,33

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	27399	27302	7760	0	7760
25	88722	88478	19520	0	19520

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	94,2

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 22/12/2008

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΑΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	4,80	x	31/365	=	1165,51
Δ.Φ.	5390	x	0,21	x	31/365	=	96,10

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 31/365 = 13,88

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.275,49

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 31/365 = 4,32

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,32

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
19520 x 0,00030 = 5,86

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΑΠ ΠΛΗΡΩΝΕΤΕ	1.285,67
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*4.006,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 09/12/2008

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,50
ΩΧΒ 21680Χ0,11529□/ΩΧΒ=	2499,49
ΧΒ 164,3Χ2,47180□/ΧΒ=	406,12
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	9,12
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,04
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,20

22/1/09 2000,00

29/1/09 2509,00

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	2.918,07
ΦΠΑ 2915,61 x 9% =	262,41
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	3.180,48

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	27496	27399	7760	0	7760
25	88993	88722	21680	0	21680

.Μ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	164,3

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 23/01/2009

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΛΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

```
        Μ²       ΕΥΡΩ/Μ²     ΣΥΝΤ.ΗΜΕΡΩΝ
Δ.Τ.  2860   x   4,80    x   32/365 =        1203,95
Δ.Φ.  5390   x   0,21    x   32/365 =          99,27
```

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

```
      Μ²     ΤΙΜΗ ΖΩΝΗΣ   ΠΑΛΑΙΟΤΗΤΑ
    4000  x   146,00 x      0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
   0,00035 x 32/365                  =        14,34
```

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.317,56

Ε.Ρ.Τ

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ΕΤΗΣΙΑ ΧΡΕΩΣΗ    ΣΥΝΤ. ΗΜΕΡΩΝ
    50,88    x      32/365       =        4,46
```

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,46

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
  21680 x 0,00030 = 6,50

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΛΠ ΠΛΗΡΩΝΕΤΕ	1.328,52
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*4.509,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 14/01/2009

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής
10 12 - 4

Τέλη

Χρονολογικό Σήμαν

358 003927
30/12

Η-Αριθμός

Αρ. Λογ/κής Απόδο
25

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ
ΔΕΗ ΑΙΓΙΟΥ
ΤΗΛΕΦ. 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
21/11/2008 ΕΩΣ 23/12/2008

3 93207420 01 0 2201
4509,00 6
(6851)
00003426Δ

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

Αριθμός Λογαριασμού (για μεταβίβα

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ
14/01/2009	*4.509,00 €

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Παρακαλούμε κόψτε εδώ ✂

>393207420012010< 4509006> 10124< 25>

Η

3580039270010

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,39
ΩΧΒ 42240Χ0,11529€/ΩΧΒ=	4869,85
ΧΒ 193,7Χ2,47180€/ΧΒ=	478,79
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	8,57
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,20
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,09
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	5.360,71
ΦΠΑ 5364,70 x 9% =	482,82
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	5.843,53

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	27689	27496	15440	0	15440
25	89521	88993	42240	0	42240

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ2		80	193,7

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 20/02/2009

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΛΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²	ΕΥΡΩ/Μ²	ΣΥΝΤ.ΗΜΕΡΩΝ	
Δ.Τ.	2860 x	5,08 x	31/365 =	1233,50
Δ.Φ.	5390 x	0,21 x	31/365 =	96,10

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 31/365 = 13,88

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.343,48

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 31/365 = 4,32

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,32

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
42240 x 0,00030 = 12,67

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΛΠ ΠΛΗΡΩΝΕΤΕ	1.360,47
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	2.509,00
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*9.713,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

ΕΙΔΟΠΟΙΗΣΗ ΔΙΑΚΟΠΗΣ

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 12/02/2009

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο
Αριθμός Λογ/σμού Ταχυπληρωμής 10 12 - 4
Τέλη 027 007867
Η-Αριθμός 29/01
Χρονολογικό Σήμαντ

ΔΕΗ ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ ΤΗΛΕΦ.
ΑΙΓΙΟΥ 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
23/12/2008 ΕΩΣ 23/01/2009
3 93207420 01 2 2002
9713,00 9
00001936Δ (3871)

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

Αρ. Λογ/κής Απόδο 18
Αριθμός Λογαριασμού (για μεταβίβας

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ 12/02/2009
ΠΟΣΟ ΠΛΗΡΩΜΗΣ *9.713,00 €

7.204

Α Μ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Παρακαλούμε κόψτε εδώ ✂

10124< 25>
9713009>
>3932074200120022<
Η

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΜΕΙΟΝ ΑΞΙΑ ΡΕΥΜ.ΕΝΑΝΤΙ	0,00
ΠΑΓΙΑ ΧΡΕΩΣΗ	6,12
ΩΧΒ 46960Χ0,11529€/ΩΧΒ=	5414,02
ΧΒ 33,6Χ2,47180€/ΧΒ=	83,05
ΜΕΙΟΝ ΑΞΙΑ ΡΕΥΜ.ΕΝΑΝΤΙ	-6556,31
ΠΑΓΙΑ ΧΡΕΩΣΗ	4,15
ΩΧΒ 31440Χ0,11529€/ΩΧΒ=	3624,72
ΧΒ 182,4Χ2,47180€/ΧΒ=	450,86
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	6,75
ΧΑΡΤΟΣΗΜΟ ΤΟΚΩΝ 3,6%	0,24
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,05
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,28
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	3.033,37
ΦΠΑ 3050,13 x 9% =	274,52
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	3.307,89

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	27836	27689	11760	0	11760
25	90108	89521	46960	0	46960
20	113	0	9040	0	9040
25	393	0	31440	0	31440

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
		80	182,4

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 27/05/2009

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΛΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	5,08	x	35/365	=	1393,31
Δ.Φ.	5390	x	0,22	x	35/365	=	113,72

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 35/365 = 15,68

● **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.522,71

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ x ΣΥΝΤ. ΗΜΕΡΩΝ /365 = 13,10
ΜΕΙΟΝ ΕΝΑΝΤΙ ΕΡΤ -8,22

● **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,88

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
  78400 x 0,00030 = 23,52

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΛΠ ΠΛΗΡΩΝΕΤΕ	1.551,11
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*4.859,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 22/05/2009

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,28
ΩΧΒ 42960Χ0,11529€/ΩΧΒ=	4952,86
ΧΒ 120,0Χ2,47180€/ΧΒ=	296,62
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	2,46
ΧΑΡΤΟΣΗΜΟ ΤΟΚΩΝ 3,6%	0,09
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,28
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,25

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	5.255,84
ΦΠΑ 5265,65 x 9% =	473,91
ΤΕ[illegible]ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	5.729,75

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	287	113	13920	0	13920
25	930	393	42960	0	42960

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	120,0

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 26/06/2009

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΛΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	M²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	5,08	x	30/365	=	1194,27
Δ.Φ.	5390	x	0,22	x	30/365	=	97,47

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

M²		ΤΙΜΗ ΖΩΝΗΣ		ΠΑΛΑΙΟΤΗΤΑ	
4000	x	146,00	x	0,80	x

ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 30/365 = 13,44

- ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ: 1.305,18

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 30/365 = 4,18

- ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ: 4,18

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
  42960 x 0,00030 = 12,89

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΛΠ ΠΛΗΡΩΝΕΤΕ	1.322,25
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*7.052,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 22/06/2009

ΔΕΗ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,28
ΩΧΒ 55520Χ0,11529€/ΩΧΒ=	6400,90
ΧΒ 152,0Χ2,47180€/ΧΒ=	375,71
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,25
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,35

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	6.779,29
ΦΠΑ 6796,55 x 9% =	611,69
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	7.390,98

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	535	287	19840	0	19840
25	1624	930	55520	0	55520

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	152,0

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 24/07/2009

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΛΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	5,08	x	30/365	=	1194,27
Δ.Φ.	5390	x	0,22	x	30/365	=	97,47

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 30/365 = 13,44

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.305,18

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 30/365 = 4,18

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,18

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
55520 x 0,00030 = 16,66

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΛΠ ΠΛΗΡΩΝΕΤΕ	1.326,02
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*8.717,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 21/07/2009

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,28
ΩΧΒ 62960Χ0,11529€/ΩΧΒ=	7258,66
ΧΒ 160,0Χ2,47180€/ΧΒ=	395,49
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	2,74
ΧΑΡΤΟΣΗΜΟ ΤΟΚΩΝ 3,6%	0,10
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,35
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,26
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	7.660,88
ΦΠΑ 7676,32 x 9% =	690,87
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	8.351,75

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	819	535	22720	0	22720
25	2411	1624	62960	0	62960

ΚΩΔ. ΤΙΜ	Σ.Ι.	KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ	KW
122			80	160,0	

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 24/08/2009

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΛΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	M^2		ΕΥΡΩ/M^2		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	5,08	x	30/365	=	1194,27
Δ.Φ.	5390	x	0,22	x	30/365	=	97,47

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

M^2 ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 30/365 = 13,44

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.305,18

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 30/365 = 4,18

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,18

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
62960 x 0,00030 = 18,89

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΛΠ ΠΛΗΡΩΝΕΤΕ	1.328,25
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*9.680,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ	393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 18/08/2009

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής: 10 12 - 4
Τέλη
Χρονολογικό Σήμαν

208 003984
29/07 Η-Αριθμός
Αρ. Λογ/κής Απόδο
46

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ
ΔΕΗ ΑΙΓΙΟΥ
ΤΗΛΕΦ. 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 X1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
26/06/2009 ΕΩΣ 26/07/2009
3 93207420 01 9 2008
9680,00 0
00002837A (5673)

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ
18/08/2009	*9.680,00 €

Αριθμός Λογαριασμού (για μεταβίβα

Παρακαλούμε κόψτε εδώ ✂

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420012008 9< 9680000> 10124< 25>

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,28
ΩΧΒ 73600Χ0,11529€/ΩΧΒ=	8485,34
ΧΒ 168,3Χ2,47180€/ΧΒ=	416,00
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,26
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,21
ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ	8.904,15
ΦΠΑ 8926,70 x 9% =	803,41
ΤΕΛΙΚΟ ΠΟΣΟ ΗΛΕΚΤΡ. ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ	9.707,56

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΚΤ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. KWH	ΣΥΝΟΛΟ
20	1126	819	24560	0	24560
25	3331	2411	73600	0	73600

ΚΩΔ. ΤΙΜ.	Σ.Ι. KVA	ΣΥΝΤ. KWH	ΧΡ. ΖΗΤ. KW
Γ22		80	168,3

ΕΠΟΜΕΝΗ ΜΕΤΡΗΣΗ: 22/09/2009

ΛΟΓΑΡΙΑΣΜΟΙ ΔΗΜΟΥ - ΕΡΤ - ΚΛΠ

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ

ΔΗΜΟΤΙΚΑ ΤΕΛΗ - ΦΟΡΟΣ

	Μ²		ΕΥΡΩ/Μ²		ΣΥΝΤ.ΗΜΕΡΩΝ		
Δ.Τ.	2860	x	5,08	x	30/365	=	1194,27
Δ.Φ.	5390	x	0,22	x	30/365	=	97,47

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ

Μ² ΤΙΜΗ ΖΩΝΗΣ ΠΑΛΑΙΟΤΗΤΑ
4000 x 146,00 x 0,80 x
ΣΥΝΤ.Τ.Α.Π. ΣΥΝΤ.ΗΜΕΡΩΝ
0,00035 x 30/365 = 13,44

- **ΓΙΑ ΤΟ ΔΗΜΟ ΠΛΗΡΩΝΕΤΕ:** 1.305,18

Ε.Ρ.Τ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ ΣΥΝΤ. ΗΜΕΡΩΝ
50,88 x 30/365 = 4,18

- **ΓΙΑ ΤΗΝ ΕΡΤ ΠΛΗΡΩΝΕΤΕ:** 4,18

- ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ Ν. 2773/99 Αρθ. 40
73600 x 0,00030 = 22,08

ΓΙΑ ΔΗΜΟ - ΕΡΤ - ΚΛΠ ΠΛΗΡΩΝΕΤΕ	1.331,44
ΑΝΕΞΟΦΛΗΤΟΙ ΛΟΓΑΡΙΑΣΜΟΙ	
ΤΕΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ	*11.039,00 €

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
Α.Π. 3 93207420-01 9

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡ. ΠΛΗΡΩΜΗΣ 393207420012

Σας παρακαλούμε να εξοφλήσετε το λογαριασμό σας μέχρι τη

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ: 16/09/2009

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογ/σμού Ταχυπληρωμής: 10 12 - 4
Τέλη
Χρονολογικό Σήμαντ
237 003656 27/08
Η-Αριθμός
Αρ. Λογ/κής Απόδοσ: 38

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ
16/09/2009	*11.039,00 €

Αριθμός Λογαριασμού (για μεταβίβασ

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΑΡΜΟΔΙΟ ΓΡΑΦΕΙΟ
ΔΕΗ ΑΙΓΙΟΥ ΤΗΛΕΦ. 2691027811
ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ: 3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ: 3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ: 26/07/2009 ΕΩΣ 25/08/2009
3 93207420 01 1 1809
11039,00 5
00002714Α (5427)

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Παρακαλούμε κόψτε εδώ ✂

Η >393207420011809I< 11039005> 10124< 25>

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

266 002952

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 2691027811
Βλάβες : 2691022408
Καταμέτρηση :

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
32

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
ΑΔΤ / ΑΦΜ :

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ

ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0034419255	23/09/2009	25/08/2009 - 22/09/2009	28 28	3020 18 X1 000400	3 93207420-01 9

Α ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 52480

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,06
KWH 52480X0,11529€/KWH=	6050,42
KW 136,6X2,47180€/KW=	337,65

ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : 15,74
kWh 52480 x 0,00030 €/kWh

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 6.406,87

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	2053,11
• **ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ**	
- Χρήση Δικτύου Μεταφοράς (€) :	315,71
- Επικουρικές Υπηρεσίες (€) :	21,52
- Λοιπές Επιβαρύνσεις (€) :	22,04
• **ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ**	
- Χρήση Δικτύου Διανομής (€) :	1006,36
• **ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) :** Ν.2773/99 αρθ. 29	671,74
• **ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) :** Ν.2773/99 αρθ. 40	15,74
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	4353,76
ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1 + 2) (€) :	6406,87

ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,21
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,45

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 6.406,63

ΦΠΑ 6406,87 x 9% = 576,62

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) Α 6.983,25

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ
R5588797	20	1364	1126	19040		19040
95588797	25	3987	3331	52480		52480

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250
ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80
συνφ : 0,9400
ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 136,6

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 22/10/2009

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 15/10/2009

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

Σε συνέχεια του υπ' αριθμόν α/α παραστατικού 0038316828 - 23/10/2009 λογαριασμού ρεύματος

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ 22/09/2009 - 22/10/2009 ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ 3 93207420-01 9

ΑΝΑΛΥΣΗ ΛΟΓΑΡΙΑΣΜΩΝ ΔΗΜΟΥ - ΕΡΤ*

B ΔΗΜΟΤΙΚΑ ΤΕΛΗ (ΔΤ) - ΔΗΜΟΤΙΚΟΣ ΦΟΡΟΣ (ΔΦ)

	τμ	€/τμ	ΣΥΝΤΕΛ. ΗΜΕΡΩΝ		
ΔΤ :	2860 x	5,08 x	30/365	=	1194,27
ΔΦ :	5390 x	0,22 x	30/365	=	97,47

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ (ΤΑΠ)

τμ	ΤΙΜΗ ΖΩΝΗΣ	ΠΑΛΑΙΟΤΗΤΑ	ΣΥΝΤΕΛ. ΤΑΠ	ΣΥΝΤΕΛ. ΗΜΕΡΩΝ	
4000	x 146,00	x 0,80	x0,00035	x 30/365 =	13,44

ΣΥΝΟΛΟ ΓΙΑ ΔΗΜΟ ΣΥΜΠΟΛΙΤΕΙΑΣ : 1.305,18

ΕΡΤ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ		ΣΥΝΤΕΛ. ΗΜΕΡΩΝ		
50,88	x	30/365	=	4,18

ΣΥΝΟΛΟ ΓΙΑ ΕΡΤ : 4,18

ΓΙΑ ΔΗΜΟ - ΕΡΤ ΠΛΗΡΩΝΕΤΕ (€) **B** 1.309,36

* Η ΔΕΗ βάσει των Νόμων 25/75, 429/76, 1080/80, 2130/93 και 2644/98 είναι υποχρεωμένη να συνεισπράττει με τους λογαριασμούς ρεύματος τ ποσά υπέρ ΔΗΜΩΝ - ΕΡΤ και να διακόπτει την παροχή εάν αυτά δεν καταβάλλονται από τον πελάτη

ΑΝΕΞΟΦΛΗΤΟ ΠΟΣΟ (€) (ΑΓΝΟΗΣΤΕ ΤΟ ΕΑΝ ΕΧΕΙ ΠΛΗΡΩΘΕΙ) **Γ**

ΣΥΝΟΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ (€) **Α + Β + Γ** *5.594,00

Είναι ΑΠΛΟ!
Κερδίστε χρόνο πληρώνοντας το λογαριασμό σας με πάγια τραπεζική εντολή.
Συμπληρώστε μία αίτηση στην Τράπεζά σας ή σε οποιοδήποτε Κατάστημα ΔΕΗ και ο λογαριασμός σας θα εξοφλείται αυτόματα στην ημερομηνία λήξης του.
Είναι εύκολο, γρήγορο, σίγουρο!!

Εξοφλείτε τους λογαριασμούς σας, μέσω των ΑΤΜ των περισσοτέρων Τραπεζών, οποιαδήποτε ώρα της ημέρας, χωρίς αναμονή και χωρίς να έχετε μετρητά μαζί σας!

ΩΔΙΚΟΣ ΗΛΕΚΤΡΟΝΙΚΗΣ ΠΛΗΡΩΜΗΣ 393207420012

Παρακαλούμε κόψτε εδώ

2960027650020

ΤΑΧΥΠΛΗΡΩΜΗ

ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ

ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ

ΑΡΜΟΔΙΟ ΚΑΤΑΣΤΗΜΑ

ΔΕΗ ΤΗΛΕΦ.
ΑΙΓΙΟΥ 2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
3 93207420-01 9

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ
3020 18 X1 000400

ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ
22/09/2009 ΕΩΣ 22/10/2009

3 93207420 01 5 1911
5594,00 7

00006117

ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογαριασμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαν
10 12 - 4		

Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
17

Η - Αριθμός

Αρ. Λογ/κής Απόδοσ

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβασ
17/11/2009	*5.594,00 €	

ΑΜ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420011911 5< 5594007> 10124< 25>

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
330 003801

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 2691027811
Βλάβες : 2691022408
Καταμέτρηση :

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

9

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

ΑΔΤ / ΑΦΜ :

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ

ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0042607811	26/11/2009	22/10/2009 - 23/11/2009	32 32	3020 18 X1 00040	3 93207420-01 9

A ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 9360

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,50
KWH 9360X0,11529€/KWH=	1079,11
KW 93,9X2,47180€/KW=	232,10
ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : kWh 9360 x 0,00030 €/kWh	2,81

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 1.317,52

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	447,87
• **ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ**	
- Χρήση Δικτύου Μεταφοράς (€) :	69,26
- Επικουρικές Υπηρεσίες (€) :	3,84
- Λοιπές Επιβαρύνσεις (€) :	3,93
• **ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ** - Χρήση Δικτύου Διανομής (€) :	248,22
• **ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) :** **Ν.2773/99 αρθ. 29**	119,81
• **ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) :** **Ν.2773/99 αρθ. 40**	2,81
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	869,65
ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1+2) (€) :	1317,52

ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ. 0,28
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ -0,34

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 1.317,46

ΦΠΑ 1317,52 x 9% = 118,57

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) A 1.436,03

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ
R5588797	20	1515	1497	1440		1440
95588797	25	4503	4386	9360		9360

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250
ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80
συνφ : 0,9880
ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 93,9

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 23/12/2009

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 18/12/2009

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
362 008574

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 2691027811
Βλάβες : 2691022408
Καταμέτρηση :

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

28

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ

ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54

ΑΔΤ / ΑΦΜ :

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0046209174	28/12/2009	23/11/2009 - 23/12/2009	30 30	3020 18 X1 000400	3 93207420-01 9

Α ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 14960

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,28
KWH 14960X0,11529€/KWH=	1724,74
KW 80,0X2,47180€/KW=	197,74

ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : 4,49
kWh 14960 x 0,00030 €/kWh

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 1.930,25

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	650,23
• **ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ**	
- Χρήση Δικτύου Μεταφοράς (€) :	100,55
- Επικουρικές Υπηρεσίες (€) :	6,13
- Λοιπές Επιβαρύνσεις (€) :	6,28
• **ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ**	
- Χρήση Δικτύου Διανομής (€) :	341,29
• **ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) :** Ν.2773/99 αρθ. 29	191,49
• **ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) :** Ν.2773/99 αρθ. 40	4,49
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	1280,02
ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1+2) (€) :	1930,25

ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	0,80
ΧΑΡΤΟΣΗΜΟ ΤΟΚΩΝ 3,6%	0,03
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,34
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,50

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 1.931,92

ΦΠΑ 1930,25 x 9% = 173,72

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) Α 2.105,64

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ
R5588797	20	1562	1515	3760		3760
95588797	25	4690	4503	14960		14960

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250 ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80 συνφ : 0,9700 ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 80,0

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 26/01/2010

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 21/01/2010

ΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
.ΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
056 003867

ΉΜΑ ΑΙΓΙΟΥ
ΝΘΟΥ 113 251 00

ιροφορίες : 26910 23755
λάβες : 26910 22408
Καταμέτρηση : 26910 27811

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

25

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ
ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54
ΑΔΤ / ΑΦΜ :

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0007466609	25/02/2010	23/12/2009 - 24/02/2010	63 63	3020 18 Χ1 000400	3 93207420-01 9

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 38080

ΠΑΓΙΑ ΧΡΕΩΣΗ	6,89
kWh 38080Χ0,11529€/kWh=	4390,24
kW 317,5Χ2,47180€/kW=	784,80

ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : 11,42
kWh 38080 x 0,00030 €/kWh

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 5.193,35

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	1615,48
• ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ	
- Χρήση Δικτύου Μεταφοράς (€) :	249,55
- Επικουρικές Υπηρεσίες (€) :	15,61
- Λοιπές Επιβαρύνσεις (€) :	15,99
• ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ	
- Χρήση Δικτύου Διανομής (€) :	835,49
• ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) : **Ν.2773/99 αρθ. 29**	487,42
• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : **Ν.2773/99 αρθ. 40**	11,42
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	3577,87
ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1+2) (€) :	5193,35

ΜΕΙΟΝ ΑΞΙΑ ΡΕΥΜ.ΕΝΑΝΤΙ	0,00
ΜΕΙΟΝ ΑΞΙΑ ΡΕΥΜ.ΕΝΑΝΤΙ	-5608,56
ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	6,78
ΧΑΡΤΟΣΗΜΟ ΤΟΚΩΝ 3,6%	0,24
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,41
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,20

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) -407,98

ΦΠΑ -415,21 x 9% = -37,37

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) Α -445,35

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ - ΚΑΤΑΝΑΛΩΤΙΚΗ ΣΥΜΠΕΡΙΦΟΡΑ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ	ΣΥΓΚΡΙΣΗ ΜΕ ΑΝΤΙΣΤΟΙΧΗ ΠΕΡΣΙΝΗ ΚΑΤΑΝΑΛΩΣΗ ΣΑΣ
R5588797	20	1695	1562	10640		10640	
95588797	25	5166	4690	38080		38080	

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250
ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80
συνφ : 0,9630
ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 317,5

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 24/03/2010
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 19/03/2010

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
088 008696

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 26910 23755
Βλάβες : 26910 22408
Καταμέτρηση : 26910 27811

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
28

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ
ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54
ΑΔΤ / ΑΦΜ :

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0011509430	29/03/2010	24/02/2010 - 24/03/2010	28 28	3020 18 Χ1 000400	3 93207420-01 9

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 8480

ΠΑΓΙΑ ΧΡΕΩΣΗ		3,06
kWh	8480X0,11529€/kWh=	977,66
kW	37,3X2,47180€/kW=	92,20

ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : 2,54
kWh 8480 x 0,00030 €/kWh

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 1.075,46

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	391,37
• ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ	
- Χρήση Δικτύου Μεταφοράς (€) :	62,27
- Επικουρικές Υπηρεσίες (€) :	3,48
- Λοιπές Επιβαρύνσεις (€) :	3,56
• ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ	
- Χρήση Δικτύου Διανομής (€) :	221,92
• ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) : Ν.2773/99 αρθ. 29	97,60
• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : Ν.2773/99 αρθ. 40	2,54
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	684,09
ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1 + 2) (€) :	1075,46

ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ. 0,20
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ 0,05

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 1.075,71

ΦΠΑ 1075,46 x 10% = 107,54

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) Α 1.183,25

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ - ΚΑΤΑΝΑΛΩΤΙΚΗ ΣΥΜΠΕΡΙΦΟΡΑ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ	ΣΥΓΚΡΙΣΗ ΜΕ ΑΝΤΙΣΤΟΙΧΗ ΠΕΡΣΙΝΗ ΚΑΤΑΝΑΛΩΣΗ ΣΑΣ
R5588797	20	1711	1695	1280		1280	
95588797	25	5272	5166	8480		8480	

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250 | ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80 | συνφ : 0,9890 | ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 37,3

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 27/04/2010

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 23/04/2010

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
118 004006

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 26910 23755
Βλάβες : 26910 22408
Καταμέτρηση : 26910 27811

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

29

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ
ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54
ΑΔΤ / ΑΦΜ :

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0015186022	28/04/2010	24/03/2010 - 28/04/2010	35 35	3020 18 Χ1 000400	3 93207420-01 9

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 22160

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,83
kWh 22160Χ0,11529€/kWh=	2554,83
kW 130,7Χ2,47180€/kW=	323,06
ΡΗΤΡΑ ΚΑΥΣΙΜΩΝ Β ΤΡΜ	1,97
ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : kWh 22160 x 0,00030 €/kWh	6,65

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	908,40
• **ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ**	
- Χρήση Δικτύου Μεταφοράς (€) :	144,42
- Επικουρικές Υπηρεσίες (€) :	9,09
- Λοιπές Επιβαρύνσεις (€) :	9,31
• **ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ**	
- Χρήση Δικτύου Διανομής (€) :	483,87
• **ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) :** Ν.2773/99 αρθ. 29	255,06
• **ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) :** Ν.2773/99 αρθ. 40	6,65
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	1981,94

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 2.890,34

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1+2) (€) : 2890,34

ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	0,33
ΧΑΡΤΟΣΗΜΟ ΤΟΚΩΝ 3,6%	0,01
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,05
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,26

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 2.890,37

ΦΠΑ 2890,34 x 10% = 289,04

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) Α 3.179,41

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ - ΚΑΤΑΝΑΛΩΤΙΚΗ ΣΥΜΠΕΡΙΦΟΡΑ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ	ΣΥΓΚΡΙΣΗ ΜΕ ΑΝΤΙΣΤΟΙΧΗ ΠΕΡΣΙΝΗ ΚΑΤΑΝΑΛΩΣΗ ΣΑΣ
R5588797	20	1795	1711	6720		6720	
95588797	25	5549	5272	22160		22160	

27/04/2010

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250
ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80
συνφ : 0,9570
ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 130,7

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 26/05/2010

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 20/05/2010

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
179 004483

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 26910 23755
Βλάβες : 26910 22408
Καταμέτρηση : 26910 27811

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
36

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ
ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54
ΑΔΤ / ΑΦΜ :

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0023015218	28/06/2010	26/05/2010 - 24/06/2010	29 29	3020 18 X1 000400	3 93207420-01 9

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 49360

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,17
kWh 49360X0,11529€/kWh=	5690,71
kW 143,8X2,47180€/kW=	355,45
ΡΗΤΡΑ ΚΑΥΣΙΜΩΝ Β ΤΡΜ	11,85

ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : 14,81
kWh 49360 x 0,00030 €/kWh

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 6.075,99

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	1884,66
• **ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ**	
- Χρήση Δικτύου Μεταφοράς (€) :	298,22
- Επικουρικές Υπηρεσίες (€) :	20,24
- Λοιπές Επιβαρύνσεις (€) :	20,73
• **ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ**	
- Χρήση Δικτύου Διανομής (€) :	962,53
• **ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) :** **Ν.2773/99 αρθ. 29**	568,13
• **ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) :** **Ν.2773/99 αρθ. 40**	14,81
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	4191,33
ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1+2) (€) :	6075,99

ΔΕΤΕ (Ν.2093/92)	30,86
ΕΦΚ (Ν.3336/05)	123,40
ΠΛΗΡΩΜΕΝΟ ΠΟΣΟ/ΠΙΣΤΩΣΗ	-1183,25
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,39
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,10

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 5.046,71

ΦΠΑ 6199,39 x 10% = 619,94

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) A 5.666,65

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ - ΚΑΤΑΝΑΛΩΤΙΚΗ ΣΥΜΠΕΡΙΦΟΡΑ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ	ΣΥΓΚΡΙΣΗ ΜΕ ΑΝΤΙΣΤΟΙΧΗ ΠΕΡΣΙΝΗ ΚΑΤΑΝΑΛΩΣΗ ΣΑΣ
R5588797	20	2204	1962	19360		19360	
95588797	25	6658	6041	49360		49360	
			26/05/2010				

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250
ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80
συνφ : 0,9310
ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 143,8

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 23/07/2010
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 20/07/2010

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
207 003653

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 26910 23755
Βλάβες : 26910 22408
Καταμέτρηση : 26910 27811

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

35

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ
ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54
ΑΔΤ / ΑΦΜ :

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0026970666	26/07/2010	24/06/2010 - 26/07/2010	32 32	3020 18 X1 000400	3 93207420-01 9

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 57280

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,50
kWh 57280X0,11529€/kWh=	6603,81
kW 174,4X2,47180€/kW=	431,08
ΡΗΤΡΑ ΚΑΥΣΙΜΩΝ Β ΤΡΜ	44,47

ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : kWh 57280 x 0,00557 €/kWh	319,05

- ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 7.401,91

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	2476,90
• **ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ**	
- Χρήση Δικτύου Μεταφοράς (€) :	345,28
- Επικουρικές Υπηρεσίες (€) :	23,48
- Λοιπές Επιβαρύνσεις (€) :	24,06
• **ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ**	
- Χρήση Δικτύου Διανομής (€) :	1105,74
• **ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) :** **Ν.2773/99 αρθ. 29**	659,29
• **ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) :** **Ν.2773/99 αρθ. 40**	319,05
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	4925,01

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1+2) (€) : 7401,91

ΔΕΤΕ (Ν.2093/92)	35,91
ΕΦΚ (Ν.3336/05)	143,20
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,10
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,15

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 7.581,07

ΦΠΑ 7545,11 x 11% = 829,96

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) Α 8.411,03

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ - ΚΑΤΑΝΑΛΩΤΙΚΗ ΣΥΜΠΕΡΙΦΟΡΑ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ	ΣΥΓΚΡΙΣΗ ΜΕ ΑΝΤΙΣΤΟΙΧΗ ΠΕΡΣΙΝΗ ΚΑΤΑΝΑΛΩΣΗ ΣΑΣ
R5588797	20	2472	2204	21440		21440	
95588797	25	7374	6658	57280		57280	

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250	ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80	συνφ : 0,9370	ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 174,4

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 24/08/2010

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 17/08/2010

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

237 003772

ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 26910 23755
Βλάβες : 26910 22408
Καταμέτρηση : 26910 27811

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

23

ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ

ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1.063,54

ΑΔΤ / ΑΦΜ :

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0030918849	25/08/2010	26/07/2010 - 25/08/2010	30 30	3020 18 X1 000400	3 93207420-01 9

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 48160

ΠΑΓΙΑ ΧΡΕΩΣΗ	3,28
kWh 48160X0,11529€/kWh=	5552,37
kW 104,0X2,47180€/kW=	257,07

ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : 268,25
kWh 48160 x 0,00557 €/kWh

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (€) : 6.080,97

ΑΝΑΛΥΣΗ ΧΡΕΩΣΕΩΝ ΛΟΓΑΡΙΑΣΜΟΥ

1. ΕΘΝΙΚΟ ΗΛΕΚΤΡΙΚΟ ΣΥΣΤΗΜΑ (€):	2151,70
• ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ	
- Χρήση Δικτύου Μεταφοράς (€) :	291,78
- Επικουρικές Υπηρεσίες (€) :	19,75
- Λοιπές Επιβαρύνσεις (€) :	20,23
• ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ	
- Χρήση Δικτύου Διανομής (€) :	997,37
• ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) : **Ν.2773/99 αρθ. 29**	554,32
• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : **Ν.2773/99 αρθ. 40**	268,25
2. ΚΑΤΑΝΑΛΩΣΗ ΡΕΥΜΑΤΟΣ (€):	3929,27
ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1 + 2) (€) :	6080,97

ΔΕΤΕ (Ν.2093/92)	29,67
ΕΦΚ (Ν.3336/05)	120,40
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	-0,15
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	-0,40

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 6.230,49

ΦΠΑ 6201,37 x 11% = 682,15

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) A 6.912,64

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ - ΚΑΤΑΝΑΛΩΤΙΚΗ ΣΥΜΠΕΡΙΦΟΡΑ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ	ΣΥΓΚΡΙΣΗ ΜΕ ΑΝΤΙΣΤΟΙΧΗ ΠΕΡΣΙΝΗ ΚΑΤΑΝΑΛΩΣΗ ΣΑΣ
R5588797	20	2667	2472	15600		15600	
95588797	25	7976	7374	48160		48160	

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250
ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80
συνφ : 0,9510
ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 104,0

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 23/09/2010

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 16/09/2010

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

Σε συνέχεια του υπ' αριθμού α/α παραστατικού 0003681745 - 25/01/2011 λογαριασμού ρεύματος

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ
ΑΔΤ / ΑΦΜ :

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ 3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ 3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ 24/12/2010 - 25/01/2011

ΑΝΑΛΥΣΗ ΛΟΓΑΡΙΑΣΜΩΝ ΔΗΜΟΥ - ΕΡΤ*

ΔΗΜΟΤΙΚΑ ΤΕΛΗ (ΔΤ) - ΔΗΜΟΤΙΚΟΣ ΦΟΡΟΣ (ΔΦ)

	τμ		€/τμ		ΣΥΝΤΕΛ.ΗΜΕΡΩΝ		
ΔΤ :	2860	x	5,08	x	32/365	=	1274,18
ΔΦ :	5390	x	0,22	x	32/365	=	103,99

ΤΕΛΟΣ ΑΚΙΝΗΤΗΣ ΠΕΡΙΟΥΣΙΑΣ (ΤΑΠ)

τμ		ΤΙΜΗ ΖΩΝΗΣ		ΠΑΛΑΙΟΤΗΤΑ		ΣΥΝΤ. ΤΑΠ		ΣΥΝΤ. ΗΜΕΡΩΝ		
4000	x	146,00	x	0,80	x	0,00035	x	32/365	=	14,34

ΣΥΝΟΛΟ ΓΙΑ ΔΗΜΟ ΣΥΜΠΟΛΙΤΕΙΑΣ 1.392,51

ΕΡΤ

ΕΤΗΣΙΑ ΧΡΕΩΣΗ		ΣΥΝΤΕΛ. ΗΜΕΡΩΝ		
50,88	x	32/365	=	4,46

ΣΥΝΟΛΟ ΓΙΑ ΕΡΤ : 4,46

ΓΙΑ ΔΗΜΟ - ΕΡΤ ΠΛΗΡΩΝΕΤΕ (€) | Β | 1.396,97

*** Η ΔΕΗ βάσει των Νόμων 25/75, 429/76, 1080/80, 2130/93 και 2644/98 είναι υποχρεωμένη να συνεισπράττει με τους λογαριασμούς ρεύματος τα ποσά υπέρ ΔΗΜΩΝ - ΕΡΤ και να διακόπτει την παροχή εάν αυτά δεν καταβάλλονται από τον πελάτη**

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€)	Α	2.337,03
ΑΝΕΞΟΦΛΗΤΟ ΠΟΣΟ (€) (ΑΓΝΟΗΣΤΕ ΤΟ ΕΑΝ ΕΧΕΙ ΠΛΗΡΩΘΕΙ)	Γ	8566,00
ΣΥΝΟΛΙΚΟ ΠΟΣΟ ΠΛΗΡΩΜΗΣ (€)	Α + Β + Γ	*12.300,00

ΠΡΟΣΟΧΗ !! ΕΙΔΟΠΟΙΗΣΗ ΔΙΑΚΟΠΗΣ

**Αγαπητέ Πελάτη,
έχετε οφειλή από προηγούμενο λογαριασμό σας.
Παρακαλούμε για την εξόφληση της οφειλής σας
το αργότερο μέχρι την ημερομηνία λήξης του
λογαριασμού, διαφορετικά, μετά λύπης μας,
θα βρεθούμε στη δυσάρεστη θέση
να διακόψουμε την ηλεκτροδότησή σας.**

ΜΕΙΓΜΑ ΚΑΥΣΙΜΟΥ ΓΙΑ ΟΛΗ ΤΗ ΧΩΡΑ
(12μηνο, 11ος /2009 έως και 10ος/2010)

ΑΝΑΛΥΣΗ ΠΑΡΑΓΩΓΗΣ & ΔΙΑΣΥΝΔΕΣΕΩΝ	ΠΟΣΟΣΤΟ (%)
ΛΙΓΝΙΤΙΚΗ	46,34%
ΠΕΤΡΕΛΑΪΚΗ	8,56%
ΦΥΣΙΚΟΥ ΑΕΡΙΟΥ	17,50%
ΥΔΡΟΗΛΕΚΤΡΙΚΗ	11,32%
ΑΠΕ	6,64%
ΔΙΑΣΥΝΔΕΣΕΙΣ	9,64%
ΣΥΝΟΛΟ	100,00%

ΚΩΔΙΚΟΣ ΗΛΕΚΤΡΟΝΙΚΗΣ ΠΛΗΡΩΜΗΣ 393207420012

0250031540020

ΤΑΧΥΠΛΗΡΩΜΗ
ΑΠΟΚΟΜΜΑ ΤΑΜΕΙΟΥ
ΑΡ. ΤΗΛΕΦΩΝΟΥ ΠΕΛΑΤΗ
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ΑΡΜΟΔΙΟ ΚΑΤΑΣΤΗΜΑ

ΔΕΗ	ΤΗΛΕΦ.
ΑΙΓΙΟΥ	2691027811

ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ: 3 93207420-01 9
ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ: 3020 18 Χ1 000400
ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ: 24/12/2010 ΕΩΣ 25/01/2011

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ΕΙΣΠΡΑΞΗ / ΜΕΤΑΒΙΒΑΣΗ Ο

Αριθμός Λογαριασμού Ταχυπληρωμής	Τέλη	Χρονολογικό Σήμαν
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Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ
31

Η - Αριθμός
Αρ. Λογ/κής Απόδοσ

ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ	ΠΟΣΟ ΠΛΗΡΩΜΗΣ	Αριθμός Λογαριασμού (για μεταβίβασ
16/02/2011	*12.300,00€	

✂ Δ Μ ΜΗ ΣΗΜΕΙΩΝΕΤΕ ΚΑΤΩ ΑΠΟ ΑΥΤΗ ΤΗ ΓΡΑΜΜΗ

Η >393207420011 8026< 12300000> 10124< 25>

ΔΗΜΟΣΙΑ ΕΠΙΧΕΙΡΗΣΗ ΗΛΕΚΤΡΙΣΜΟΥ Α.Ε.
ΧΑΛΚΟΚΟΝΔΥΛΗ 30 - 104 32 ΑΘΗΝΑ Α.Φ.Μ. 090000045 ΔΟΥ ΦΑΒΕ ΑΘΗΝΩΝ

ΛΟΓΑΡΙΑΣΜΟΣ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ / ΔΗΜΟΥ & ΕΡΤ

ΕΚΚΑΘΑΡΙΣΤΙΚΟΣ
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ΚΑΤΑΣΤΗΜΑ ΑΙΓΙΟΥ
ΚΟΡΙΝΘΟΥ 113 251 00

Πληροφορίες : 26910 23755
Βλάβες : 26910 22408
Καταμέτρηση : 26910 27811

ΟΝΟΜ/ΜΟ - Δ/ΝΣΗ ΕΠΙΔΟΣΗΣ
Α.ΔΙΑΜΑΝΤΟΠΟΥΛΟΣ Θ.ΠΑΠΠΑΣ
ΛΟΓΓΟΣ
251 00 ΑΙΓΙΟΝ

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ΤΙΜΟΛΟΓΙΟ : Γ22 ΓΕΝΙΚΗ ΧΡΗΣΗ
ΠΡΟΚΑΤΑΒΟΛΗ (€) : 1063,54
ΑΔΤ / ΑΦΜ :

Δ/ΝΣΗ ΑΚΙΝΗΤΟΥ
ΛΟΓΓΟΣ
250 09 ΛΟΓΓΟΣ

Α/Α ΛΟΓΑΡΙΑΣΜΟΥ	ΗΜΕΡΟΜΗΝΙΑ ΕΚΔΟΣΗΣ	ΠΕΡΙΟΔΟΣ ΚΑΤΑΝΑΛΩΣΗΣ	ΗΜΕΡΕΣ	ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	ΑΡΙΘΜΟΣ ΠΑΡΟΧΗΣ
0003681745	25/01/2011	24/12/2010 - 25/01/2011	32 32	3020 18 Χ1 000400	3 93207420-01 9

1. ΧΡΕΩΣΗ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ

ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ (kWh) : 15360

ΠΑΓΙΑ ΧΡΕΩΣΗ	1,29
kWh 15360Χ0,07787€/kWh=	1196,12
kW 102,4Χ2,04296€/kW=	209,20
ΣΥΝΟΛΟ (1) :	1406,61

2. ΧΡΕΩΣΕΙΣ ΕΘΝΙΚΟΥ ΗΛΕΚΤΡΙΚΟΥ ΣΥΣΤΗΜΑΤΟΣ ΑΠΟ 1/1/2011

• ΔΙΚΤΥΟ ΜΕΤΑΦΟΡΑΣ	
- Χρήση Δικτύου Μεταφοράς (€) :	77,87
- Επικουρικές Υπηρεσίες (€) :	
- Λοιπές Επιβαρύνσεις (€) :	5,30
• ΔΙΚΤΥΟ ΔΙΑΝΟΜΗΣ	
- Χρήση Δικτύου Διανομής (€) :	273,79
• ΥΠΗΡΕΣΙΕΣ ΚΟΙΝΗΣ ΩΦΕΛΕΙΑΣ (€) : **Ν.2773/99 αρθ. 29**	165,54
• ΕΙΔΙΚΟ ΤΕΛΟΣ ΑΠΕ (€) : **Ν.2773/99 αρθ. 40** kWh 15360 x 0,00326 €/kWh	50,07
ΣΥΝΟΛΟ (2) :	572,57

ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ (1 + 2) (€) : 1979,18

ΤΟΚΟΙ ΥΠΕΡΗΜΕΡΙΑΣ	13,39
ΧΑΡΤΟΣΗΜΟ ΤΟΚΩΝ 3,6%	0,48
ΔΕΤΕ (Ν.2093/92)	9,98
ΕΦΚ (Ν.3336/05)	67,20
ΠΟΣΟ ΣΤΡΟΓΓ.ΠΡΟΗΓ/ΝΟΥ ΛΟΓ.	0,26
ΣΤΡΟΓΓ/ΣΗ ΠΛΗΡΩΤΕΟΥ ΠΟΣΟΥ	0,50

ΓΙΑ ΤΟ ΗΛΕΚΤΡΙΚΟ ΡΕΥΜΑ ΠΛΗΡΩΝΕΤΕ (€) 2.070,99

ΦΠΑ 2046,38 x 13% = 266,04

ΣΥΝΟΛΙΚΗ ΑΞΙΑ ΗΛΕΚΤΡΙΚΟΥ ΡΕΥΜΑΤΟΣ ΚΑΙ ΦΠΑ (€) **A** 2.337,03

ΕΝΔΕΙΞΕΙΣ ΜΕΤΡΗΤΗ - ΚΑΤΑΝΑΛΩΤΙΚΗ ΣΥΜΠΕΡΙΦΟΡΑ

ΑΡΙΘΜΟΣ ΜΕΤΡΗΤΗ	ΚΩΔΙΚΟΣ ΤΙΜΟΛΟΓΙΟΥ	ΤΕΛΕΥΤΑΙΑ	ΠΡΟΗΓΟΥΜΕΝΗ	ΔΙΑΦΟΡΑ	ΠΡΟΣΘ. kWh	ΣΥΝΟΛΟ ΚΑΤΑΝΑΛΩΣΗΣ	ΣΥΓΚΡΙΣΗ ΜΕ ΑΝΤΙΣΤΟΙΧΗ ΠΕΡΣΙΝΗ ΚΑΤΑΝΑΛΩΣΗ ΣΑΣ
R5588797	20	2991	2929	4960		4960	
95588797	25	8959	8767	15360		15360	

ΣΥΜΦΩΝΗΜΕΝΗ ΙΣΧΥΣ ΠΑΡΟΧΗΣ (kVA) : 250
ΣΥΝΤΕΛΕΣΤΗΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΥ : 80
συνφ : 0,9520
ΧΡΕΩΣΤΕΑ ΖΗΤΗΣΗ (kW) : 102,4

ΕΠΟΜΕΝΗ ΚΑΤΑΜΕΤΡΗΣΗ : 21/02/2011
ΛΗΞΗ ΠΡΟΘΕΣΜΙΑΣ ΠΛΗΡΩΜΗΣ : 16/02/2011

Appendix 6 -Airflow analysis

AIRFLOW ANALYSIS

Airflow analysis was carried out using the AIOLOS software in order to calculate the achieved airflows in two typical rooms of the hotel:

a. a room of ground floor and

b.a room of 4th floor.

The airflows were calculated for daytime and night time ventilation for the months May – September because natural ventilation will be used most during this period.

AIOLOS software

AIOLOS is a computational tool for the calculation of the airflows in naturally ventilated buildings. It is based on the concept of the network modelling. The input of the program requires geometrical data of the studied zone, geometrical information of the openings, climatic data for the simulation period, schedules of window opening and indoor air temperature for the simulated zone. The output includes airflow rates for each simulated zone.

Assumptions – input to the model

Table 1 Input – geometry of the room and indoor temperature

	Zone volume	Indoor temperature	External opening	Reference height (from ground)
Room of ground floor	65.6	28C stable	1	0.0
Room of 4th floor	65.6	28C stable	1	12.9

Geometry of opening

Table 2 Geometry of openings

Width	Top	Bottom	Orientation	Pressure Coefficient	Discharge Coefficient
0.65	2.20	0.00	347	0.0	0.9

Correction factor for single sided ventilated zones: 7m (depth of zone)

Opening of door balcony: 50% open

- **Results : Airflows for daytime ventilation**
  - **Room of ground floor**

Table 3 Average airflows in room of ground floor for day time ventilation

AVERAGE VALUES OF AIRFLOWS (ACH) - ROOM OF GROUND FLOOR - DAY TIME VENTILATION (SCHEDULE 8.00-23.00)					
YEARS	**MAY**	**JUNE**	**JULY**	**AUGUST**	**SEPTEMBER**
PRESENT	9.4	6.5	5.9	5.8	7.1
2020	8.7	6.1	6.1	5.9	6.5
2050	8.1	5.9	6.4	6.2	6.1
2080	7.2	5.9	7.0	6.7	5.8

  - **Room of 4th floor**

Table 4 Average airflows in room of 4th floor for day time ventilation

AVERAGE VALUES OF AIRFLOWS (ACH) ROOM OF 4TH FLOOR - DAY TIME VENTILATION 8.00-23.00 (SCHEDULE 8.00-23.00)					
YEARS	**MAY**	**JUNE**	**JULY**	**AUGUST**	**SEPTEMBER**
PRESENT	9.4	6.6	6.0	5.8	7.1
2020	8.7	6.1	6.1	5.9	6.5
2050	8.1	5.9	6.4	6.2	6.2
2080	7.2	5.9	7.0	6.7	5.9

- **Results : Airflows for nighttime ventilation**

  - **Room of ground floor**

Table 5 Average airflows in room of ground floor for night time ventilation

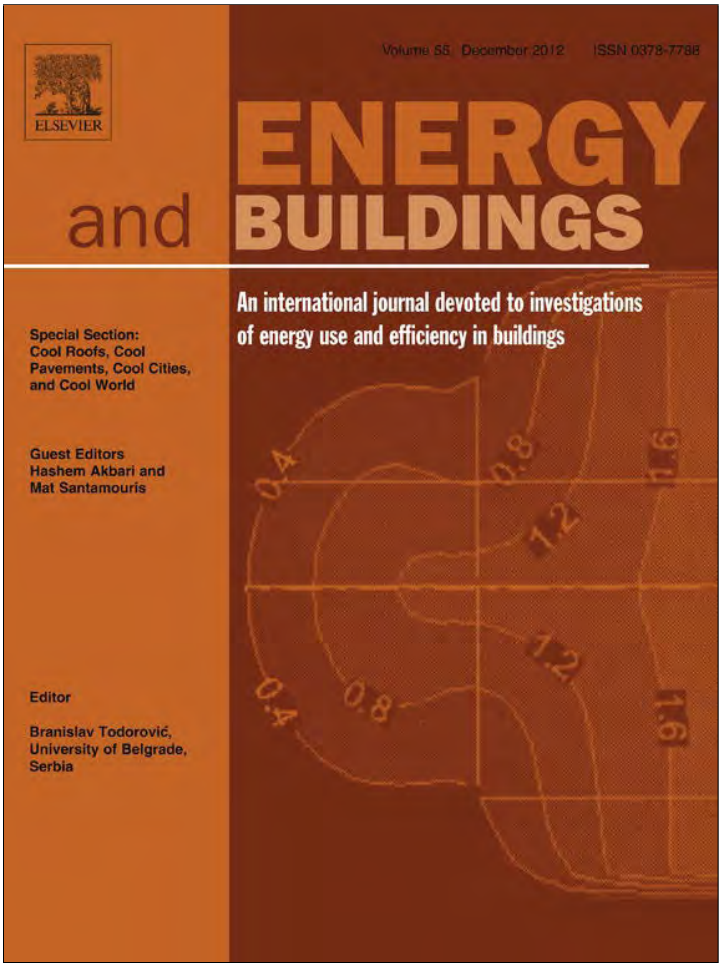
AVERAGE VALUES OF AIRFLOWS (ACH) - ROOM OF GROUND FLOOR - NIGHT TIME VENTILATION (SCHEDULE 23.00-7.00)					
YEARS	**MAY**	**JUNE**	**JULY**	**AUGUST**	**SEPTEMBER**
PRESENT	10.9	11.1	9.0	8.5	11.0
2020	12.9	10.6	8.3	7.9	10.6
2050	12.3	9.9	7.5	7.2	10.0
2080	11.4	9.0	6.4	6.2	9.3

  - **Room of 4th floor**

Table 6 Average airflows in room of 4th floor for night time ventilation

AVERAGE VALUES OF AIRFLOWS (ACH) ROOM OF 4TH FLOOR - NIGHT TIME VENTILATION (SCHEDULE 23.00-7.00)					
YEARS	**MAY**	**JUNE**	**JULY**	**AUGUST**	**SEPTEMBER**
PRESENT	13.3	11.1	9.0	8.5	11.0
2020	12.9	10.6	8.3	7.9	10.6
2050	12.3	9.9	7.5	7.2	10.0
2080	11.4	9.0	6.4	6.3	9.3

Appendix 7 - Paper in 'Energy and Buildings' journal



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University of Belgrade,
Serbia

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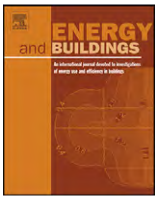

A method for energy classification of hotels: A case-study of Greece

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ABSTRACT

Hotels are a diverse building type with high normalized energy end-use because of its focus to provide best facilities for guests. There is scope, and in many countries legislative requirements, to reduce energy consumption without compromising facilities; case-studies from tourism intensive countries could be useful for demonstrating such possibilities. This paper presents a method of deriving energy benchmarks to enable classification of hotels in Greece based on operational energy use in terms of electricity and oil. The method of classification defines clusters of hotels using the *k*-means algorithm controlled with the silhouette plot after applying normalization factors for the operational energy data to correct for size, operation (seasonal or annual) and climatic conditions. Ninety hotels are analysed in the sample presented in this paper; and well separated clusters are defined for the whole sample and for the sample split in hotels with annual and seasonal operation. Energy consumption varies considerably between and within clusters indicating that a range of energy consumption targets might be more suitable than single value benchmarks for this type of building.

1. Introduction

Worldwide, buildings account for almost a third of final energy consumption and are an equally important source of CO_2 emissions. 'Currently, space heating and cooling as well as hot water are estimated to account for roughly half of global energy consumption in buildings. These end-uses represent significant opportunities to reduce energy consumption, improve energy security and reduce CO_2 emissions due to the fact that space and water-heating provision is dominated by fossil fuels while cooling demand is growing rapidly in countries with very carbon-intensive electricity systems' [1]. More than 40% of final energy consumption in developing countries is due to the residential and tertiary sector, the major part of which is buildings [2]. In the European Union, buildings are also responsible for 40% of energy consumption and 36% of CO_2 emissions [3].

Hotels are the highest energy consuming buildings of the tertiary sector because of their operational characteristics and the large number of users; data indicate that they are the highest of the building stock after shopping malls and hospitals [4,5]. Their energy consumption can vary widely from hotel to hotel depending on location, size and guest facilities. A broad overview of the hotel industry shows that there are 300,000 hotels world-wide, accounting for more than 11 million rooms, of which 70% are located in Europe and North America [6]. Their energy consumption is highly diversified and very difficult to quantify in detail.

This paper first reviews the current energy use by hotels through available literature.

1.1. Available data of energy consumption by hotels

Various researches report the energy consumption of hotels in different parts of the world in terms of the energy use index or energy intensity (defined as the site energy consumption per unit of gross floor area): in 1995 the average annual energy intensity for hotel buildings in the United States was 401 kWh/m^2, 40.9% accounting for electricity and 51.9% for gas. The average annual energy use for 19 hotels in Ottawa, Canada (1991) is 688.7 kWh/m^2 with electricity accounting for 28.9%, gas 26.4% and steam 44.7% respectively [5,7] whereas in another study the reported energy performance of 16 hotels in Ottawa is 612 kWh/m^2 [8]. A study on hotels of Singapore (1993) shows average energy use intensity 468 kWh/m^2. A later survey conducted in 2005–2006 on 29 hotels of Singapore reports average annual electricity consumption 361 kWh/m^2, fossil fuel energy 66 kWh/m^2, and total energy intensity 427 kWh/m^2 [8]. Past studies on hotels of Hong Kong report average electrical energy consumption of 257.8 kWh/m^2

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and 366 kWh/m^2 [7]. More recent researches on hotels of Hong Kong covering the periods 1995–1997 report average energy use 406 kWh/m^2 and 564 kWh/m^2 [5,8]. The majority of hotels in Hong Kong consume 3 types of fuel: electricity, gas and diesel but the consumption is dominated by electricity.

In *Europe*, the estimated total energy consumption of hotels is 39 TWh, of which 50% is attributed to electricity [5,9,10]. This accounts approximately to 0.7–1% of the final energy consumption of buildings in Europe which for 2010 was 5774 TWh in the EU-27 and 3970 TWh in EU-17 (Euro area) [11].

The reported average energy use for the European hotels for the 1990s is between 239 and 300 kWh/m^2/year [5]. In absolute values hotel energy consumption is 215 kWh/m^2 in Italy, 273 kWh/m^2 in Greece, 278 kWh/m^2 in Spain and 420 kWh/m^2 in France [4,12,13]. In the UK, current energy benchmarks quote 540 kWh/m^2 (400 kWh/m^2 fossil fuel and 140 kWh/m^2 electricity) for typical holiday hotels and 340 kWh/m^2 (280 kWh/m^2 fossil fuel and 80 kWh/m^2 electricity) for best practice holiday hotels [14].

1.2. Available data for energy consumption of hotels in Greece

In Greece, energy data of 158 hotels reported total annual energy consumption of 4.3 TWh with an average of 273 kWh/m^2/annually [4]. According to data by EUROSTAT this accounts to 4.3–5% of the final energy consumption of buildings in Greece for the years 2007–2010 which varied from 100 TWh in 2007 to 86 TWh in 2010 [11].

In Greek hotels, energy is mainly used for heating accounting for 197.9 kWh/m^2 that represents 72% of the total energy consumption. Artificial lighting accounts for 24.5 kWh/m^2 (9% of the total), cooling for 10.7 kWh/m^2 (4% of the total) and other electrical appliances for 39.9 kWh/m^2 (14.6% of the total). Within the EU CHOSE project [9] data was collected from 10 hotels in Greece. Five of these hotels use electricity and oil, four hotels use electricity, oil and liquefied petroleum gas (LPG) and one hotel uses electricity and LPG. Their energy consumption varies between 72 kWh/m^2 and 519 kWh/m^2 [15] resulting in an average of 289.9 kWh/m^2/year [5]. It is surprising that very few hotels have implemented renewable energy technologies (solar, thermal, solar passive, solar PV, biomass and geothermal). According to the EU 'HOTRES' project thermal solar systems are used for domestic hot water, swimming pool heating and solar air-conditioning in 100 hotels. The total surface area of these systems is 28,820 m^2 and their size varies between 20 m^2 (Tsangarakis Hotel in Crete) and 2783 m^2 (Cretan Village in Crete). The majority of these systems are installed in hotels of Crete [13,16,17].

1.3. Energy consumption reduction requirements and classification

In Europe, classification of the building stock aiming at energy performance rating is being implemented in all countries as part of the Energy Performance in Building Directive (EPBD). Some countries, such as the UK, have produced energy benchmarks and performance guides that include typical and best practice values for the building stock including hotels. Other countries, including Greece, are working towards establishing official benchmarks; however information on the energy rating of various types of buildings is given in studies during the last 20 years which is compatible with information that benchmarks in other countries have been derived from [4,18–23]. At a European level, a classification of hotels based on their energy performance is developed by the EPLabel programme [24,25] and highlights the 'typical', 'best practice' and 'passive' reference buildings. Within this project, the benchmarking system for Greece is developed based on the operational energy data of 158 hotels that is collected within the National Energy Programme sponsored by the CEC Valoren Programme [4]. The sample is split in insulated and non-insulated buildings and in air-conditioned and non-air-conditioned hotels. The energy benchmarking proposes 5 energy categories, rated from 'A' to 'E'. The 'typical' insulated air-conditioned building consume energy for heating, lighting and cooling around 180 kWh/m^2/year and belongs to energy category 'B', the 'good practice' building consumes energy around 105 kWh/m^2/year and belongs to energy category 'B' while the 'passive' building consumes energy around 45 kWh/m^2/year and belongs to category 'A'. A more recent study classifies a sample of 100 Greek hotels of climatic zone C in 'small', 'medium' and 'large' hotels according to the number of their beds. The 'small' hotel (a 2-star hotel) has electricity consumption of 39 kWh/m^2/year; the 'medium' hotel (3-star) has electricity consumption of 13,000 kWh/month and the 'large' hotel (4-star) 950,269 kWh/year [26,27].

Available literature reported in this section indicates that classification methods and benchmarks for hotels is still developing and this paper adds in the field energy data by presenting the collection of *new* operational energy data of 90 hotels in Greece. It follows an analysis of the data and the presentation of a method for deriving energy benchmarks based on clusters to enable classification of hotels in Greece which will be also be of use to other researchers in other parts of the world.

2. Methodology

2.1. Data collection

Different data collection methods for the building environmental and energy performance are reported in the literature. Standard reporting protocols, energy audits, specific questionnaires to perform surveys, questionnaires uploaded on websites are some of the preferred methods [4,18,21,26]. However, lack of energy consumption data is noted in many studies and remains a significant drawback for extracting general conclusions on the energy performance of the building stock [28].

In this study, the energy data of the hotels is collected using questionnaires and visits on site.

At first, information on the hotel stock was derived from the Hellenic Chamber of hotels [29] that is the institutional consultant of the Government as far as tourism and hospitality issues are concerned. Currently, the Chamber numbers approximately 10,000 members (all types of tourist lodgement, hotels and camping sites) of which classical hotels are the most numerous. According to the National Statistical Agency of Greece [30] and based on information for year 2000 hotels account for 22,830 buildings that is approximately 0.6% of the Greek building stock.

A cd was provided to the author by the constitution with contact details of the registered hotels. In the beginning the research focused on hotels of climatic zone B, in the greater area of Athens. A phone conversation was realised asking for the manager of the hotels and then the questionnaire was sent via email. Additionally around 500 questionnaires were sent via emails to hotels of climatic zone C [26].

No feedback was received with this method as only one hotel of climatic zone C responded and it was decided to carry out visits on site in order to collect the required information. Out of 100 visits finally 90 hotels fully corresponded to the research that is approximately 0.4% of the Greek hotel stock.

Information is collected for hotels in 3 out of 4 climatic zones of Greece (climatic zones A, B and C). The data of hotels in climatic zone C (approximately 44% of the examined sample) is collected through a collaborative research project in Greece [26,27] while data of the rest of the sample (50 hotels in climatic zones A and B) is collected specifically for this study.

The aim of the questionnaire is to collect information of the hotels on:

1. General characteristics such as location, construction year, floor area, occupancy pattern and possible renovations.
2. Electrical and thermal energy consumption.
3. The presence or not of a Building Energy Management System and whether there is a policy towards energy savings.
4. The building construction.
5. The building environmental systems (heating, cooling, lighting, domestic hot water).
6. Electrical appliances.

Information on the hotels of climatic zone C is less detailed and is limited only to the electrical consumption.

2.2. Average energy consumption

The information on the electrical and thermal energy use covers the year 2007 and is provided by the hoteliers. The normalized average thermal and electrical consumption of the hotels is calculated (kWh/m^2/year) taking into account the size and location of the hotels.

2.2.1. Size normalization

The area of the hotels varies significantly according to the category of the hotel, number of rooms and guest facilities. The smaller hotel has an area of around 500 m^2 and the larger 60,000 m^2. The buildings are normalized in terms of their conditioned floor area (m^2). The annual energy consumption for space heating and cooling is divided by the total heated/cooled floor area respectively, so that all data is referred to as energy per unit area (kWh/m^2/year) in order to compare buildings of different size.

2.2.2. Climatic normalization

The 90 hotels are located in climatic zones A, B and C of Greece with different climatic characteristics. The climate in Greece is typical of the Mediterranean climate; mild and rainy winters and relatively warm and dry summers with long sunshine duration throughout the year. However, the peculiar topography of the country results in a great variety of climate subtypes, among the several regions of Greece. Thus from the dry climate of Attiki (the great area of the capital, Athens) and of East Greece, the climate becomes wetter towards North and West Greece [31].

In order to compare buildings in different locations, the energy consumption is normalized in terms of climatic zones using the degree day method. The heating–cooling degree day method (DDM) is based on the temperature difference between a base indoor temperature and the outdoor temperature. In general, when the outdoor temperature is below the base temperature then heating is required, and reversely when the outside temperature is higher than the base temperature then cooling is required; base temperature is usually different for heating and cooling to allow for contribution of heat gains and possible passive cooling such as ventilation. The heating and cooling degree days are a measure showing the amount of heating or cooling needed to achieve the base temperature and are the sum of the difference between the outside and the base temperature (or reverse in the case of cooling) [32]. The energy consumption of the hotels that operate seasonally (thus only during the cooling season) is normalized using the cooling degree days. The energy consumption of the hotels that operate throughout the year (during the heating and cooling season) is normalized using the heating and cooling degree days. The procedure is described with the following equations:

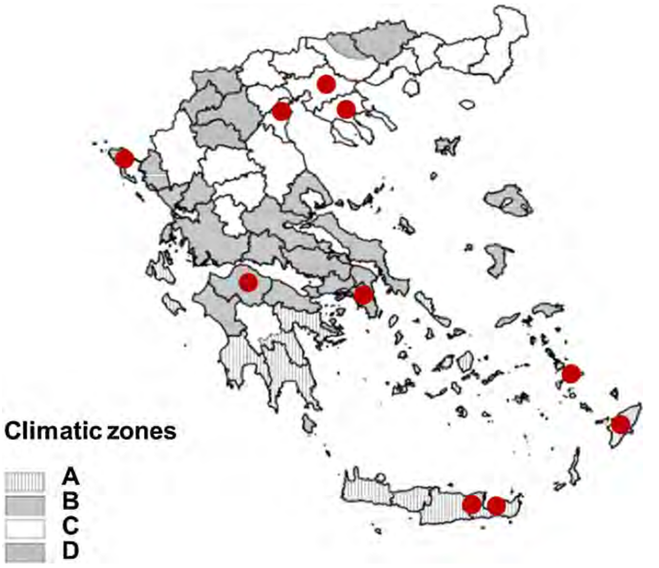

Fig. 1. Map showing the location of the hotels in the 3 climatic zones of Greece [47].

$$\text{Heating degree days,}\quad D_d = \frac{\displaystyle\sum_{j=1}^{24}(\theta_b-\theta_{o,j})_{((\theta_b-\theta_{o,j})>0)}}{24} \quad [32] \qquad (1)$$

$$\text{Cooling degree days,}\quad D_d = \frac{\sum_{j=1}^{24}(\theta_{o,j}-\theta_b)_{((\theta_{o,j}-\theta_b)>0)}}{24} \quad [32] \qquad (2)$$

where D_d is the daily degree-days for one day, θ_b is the base temperature and $\theta_{o,j}$ is the outdoor temperature in hour j [32].

Information on the degree days for the climatic zones of Greece is taken from TOTEE 20701-3/2010 [33] (see Fig. 1 and Tables 1 and 2). As default, in the Technical Directive, the base temperature is set to 18 °C for the heating degree days and 26 °C for the cooling degree days. Within the frames of the normalization procedure, climatic zone B is taken as reference.

2.3. Frequency distribution analysis

The energy data of the hotels is analysed with the frequency distribution analysis aiming at finding a ‘best practice’ and ‘typical’ building. Frequency distribution counts the occurrences of values within a particular group or range of values. It is a way of classifying unorganized data. In many studies the cumulative frequency distribution is used to define the median value (50% of the sample), and the quartile boundaries (25% and 75%). Usually the 25% represents the best practice example and the 75% represents the typical value of a sample [19,20,34,35].

2.4. Benchmarks and classification

Classification schemes help to organize a large set of data so that future reference in this data can be made more effectively. The classification aims at allocating objects in groups with similar characteristics. It is served in many sciences; wide application is found in the medicine area [36]. The aim of the benchmarking process is the comparative analysis in order to define best practice examples. In the case of buildings, it gives an idea of their energy performance and highlights the best and worst case studies.

Table 1
Heating degree days according to TOTEE 20701-3/2010.

Months	Location						
	Athens	Crete	Corfu	Thes/ki	Rhodes	Kos	Patra
Climatic zone	B	A	B	C	A	A	B
Heating degree days (base temperature 18 °C)							
January	239	220	257	394	186	217	248
February	207	196	216	314	162	210	207
March	177	167	186	254	133	183	171
April	60	66	90	111	42	78	72
May							
June							
July							
August							
September							
October				53			
November	78	72	111	207	39	90	105
December	186	167	214	344	140	174	205
Total	947	888	1074	1677	702	952	1008

So far, most of the proposed techniques for the assessment of the energy classification of buildings are based on the cumulative frequency distribution analysis. This method presupposes a representative sample [20]. However, this does not apply in the sample of the hotels. A grouping methodology is required that would allocate the data in subgroups with identical characteristics. Cluster analysis determines similar groups, or clusters, of data of an initially unclassified set of data. Objects in the same cluster have similar characteristics in a sense, where the profile of objects in different clusters is quite distinct. The *k*-means algorithm is one of the simplest unsupervised learning algorithms that deals with clustering unorganised data. The main advantages of the *k*-means algorithm is that (a) the clusters are non-hierarchical and they do not overlap and (b) every member of a cluster is closer to its cluster than any other cluster.

The aim of this research is to organise the large set of hotel data in quite distinct subgroups; thus the clustering of the Greek hotels is carried out using the *k*-means algorithm being one of the most used and efficient clustering methods [20,37–40]. The *k*-means algorithm assigns each point to the cluster whose center (also called centroid) is nearest. The algorithm uses an iterative algorithm that minimizes the sum of distances from each object to its cluster centroid, over all clusters. This algorithm moves objects between clusters until the sum of distances from all objects in that cluster cannot be decreased further. When all objects have been assigned then the *k* centroids are recalculated several times until they do not move any longer. The application of the *k*-means algorithm results in a number of well separated and compact clusters [40–42].

The algorithm is described by the following equation:

$$\mathrm{IDX} = k\text{-means}(X, k) \tag{3}$$

where IDX = the resulting set of data, an n-by-p vector IDX, (n) corresponding to points and (p) columns corresponding to variables; X = a given data set in a form of matrix X; k = number of k centroids, one of each cluster [42,43].

An important decision when using the *k*-means algorithm is the number of clusters that should be determined a priori. The determination of the correct number of clusters and how well these are separated is controlled by the ‘Silhouette plot’:

$$S = \mathrm{Silhouette}(X, \mathrm{clust}) \quad [42, 43] \tag{4}$$

The plot shows the number of k clusters and how well these are separated; it takes values from ‘+1’, indicating that objects are well separated and belong to different clusters, through ‘0’, indicating points that may belong in more than one clusters, to ‘−1’ indicating that probably some objects are located into the wrong cluster [40].

The clustering of the Greek hotels is performed using the MATLAB environment, a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features [41]. In the literature many examples can be found on the MATLAB use for assessing the application of fuzzy control systems and artificial neural networks

Table 2
Cooling degree days according to TOTEE 20701-3/2010.

Months	Location					
	Athens	Crete	Corfu	Thes/ki	Rhodes	Kos
Climatic zone	B	A	B	C	A	A
Cooling degree hours (base temperature 26 °C)						
January						
February						
March						
April						
May						
June	794	497	391	526	158	158
July	1901	1276	1122	1211	870	870
August	1853	1051	1236	1058	1046	1046
September	292	157	1		161	161
October						
November						
December						
Total	4840	2981	2750	2795	2235	2235

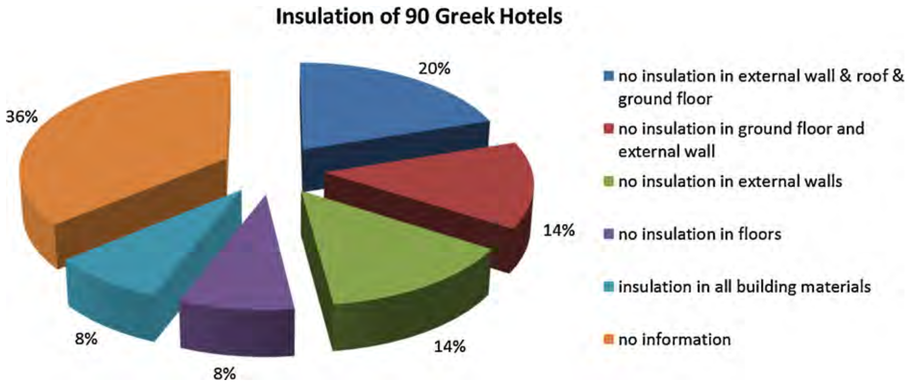

Fig. 2. External envelope thermal insulation of 90 Greek hotels.

Table 3
Distribution of hotels in different climatic zones of Greece.

Climatic zone	Percentage of hotels
A (islands of Crete, Kos, Rhodes, Kefalonia)	32%
B (Athens, island of Corfu and Aigaion)	22%
C (Thessaloniki, Platamonas)	46%

in assessing buildings components/systems [44,45] and/or rating the buildings' energy performance [19,20,46,47].

The hotels are clustered based on their normalized electrical and oil (heating) energy consumption (kWh/m^2/year). Several iterations were carried out in order to obtain the optimum number of clusters and this was controlled with the silhouette plot. Finally, the energy data is classified into different clusters and the 'centroid' values are calculated representing the average energy consumption of each cluster.

3. Hotel building characteristics

The hotels are located in all 3 climatic zones of Greece (A, B, and C) as shown in Table 3 and Fig. 1. Given the restricted area of climatic zone D and the limited number of hotels in this zone compared to the other climatic zones, the research is focused on hotels of climatic zones A, B and C.

Almost half of the sample (54%) operates throughout the year whereas the rest operates seasonally during the summer months.

The hotels are grouped according to the number of their beds based on the legislation ΦΕΚ Α′ 43/7.3.2002: 'small' hotels with beds less than 100 (34% of the sample), 'medium' hotels with number of beds between 100 and 300 (39%), and 'large' hotels with number of beds greater than 300 (27%).

3.1. Building elements

From the sample 40% of the hotels are constructed before 1979 when the national thermal insulation code was put into force. 37% of the sample is constructed between 1979 and 2000. Only 9% is constructed after 2000.

Information on the building materials is not available for the hotels of climatic zone C. Information on the construction of the hotels and whether the buildings are insulated is shown in Fig. 2. In summary, a very small percentage of the hotels are fully insulated, whereas the majority is non-insulated. Concerning the glazing, a very small percentage of the sample has energy efficient glazing, whereas the majority has typical double glazing (U-value: 3 W/m^2 K) and a significant portion has single glazing (U-value: 5.6 W/m^2 K); see Fig. 3.

3.2. Building systems

Information on the building systems (heating, cooling, domestic hot water) and the fuels used in 50 hotels is shown in Table 4. It is concluded that for heating and cooling all hotels are mostly dependent on the use of conventional energy sources thus fossil fuels. The use of renewable energy sources is limited on the production of domestic hot water via solar collectors. Additionally, out of 50 hotels, in 14% there is a building management system that is connected to the central cooling system. In 52% there is not a BMS. Only in 2 hotels, the energy consumption is recorded by a BMS daily, on an hourly time step.

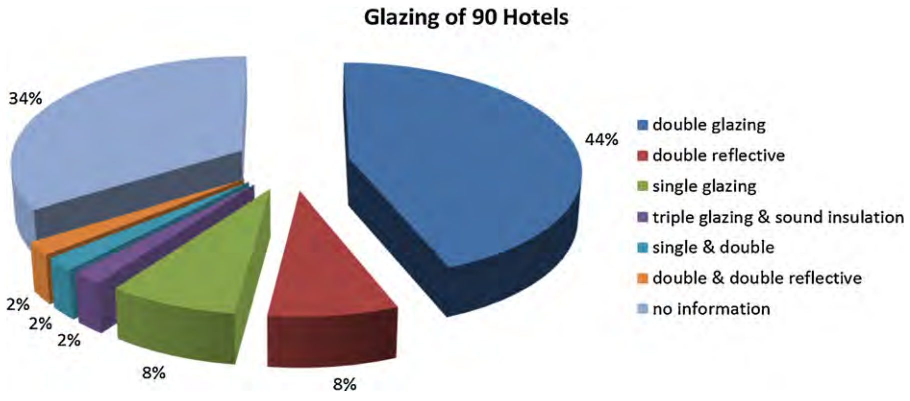

Fig. 3. Glazing characteristics of 90 Greek hotels.

Table 4
Building systems and fuel used in 50 Greek hotels.

50 Hotels in Greece building systems and fuel used for heating, cooling and DHW—percentage of hotels	
Heating	
Central heating-radiators and oil fired boilers	12%
Central heating AHU and fan coil units – electricity	18%
Central heating – natural gas	14%
Central heating – natural gas and oil	4%
Central heating – LPG	6%
No heating (operation during cooling period)	46%
Cooling	
Central cooling (chillers and fan coil) – electricity	74%
Local units – electricity	6%
Central cooling with heat recovery and exhaust to the sea	2%
No information	18%
DHW	
Solar collectors	18%
Solar collectors and auxiliary systems	24%
Central system with oil	18%
Central system with gas	18%
Central system with LPG	2%
Central system with gas and oil	2%
No information	18%

Table 5
Number of hotels with available data.

Available data	Number of hotels
Electrical consumption	
Available data	90
Annual operation	49
Seasonal operation	41
Oil consumption	
Not available information	34
Oil is not used	26
Available data	30
Annual operation	12
Seasonal operation	18

Energy measures have been performed in 52% of the hotels. These include the use of control cards in the rooms in order to switch on/off the lights (48%), the use of low energy luminaires (6%), the use of air conditioners with inverter (6%), the use of low flush toilets (4%), and the use of thermostats (6%).

The number of hotels with available data is summarized in Table 5.

4. Results

4.1. Average energy consumption

The average thermal and electrical energy consumption of the whole sample (90 hotels) and the sample split in hotels with annual and seasonal operation is shown in Table 6.

4.2. Cumulative frequency distribution

Table 7
Clustering of the normalized electrical energy consumption (year 2007) of 90 hotels in Greece.

Clusters for the normalized electricity consumption (2007) of 90 hotels in Greece					
Values (kWh/m^2)	1	2	3	4	5
Minimum	7	86	174	315	623
Maximum	86	174	315	623	1260
Centroid	39	129	234	378	945

Fig. 4 shows the cumulative frequency distribution of the electrical consumption for 90 hotels; from this the following benchmarks apply for the hotel buildings in terms of their normalized electricity consumption:

- Typical hotel building (50% of the sample), approximately 140 kWh/m^2/year.
- Best practice of the building (25% of the sample), 58 kWh/m^2/year.

Fig. 5 shows the cumulative frequency distribution of the oil consumption for 30 hotels; from this the following benchmarks apply for the hotel buildings in terms of their normalized oil consumption.

- Typical hotel building (50% of the sample), approximately 28 kWh/m^2/year.
- Best practice of the building (25% of the sample), 11 kWh/m^2/year.

4.2.1. Classification of the data

The classification of the hotels is performed for:

- The total of the sample (90 hotels of which only 30 hotels consume oil).
- Hotels with annual operation (49 hotels of which 12 hotels consume oil).
- Hotels with seasonal operation (41 hotels of which 18 hotels consume oil).

4.3. Electricity consumption

The result is 5 clusters for the whole sample (90 hotels), 5 clusters for 49 hotels with annual operation and 4 clusters for 41 hotels with seasonal operation.

4.3.1.1. Whole sample (90 hotels)

The clusters for the whole sample are shown in Fig. 6 and the boundaries of each cluster (minimum, maximum and centroid values) are shown in Table 7.

The average electricity consumption for cluster 1 is 39 kWh/m^2, for cluster 2 it is 129 kWh/m^2 for cluster 3 it is 234 kWh/m^2, for cluster 4 it is 378 kWh/m^2 and for cluster 5 it is 945 kWh/m^2. 32% of the sample belongs in cluster 1, 26% belongs in cluster 2, 29% in cluster 3, 10% in cluster 4 and 3% in cluster 5. Also based on the frequency distribution analysis approximately 50% of the sample belongs in clusters 1 and 2.

The number of the obtained clusters is checked with the silhouette plot. The absence of negative values as shown in Fig. 7 indicates that the distinction in five clusters is made successfully.

Table 6
Average electricity and oil consumption (kWh/m^2/year) for 90 hotels.

	No. of hotels	Electricity (kWh/m^2/year)	No. of hotels	Oil (kWh/m^2/year)
Average energy consumption				
Whole sample	90	182	30	61
Annual operation	49	202	12Space and water heating	87
Seasonal operation	41	159	18 Water heating	43

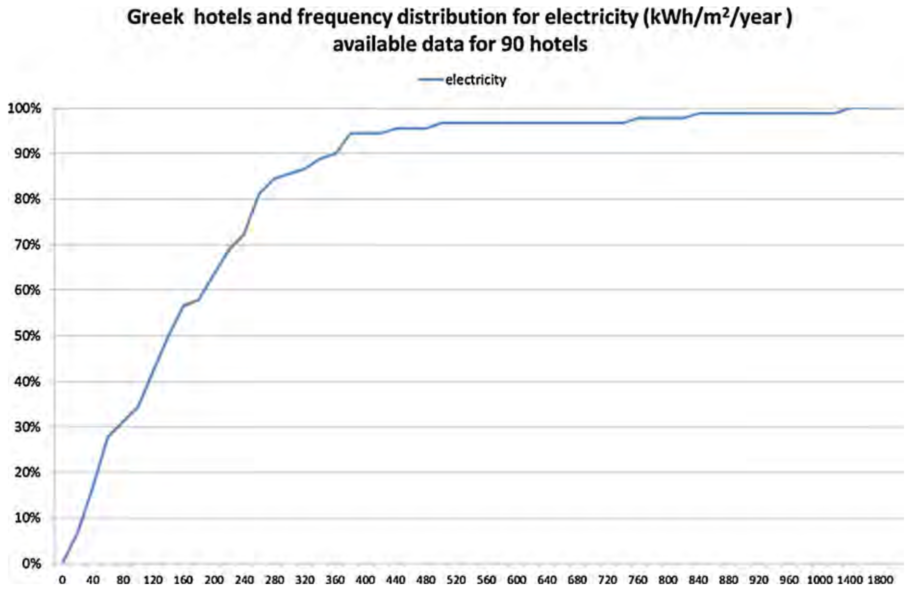

Fig. 4. Cumulative frequency distribution of the electrical consumption for 90 hotels in Greece (year 2007).

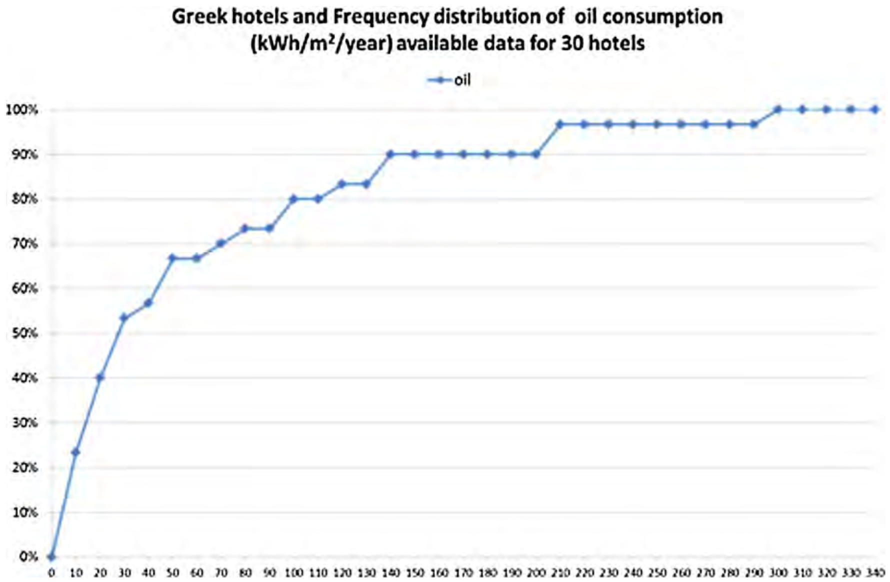

Fig. 5. Cumulative frequency distribution of the oil consumption for 30 hotels in Greece (year 2007).

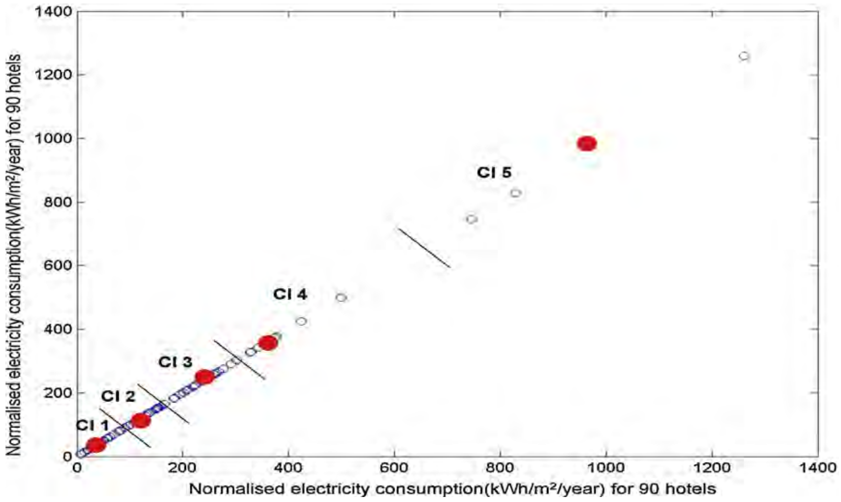

Fig. 6. Clustering of the electrical energy consumption (year 2007) of 90 hotels.

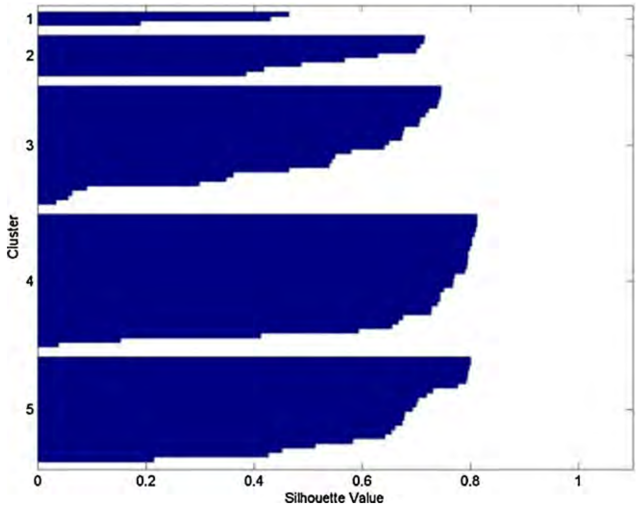

Fig. 7. Plot silhouette for the clustering of the normalized electrical consumption of 90 hotels.

Table 8
Clustering of the electrical consumption of 49 hotels (year 2007).

Clusters for the normalized electricity consumption (2007) of 49 hotels with annual operation

Values (kWh/m^2)	1	2	3	4	5
Minimum	14	85	174	282	664
Maximum	85	174	282	664	1260
Centroid	38	132	225	369	1045

4.3.1.2. Hotels with annual operation (49 hotels)

The boundaries of each cluster (minimum, maximum and centroid values) are shown in Table 8.

The average electricity consumption for cluster 1 is 38 kWh/m^2, for cluster 2 it is 132 kWh/m^2 for cluster 3 it is 225 kWh/m^2, for cluster 4 it is 369 kWh/m^2 and for cluster 5 it is 1045 kWh/m^2. 26.5% of the sample belongs in cluster 1, 32.6% belongs in cluster 2, 20.4% in cluster 3, 16% in cluster 4 and 4% in cluster 5.

4.3.1.3. Hotels with seasonal operation (41 hotels)

The boundaries of each cluster (minimum, maximum and centroid values) are shown in Table 9.

Table 9
Clustering of the electrical consumption of 41 hotels (year 2007).

Clusters for the normalized electricity consumption (2007) of 41 hotels with seasonal operation

Values (kWh/m^2)	1	2	3	4
Minimum	7	76	175	586
Maximum	76	175	586	746
Centroid	37	117	252	746

Table 10
Clustering of the normalized thermal consumption (oil) for 30 hotels in Greece (year 2007).

Clusters for the normalized oil consumption (2007) of 30 hotels in Greece

Values (kWh/m^2)	1	2	3	4	5
Minimum	1	16	44	86	173
Maximum	16	44	86	173	294
Centroid	8	27	58	117	237

The average electricity consumption for cluster 1 is 37 kWh/m^2, for cluster 2 it is 117 kWh/m^2 for cluster 3 it is 252 kWh/m^2, for cluster 4 it is 746 kWh/m^2. Also 37% of the sample belongs in cluster 1, 20% belongs in cluster 2, 41% in cluster 3, and 2% in cluster 4. Again approximately 50% of the sample belongs in clusters 1 and 2. Additionally only 2% of the sample, thus only 1 hotel, belongs in cluster 4 therefore the upper value and the centroid of this cluster is identified with the energy consumption of this hotel.

4.3.2. Oil consumption

The result is 5 clusters for the whole sample (30 hotels), 4 clusters for 12 hotels with annual operation and 4 clusters for 18 hotels with seasonal operation.

4.3.2.1. Whole sample (30 hotels). The clusters for the whole sample are shown in Fig. 8 and the boundaries of each cluster (minimum, maximum and centroid values) are shown in Table 10.

The average oil consumption for cluster 1 is 8 kWh/m^2, for cluster 2 it is 27 kWh/m^2 for cluster 3 it is 58 kWh/m^2, for cluster 4 it is 117 kWh/m^2 and for cluster 5237 kWh/m^2. 33% of the sample belongs in cluster 1, 27% belongs in cluster 2, 13% in cluster 3, 17% in cluster 4 and 10% in cluster 5.

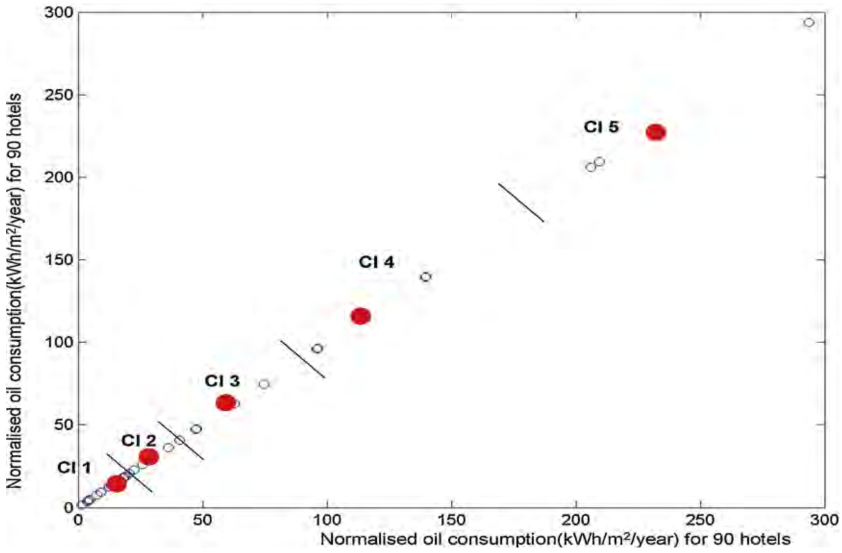

Fig. 8. Clustering of the thermal consumption (oil) for 30 hotels in Greece (year 2007).

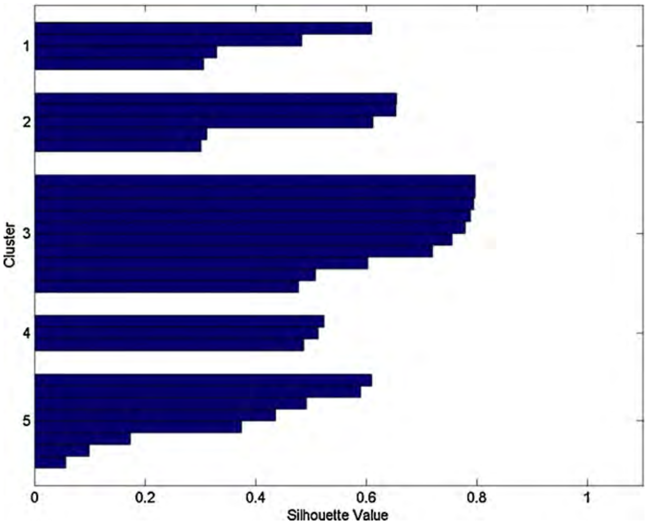

Fig. 9. Plot silhouette for the clustering of the normalized oil consumption of 30 hotels.

Table 11
Clustering of the thermal consumption (oil) of 12 hotels (year 2007).

Clusters for the normalized oil consumption (2007) of 12 hotels with annual operation				
Values (kWh/m^2)	1	2	3	4
Minimum	1	25	72	173
Maximum	25	72	173	209
Centroid	11	42	118	208

The number of the obtained clusters is checked with the silhouette plot. The absence of negative values as shown in Fig. 9 indicates that the distinction in five clusters is made successfully.

4.3.2.2. Hotels with annual operation (12 hotels). The boundaries of each cluster (minimum, maximum and centroid values) are shown in Table 11.

The average energy consumption for cluster 1 is 11 kWh/m^2, for cluster 2 it is 42 kWh/m^2 for cluster 3 it is 118 kWh/m^2, for cluster 4 it is 208 kWh/m^2. 25% of the sample belongs in cluster 1, 25% belongs in cluster 2, 33% in cluster 3, and 17% in cluster 4.

4.3.2.3. Hotels with seasonal operation (18 hotels). The boundaries of each cluster (minimum, maximum and centroid values) are shown in Table 12.

The average energy consumption for cluster 1 is 9 kWh/m^2, for cluster 2 it is 29 kWh/m^2 for cluster 3 it is 84 kWh/m^2, for cluster 4 it is 294 kWh/m^2. 50% of the sample belongs in cluster 1, 27.8% belongs in cluster 2, 17% in cluster 3, and 5%, in cluster 4. Only one hotel belongs in cluster 4 thus the upper value and the centroid of cluster 4 is identified with the energy consumption of this hotel.

Table 12
Clustering of the thermal consumption (oil) of 18 hotels (year 2007).

Clusters for the normalized oil consumption (2007) of 18 hotels with seasonal operation				
Values (kWh/m^2)	1	2	3	4
Minimum	4	20	52	204
Maximum	20	52	204	294
Centroid	9	29	84	294

5. Discussion

The majority of the sample analysed is characterized by large thermal losses from the building envelope and does not comply with the current national energy legislative EPBD [48] put in force since July 2010. Additionally none of the studied buildings, apart from one, incorporates an innovative building system; all systems are rather old and energy consuming and in need of significant upgrade. Moreover the lack of an energy management system in the majority of the hotels results in enhanced energy losses and large operational and energy costs.

The average electricity and thermal energy consumption of the sample is rather high and is calculated to approximately 290 kWh/m^2/year for hotels with annual operation and approximately 200 kWh/m^2/year for hotels with seasonal operation. Furthermore, 50% of the hotels consume electricity above 140 kWh/m^2/year where the current best practice building consumes electricity of around 58 kWh/m^2/year resulting in a rather high energy consuming building. The results range the hotels as the second most energy consuming buildings in Greece compared to hospitals (406.8 kWh/m^2), office buildings (187 kWh/m^2), commercial buildings (152 kWh/m^2) and school buildings (92 kWh/m^2) [4].

The approach followed in this paper is to analyse the operational energy data using the *k*-means algorithm and controlled with the silhouette plot. This has led to a classification of the hotels in clusters in terms of their electricity and oil consumption. The results are well-separated clusters for the whole sample and for the sample split in hotels with annual and seasonal operation. It is noted that each cluster has high average energy consumption compared to other buildings in Greece which supports the argument that improvements are possible and necessary in the majority of the hotels. It is noteworthy that the average electricity consumption varies considerably between the different clusters; for example in the case of the whole sample, the average value of cluster 5 is 24 times higher that this of cluster 1 (see Table 7) whereas in the case of the hotels with annual operation the difference becomes even higher. This could be attributed to the different size and category of the hotel.

The classification aims at the creation of benchmarks and 'reference' values so that techniques might be sought in the future for reducing the energy consumption. The data processing shows that there is enormous potential of energy savings in the hotel sector in Greece. This applies mainly in the electricity field as a significant portion of the hotels operates during the cooling period and does not uses any oil. Techniques in order to reduce the overall energy consumption of the hotel sector would include firstly the upgrade of the building envelope and the use of energy efficient systems for heating, cooling and ventilation. Energy saving techniques, like the use of low e glazing and frames with thermal breaks, the installation of external insulation in non-insulated buildings, the addition of shading in northern facades, the use of building systems with high COP, the installation of BEMS are well known and widely used with diminished cost. In addition, the implementation of renewable energy sources should be considered, that would result in up to date buildings with low energy performance and low carbon footprint. Especially the use of ground heat source and solar energy would find wide application in the Greek hotel sector.

6. Conclusions

This paper presents a method for classifying hotel buildings. Operational energy use is collected for 90 Greek hotels and using the k-means algorithm in the MATLAB environment the hotels are clustered in well separated clusters based on their electricity and thermal (oil) consumption. The average values of each cluster identify high energy consuming 'typical' buildings for each cluster and indicate the need for upgrade of the Greek hotel sector. In the future, energy efficient techniques can be investigated for the 'typical' buildings aiming at minimizing the energy consumption of the Greek hotel sector.

The overall analysis shows the usefulness of a classification scheme based on clusters for a better understanding of the energy performance of a large group of buildings with diverse sizes, operation and energy use.

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Appendix 8 - Paper in AIVC conference

PAPER TEMPLATE FOR THE
34TH AIVC-3RD TIGHTVENT-2ND COOL ROOFS'- 1ST VENTICOOL CONFERENCE, 2013

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Building Envelope Design for climate change mitigation: a case-study of hotels in Greece

ABSTRACT

Future climate change might have a tremendous impact on energy use, ventilative cooling strategies and thermal comfort in buildings, since these parameters are strongly correlated with the external weather conditions.
This paper will present results of a study of the impact future climate change scenarios as developed by the Intergovermental Panel on Climate Change (IPPC) and implemented in weather files for specific future time slices (2020, 2050 and 2080) on the design of the external envelope of a hotel building in Greece. Three climatic regions of Greece are considered.
The impact of climate change on the building is assessed via hourly simulations using a calibrated model developed using the software TRNSYS. The model was calibrated using measured energy use data from an existing hotel building. Future climate weather files were constructed for the three climatic regions using METEONORM data and the 'morphing' method using a weather generator software (Weather Generator v1).. The heating and cooling loads (kWh/m^2/yr) of the building are calculated using monitored climatic data for the years 1970-2010 and future climatic files for the years 2020, 2050 and 2080. Two modes of buildings are studied: a. all year operated, and b. seasonally operated. The effectiveness of the most energy efficient techniques is investigated for the three climatic zones of Greece via a parametric study. The climate change mitigation strategies examined are described by the principles: 'blow away' (intelligently controlled night and day ventilation), 'switch off'; (shading), 'reflect' (cool materials) 'reflect and switch off' (glazing), 'switch off & absorb' (insulation) and 'convection' (ceiling fans). For each principle, a parametric analysis was carried out to define the 'optimum' buildings in each climatic period.
Results indicate an increase of the cooling load by 15% in year 2020, 34% in year 2050 and 63% in year 2080. On the other hand heating load is expected to decrease by 14% in year 2020, 29% in year 2050 and 46% in year 2080.
It was found that different strategies can be applied to all year and seasonally operated buildings for the most energy efficient performance. These include:
a. For all year operated buildings: high levels of insulation, double low e glazing, intelligently controlled night and day ventilation, ceiling fans and shading. The building of year 2050 would need more shading and the building of year 2080 would need additional shading and cool materials.
b.For seasonally operated buildings: Intelligently controlled night and day ventilation, cool materials, ceiling fans, shading and double low e glazing. Only the building of year 2080 would need insulation.

KEYWORDS

Climate change, generation of future files, morphing method, mitigation strategies, degree days

1 INTRODUCTION

Future climate change is defined by an increase in the Greenhouse Gas emissions (GHG) and in turn in the global mean temperatures (IPPC 2011; European Environment Agency 2004). The evaluation of the climate change is uncertain since the climate process is not totally predictable and the socio-economic development is a complex procedure. However, using projections of greenhouse gas emissions in the future, several scenarios have been modeled combining possible future CO_2 concentration and social-economic development in order to predict possible increase of mean temperature. The main aim of these scenarios is to achieve stabilization of the GHG concentration in the future.

The main objective of this paper is to assess the impact of the climate change on the energy demand of a hotel building using real climatic data and future climate change scenarios as developed by the Intergovernmental Panel on Climate Change (IPPC) and implemented in weather files for specific future time slices (2020, 2050 and 2080) on the design of the external envelope of a hotel building in Greece.

2 LITERATURE

The energy use in buildings is correlated to the external temperature. As this relation is non-linear, the method of the degree days is used to calculate the energy consumption of buildings according to the variations of the external temperature. (Giannakopoulos et al 2009; Committee for the Study of the Climate Change Impact 2011; CIBSE TM41 2006; Cartalis et al 2001; Tselepidaki et al 1994). Accumulation of a large number of degree days above the base temperature indicates intense need for cooling whereas accumulation of a large number of degree days below the base temperature implies intense need for heating. The differences in the cumulative numbers of CDDs and HDDs between the reference and the future period show the changes in the energy demand of buildings.

It is predicted that due to the climate change and the increase of the air temperature, more cooling will be required in the Mediterranean countries. The increase in cooling requirements will be larger over Southern Spain, the Eastern parts of Greece, Western Turkey and more so over Cyprus/North Africa. Until now, the increase of the cooling requirements in Greece is correlated to the increased use of air-conditioning and the associated problems of supply of electric power during the peak periods (i.e. blackout) and the sick -building syndrome.

On the other hand, the heating requirements will be decreased during all seasons, especially spring and winter. Continental areas of Europe like Northern Spain, central Italy, Greece and Turkey will require less heating. (Giannakopoulos et al 2009; Committee for the Study of the Climate Change Impact 2011).

Many studies focus on simulations using projected future files in order to predict the impact of the climate change on the building energy use (Oxizidis et al 2008; Eames et al 2012; Guan 2009; Guan 2012; Jentsch et al 2008, Kolokotroni et al 2012, Giannakidis et al 2011). In the literature four methods appear for the preparation of future weather data, these include: the extrapolating statistic method, the morphing procedure based on the imposed offset method, the stochastic weather model and global climate models. The comparison and analysis of these four methods conclude that the ‘morphing’ method is the one most reliable for building simulations (Belcher et al 2005; Guan 2009).

3 METHODOLOGY

The impact of the climate change is computed by modelling a hotel building. The building is a real building and is located in climatic zone B of Greece. The simulations are carried out using the software TRNSYS. The impact of the climate change is assessed a. for the period 1970 – 2010 using real climatic data for the area of Athens, provided by the Hellenic National Meteorological Service and b. for the years 2020, 2050 and 2080 using generated future files for Patra (climatic zone B), Thessaloniki (climatic zone C) and Iraklio of Crete (climatic zone A). Future climate weather files are constructed for the three climatic regions A,B and C using METEONORM data and the 'morphing' method using a weather generator software (Weather Generator v1).Then climate change mitigation strategies are defined for an optimum building envelope design for climatic zone B. The effectiveness of these strategies is also assessed for the climatic zones A, C of Greece. It is found that different strategies can be applied to all year and seasonally operated buildings for the most energy efficient performance

3.1 Description of the simulated building

The hotel building taken into consideration is located in Peloponese, in the Loggos area, 7.5 klm away from the city of Aegio, and west of Athens (Greece). Its construction dates back to 1972. The hotel offers 115 rooms, reception area, restaurant and kitchen facilities, lounge with bar, and one meeting room. The hotel operates from April to October and occasionally, during the heating period, i.e. during the Christmas holidays. The hotel is a freestanding building and located next to the sea. The building has a rectangular layout with the main facades facing northwest and southeast.

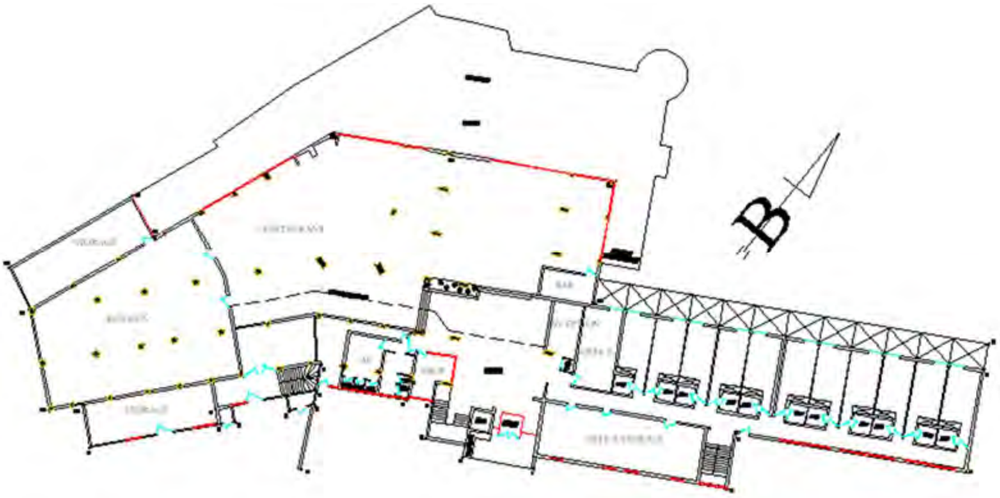

Figure 1 Ground floor

The building elements have no insulation and the u-values do not comply with the national legislation EPBD (Table 1).

Table 1: U-values of the building elements considered in the simulations

Building element - U-value (W/m^2K)	**Typical U values for constructions before 1979 TOTEE 20701-1/2010 ppg 46/47)**	**Required u-value (TOTEE 20701-1/2010) for climatic zone B (ppg 43 table 3.3a)**
External wall: Plaster – brick – plaster, with plaster externally & internally	2.20	0.50
External wall-concrete frame, with plaster externally & internally	3.40	0.50
Roof: Plaster - concrete – plaste	3.05	0.45
Floor (concrete slab) to external air	2.75	0.45
Ground floor : concrete slab	3.10	0.90
Windows (glazing & frame)		
Common areas: single with aluminum frame	Ugl:5.68 Ufr: 7.00	3.00
Corridors to the rooms (facing south): double with aluminum frame	Ugl: 2.95 Ufr: 7.00	3.00
Beds: single with wooden frame	Ugl:5.68 Ufr: 2.20	3.00
Infiltration	0.44ach (according to the Technical Guidelines TOTEE 20701-1/2010)	

The building systems of the hotel building are shown in Table 2.

Table 2: Building systems of the hotel building

Building systems of the hotel building	
Heating	Central heating is with gas via radiators and operates in the rooms and the common areas of the hotel. Central heating operates occasionally during the heating period, when the hotel is open, i.e. during the Christmas period. (Design temperature 20°C)
Cooling	A/C split units in each room. There is no cooling in the common areas. (Design temperature 26° C)
Ventilation	All areas of the hotel are naturally ventilated via openable windows. No mechanical ventilation is installed in the main areas of the hotel.
DHW	Flat plate solar collectors are used for DHW
Airflow rates	Common areas: 9 m3/h/m2, Rooms: 1.2 m3/h/m2 (according to the Technical Guidelines TOTEE 20701-1/2010)

The floor slabs provide shading to the southeast and northwest windows (Table 3).

Table 3: Shading factors calculated according to the Technical Guidelines TOTEE 20701-1/2010

Shading factor (according to the Technical Guidelines TOTEE 20701-1/2010)				
Rooms	1st and 2nd floor	3rd and 4nd floor	2.85m height	3.75m height
Windows southeast	0.43	0.14		
Windows northwest			0.28	0.2

3.2 Generation of Future Climate files

The future files for the building simulations are generated using the CCWorldWeather Generator tool, developed by Southampton University (Southampton University 2010; Jentsch 2010; Jentsch et al 2008). The tool uses the ‘morphing method’, developed by (Belcher et al). The ‘morphing’ methodology is published by the Chartered Institution of Building Services Engineers (CIBSE) and is utilised as a baseline for transforming current CIBSE Test Reference Years (TRY) and Design Summer Years (DSY) into climate change weather years (Jentsch et al 2008).

The algorithms used in the morphing method are described by the following equations (Belcher, Hacker, and Powell 2005; Chan 2011):

- $x = xo + \Delta xm$, (shift) (1)
- $x = \alpha_m xo$ (linear stretch) (2)
- $x = xo + \Delta xm + \alpha\ m \times (xo - (xo)m)$ (a combination of shift and stretch) (3)

where:

x_o: the existing hourly climatic data,

Δxm : the absolute change in monthly-mean climatic variable for month m,

α_m : the fractional change in monthly –mean climatic variable for month m and

$(xo)_m$: the climatic variable xo average over month m.

The tool enables the generation of future climatic files ready for use in building simulation programs. It is Microsoft Excel based and transforms 'present-day' EPW or TMY files into future files (Jentsch et al 2008). The toolkit uses IPCC TAR model summary data of the HadCM3 A2 experiment ensemble which is available from the IPCC Data Distribution Centre.

3.3 Mitigation strategies

In order to tackle the climate change, a number of energy efficient techniques are studied for each climatic period. The energy efficient strategies that are studied for the hotel building are based on the example given in CIBSE TM36 (Hacker et al 2005) and are summarised in Table 4.

Table 4: Climate change mitigation strategies for the hotel building

Principle	Type of Principle	Techniques
switch off	Passive cooling	Shading, double low emission glazing
absorb & switch off	Passive cooling	adding insulation in walls & roof
Reflect	Passive cooling	cool materials & double low e glazing
blow away	Passive cooling	Intelligent night and day time control
Convection	Hybrid cooling	using ceiling fans

Five principles are used to tackle the energy increase and overheating of the hotel: 'switch off', 'absorb', 'reflect', 'blow away' and 'convect'. The principle 'switch off' is realized with the control of solar gains in the interior of the building, with the use of external shading and the use of energy efficient glazing. The 'switch off & absorb' principle is approached with the addition of external insulation in the non-insulated fabric. Energy efficient glazing summarizes both principles 'switch off' and reflect' by removing and 'reflecting' the undesirable solar gains. Apart from the glazing, the 'reflect' option is also illustrated by increasing the reflectance of the external surfaces and relieving indoor spaces from excessive peak temperatures. The 'blow away' principle is illustrated by an 'intelligent' ventilation system and the use of automated control in the daytime and nighttime ventilation according to the external temperature and the indoor temperature of each zone. In addition to the minimum airflow rates in each zone of the hotel as defined by the national legislation, extra fresh air is supplied in the areas of the hotel according to the external temperature and the internal temperature, both at day and night. The convection principle is illustrated with the use of ceiling fans by blowing the 'cool' air downwards to the occupied zone and extending the thermal comfort zone without the use of air conditioning.

For every principle different scenarios are simulated as shown in Table 5, in order to define the most energy efficient ones.

Table 5: Energy efficient techniques for the upgrade of the building envelope of the demonstration hotel as a response to the climate change

Principle	**Technique**	**Description**
Absorb & switch off-(insulation)	National legislation	U roof=0.45W/m^{2}K, Uwalls=0.5 W/m2K
	7 cm	U roof=0.45W/m^{2}K, Uwalls=0.34 W/m2K
	10 cm	U roof=0.32W/m^{2}K, Uwalls=0.25 W/m2K
	12 cm	U roof=0.27W/m^{2}K, Uwalls=0.21 W/m2K
Switch off & reflect – (glazing)	Double glazing	U=2.95 W/m^{2}K, g=0.8
	Double low –e	U=1.8 W/m^{2}K, g=0.6
	Double low e	U=1.8 W/m^{2}K, g=0.45
	Double low –e & argon	U=1.43 W/m^{2}K, g=0.6
	Double low e	U=1.06 W/m^{2}K, g=0.55
Switch off – (shading)	Shading to corridors	Shading factor 0.5
	Shading to corridors	Shading factor 0.7
	Shading to corridors	Shading factor 0.8
	Shading to corridors & rooms	Shading factor 0.8 & 0.5
	Shading to corridors & rooms	Shading factor 0.8 & 0.7
Reflect – (cool materials)	External walls	Solar absorptance:0.2
	External walls & roofs	Solar absorptance:0.2
Blow away – (ventilation)	Day time	Indoor temp of each zone > 23°C & external temperature < 25°C, may-sept
	Day time	Indoor temp of each zone > 23°C & external temp< internal temp, may-sept
	Night time	Ventilation at a constant rate from 23:00 – 7:00, for the period may-sept
	Night time	Ventilation when the indoor temp of each zone > 23°C, 23:00 – 7:00, may -sept
	Night time	Ventilation when the outdoor temp >15°C, 23:00 – 7:00, may-sept
Convection – (ceiling fans)	Hybrid cooling	Cooling setpoint at 27.5°C instead of 26°C, increase of 1°C assuming that the fans cover 60% of the thermal zone – TOTEE 20701-1

4 ANALYSIS OF CLIMATIC FILES

The climatic data is analysed with the mean degree hours using the formulas below as given in CIBSE TM 41.

$$D_d = \frac{\sum_{j=1}^{24} \left(\theta_b - \theta_{o,j}\right)_{\left(\left(\theta_b - \theta_{o,j}\right) > 0\right)}}{24} \qquad \text{HDD} \quad (4)$$

$$D_d = \frac{\sum_{j=1}^{24} \left(\theta_{o,j} - \theta_b\right)_{\left(\left(\theta_{o,j} - \theta_b\right) > 0\right)}}{24} \qquad \text{CDD} \quad (5)$$

Where:

Dd is the daily degree-days for one day, θb is the base temperature and θo,j is the outdoor temperature in hour j. Only the positive values are taken. (CIBSE TM41 2006)

As default by the Technical Chamber of Greece, the base temperature for heating degree days is 18°C and 26 °C for cooling degree days (Technical Chamber of Greece 20701-3/ 2010).

4.1 Period 1970 – 2010

Table 6: Mean degree hours for the area of Athens for the period 1970-2010

Mean degree hours for the area of Athens											
	CDD	**HDD**		**CDD**	**HDD**		**CDD**	**HDD**		**CDD**	**HDD**
1970	128	1159	**1981**	124	1101	**1991**	153	1261	**2001**	282	996
1971	118	1178	**1982**	122	1273	**1992**	191	1189	**2002**	223	1032
1972	139	1120	**1983**	87	1260	**1993**	276	1013	**2003**	281	1217
1973	160	1127	**1984**	95	1156	**1994**	201	1069	**2004**	184	1099
1974	136	1134	**1985**	145	1093	**1995**	200	1145	**2005**	196	1161
1975	68	1171	**1986**	169	1067	**1996**	165	1171	**2006**	234	1242
1976	162	996	**1987**	203	1234	**1997**	275	1098	**2007**	313	1052
1977	114	1082	**1988**	222	1180	**1998**	262	914	**2008**	308	1026
1978	131	1024	**1989**	133	1139	**1999**	271	1023	**2009**	209	954
1979	131	1138	**1990**	190	993	**2000**	153	1261	**2010**	278	805
1980	128	1159									

An increasing trend characterizes the mean cooling degree days and a decreasing trend characterises the heating degree days. Between the years 1970 – 2010 the increase in the mean cooling degree hours is calculated to 78% whereas the decrease of the heating degree days is 18%.

4.2 Generated future files 2020, 2050 and 2080

- Heating and Cooling Degree days

Table 7: Cooling and heating mean degree hours for Patra, Iraklio and Thessaloniki, for present climatic file and years 2020, 2050 and 2080

Heating (base temp 18 °C) and Cooling (base temp 26°C) Degree Days				**Variation % from present**			**Variation in degree days**		
	Patra	**Thes.**	**Iraklio**	**Patra**	**Thes.**	**Iraklio**	**Patra**	**Thes.**	**Iraklio**
Present									
CCD	169	141	122						
HDD	1121	2123	871						
2020									
CCD	200	177	159	**19**	**25**	**31**	**32**	**36**	**38**
HDD	990	1961	753	-12	-8	-13	-130	-162	-118
2050									
CCD	250	**218**	**212**	**48**	**54**	**75**	**82**	**77**	**91**
HDD	851	1812	631	-24	-15	-28	-269	-311	-240
2080									
CCD	330	**289**	**302**	**96**	**104**	**149**	**161**	**147**	**181**
HDD	681	1607	478	-39	-24	-45	-440	-517	-393

- Night- time cooling degree days

Table 8: Night-time cooling degree days for Patra, Iraklio and Thessaloniki, for present climatic file and years 2020, 2050 and 2080

Night Cooling (base temp 20°C) Degree Days				Variation % from present			Variation in degree days		
	Patra	Thes.	Iraklio	Patra	Thes.	Iraklio	Patra	Thes.	Iraklio
Present									
CCD	101	64	143						
2020									
CCD	126	85	172	25	33	20	25	21	29
2050									
CCD	157	109	211	55	70	48	56	45	68
2080									
CCD	206	149	273	104	133	91	105	85	130

The weather analysis of the three climatic zones shows that in all areas there will be an increase in the cooling degree days and a decrease in the heating degree days, predicting an increase in the cooling energy demand and decrease in the heating energy demand respectively. Iraklio (zone A) has the maximum number of night cooling degree days, the highest values of solar radiation and wind speed at present and in the future and presents the smallest diurnal differences. On the other hand, Thessaloniki (zone C) presents the maximum number of heating degree days along with the lowest values of solar radiation. Patra has the maximum cooling degree days and large diurnal differences. Also in all areas, relative humidity is increasing with the years. Thessaloniki is the most humid city during the winter and spring months apart from the months May –August when Patra is the most humid area.

5 SIMULATION RESULTS

5.1 Impact of the climate change on the hotel building using real monitored data

Using real monitored data for the period 1970 – 2010 for the area of Athens, the simulation results show an increase of the cooling loads of the hotel building by 33% and a decrease in the heating demand by 22% in 2010 compared to 1970.

5.2 Impact of the climate change on the hotel building using generated future files

Using generated future files for the area of Patra, results indicate an increase of the cooling load of the building by 15% in year 2020, 34% in year 2050 and 63% in year 2080. On the other hand heating load is expected to decrease by 14% in year 2020, 29% in year 2050 and 46% in year 2080.

5.3 Mitigation strategies for an optimum building envelope design

The most energy efficient techniques as these are defined by the simulations are applied to the hotel building (in climatic zone B) in order to define the 'optimum' building' for the present day, period 2020, 2050 and 2080. For the purposes of the study, two modes of building operation are considered:

- All year operation.

The selected principles and energy techniques are those that have the best benefit for the building for both the heating and cooling period. The optimum buildings with all year operation comprise: Insulation (10cm) in external walls and roof, double low e glazing

(U=1.8 W/m^{2}K, g=0.45), intelligently controlled night ventilation, intelligently controlled day ventilation, ceiling fans in the rooms, and shading to the corridors. The optimum building for present day and the optimum building for year 2020 comprise the same energy techniques. The optimum building for year 2050 comprises more shading. The optimum building for year 2080 includes even more shading and is also equipped with cool materials on the walls.

The heating and cooling loads of the optimum buildings based on the simulation results are:

Table 9: Heating and cooling loads (kWh/m2/yr) for the optimum building with all year operation

Optimum buildings – ALL YEAR operated		
	Heating Loads (kWh/m^2/yr)	**Cooling Loads (kWh/m^2/yr)**
Present day	21	8
2020	16	11
2050	13	15
2080	9	22

- Seasonal operation.

In that case the building is operating during the months May to September. The simulations are carried out for the whole year but heating, cooling, ventilation and all internal gains (lighting, people) are operating only for the months May – September whereas for the months January – April and October to December the systems and internal gains are set to 0. The 'optimum' buildings comprise: Intelligently controlled night ventilation, cool materials, ceiling fans, intelligently controlled day ventilation, shading and double low e glazing. The optimum building for the present day and year 2020 comprise the same energy techniques. The optimum building for year 2050 differs in the type of night ventilation control. The optimum building for year 2080 is also equipped with insulation.

The heating and cooling loads of the optimum buildings based on the simulation results are:

Table 10 Heating and cooling loads (kWh/m2/yr) for the optimum building with seasonal operation

Optimum buildings – SEASONALLY operated		
Heating, cooling ventilation Operation May - Sept	**Heating Loads (kWh/m^2/yr)**	**Cooling Loads (kWh/m^2/yr)**
Present day	1	6
2020	1	8
2050	1	13
2080	1	19

5.4 Effectiveness of the proposed measures in different climatic regions

The effectiveness of the proposed measures is investigated for the area of Thessaloniki (climatic zone C) and Iraklio -island Crete (climatic zone A), shown in Table 11 & Table 12:

Table 11 Heating and cooling loads for the 'all year operated' optimum buildings for the 3 climatic zones

OPTIMUM BUILDINGS – ALL YEAR OPERATED						
	HEATING LOADS kWh/m^2/yr			**COOLING LOADS kWh/m^2/yr**		
	Patra	**Thessaloniki**	**Iraklio**	**Patra**	**Thessaloniki**	**Iraklio**
present day	21	58	12	8	4	10
2020	16	53	9	11	6	14
2050	13	48	7	15	9	19
2080	9	41	4	22	14	29

Table 12 Heating and cooling loads for the ‘seasonally operated’ optimum buildings for the 3 climatic zones

OPTIMUM BUILDINGS – SEASONALLY OPERATED						
	HEATING LOADS kWh/m²/yr			COOLING LOADS kWh/m²/yr		
	Patra	Thessaloniki	Iraklio	Patra	Thessaloniki	Iraklio
present day	1	2	1	6	3	6
2020	1	2	1	8	5	9
2050	1	2	0	13	8	15
2080	1	2	0	19	13	24

6 DISCUSSION

The simulations show that optimum buildings in Iraklio present the highest cooling energy demand, whereas optimum buildings in Thessaloniki present the highest heating energy demand.

From the climatic analysis, it seems that Patra (climatic zone B) presents maximum cooling degree days, large diurnal differences and small night time temperatures. As a result, during the year, Patra is cooler than Iraklio, and presents the mildest climatic characteristics, compared to Thessaloniki and Iraklio. As the most energy efficient techniques were selected for the optimum buildings of that climatic zone (B), it seems that in terms of cooling the techniques are performing very well for buildings in Thessaloniki (that is cooler area than Patra) but not so well for buildings in Iraklio that in overall is warmer area than Patra. Therefore, the optimum buildings in Thessaloniki present nearly zero cooling loads, ranging from 4 kWh/m^2/yr in present year to 14 kWh/m^2/yr in year 2080. However in areas as Iraklio with higher night time temperatures and solar radiation than Patra, optimum buildings present quite high energy demand for cooling, ranging for the ‘all year’ operated building from 10 kWh/m^2/yr (present) to 29 kWh/m^2/yr (year 2080) and for the ‘seasonally’ operated building from 6 kWh/m^2/yr (present) to 24 kWh/m^2/yr (year 2080). For this area and especially for the long term future (2080) more drastic climate change solutions are required; the development of a design strategy based on the principles ‘switch off’, ‘reflect’ and ‘blow away’ would help for the removal of solar gains and excessive heat gains. This strategy could include even more shading, different type of glazing (reflecting), cool materials of better performance and probably exploitation of the wind patterns of the area with another strategy/control of daytime and nighttime ventilation.

In terms of heating loads, the optimum buildings in areas colder than Patra with more HDD, i.e.Thessaloniki, are not well equipped with the specific mitigation strategies and require high energy demand that ranges between 58 kWh/m^2/yr in present to 41 kWh/m^2/yr in year 2080. The selected energy techniques are not coping with the climate of this area, more efficient strategies are in need to tackle the climate change. A design strategy based on the ‘switch off and absorb’ principle would provide higher level of insulations, combined with a more appropriate glazing that would prevent heat losses, the minimization of shading and the avoidance of cool materials. On the hand, the optimum buildings of areas with less HDD than Patra, i.e. Iraklio, would present almost zero heating energy demand in 2080.

The climatic analysis of the forecast future years shows that the decrease in heating degree days is almost double than the increase of the cooling degree days. This results in increase of the cooling demand and decrease of the heating demand in the future. Taking into consideration that cooling mainly relies on electricity; this signifies a modification on the use of the primary energy and a shift towards electrical power. Other alternatives like renewable energy source should be considered for the generation of electrical energy.

The simulations were performed taking into consideration current conventional mitigation measures, thus passive cooling techniques that focus on the upgrade of the building envelope and deal with the control of heat transfer (switch off and absorb principle), solar control (switch off and reflect principle), heat gain (thermal storage capacity, absorb principle), heat dissipation (blow away principle) and the adjustment of the cooling set point (convection principle). With the implementation of the above climate change adaptation methods a significant reduction of the building energy demand is achieved in both the cooling and heating season but still the building presents rather high cooling in the long term future. This may indicate the inefficiency of the conventional mitigation methods to cope with the climate change and the necessity to develop further the technical characteristics of the current technologies to cope with severe climatic characteristics, in the long term future.

7 CONCLUSIONS

The climate change and in particular the increase of the air temperature has a significant impact on the energy demand of the hotel building, an increase of the cooling loads and a decrease of the heating loads. Between the three climatic regions, the optimum buildings require more cooling in climatic zone A and extra mitigation strategies are in need based on the principles ‘switch off’, ‘reflect’ and ‘blow away’ to cope with the increased solar gains. In terms of heating, the optimum buildings in climatic zone C require extra mitigation strategies based on the ‘switch off and absorb’ principle to cope with the heat losses through the building envelope. Additionally, it was found that different strategies can be applied to all year and seasonally operated buildings for the most energy efficient performance. Therefore, for an all year operated building, extra shading and cool materials are required in time, whereas for a seasonally operated building insulation is required for the long term future, i.e. after year 2080.

The simulation results show that cooling loads of optimum buildings are rather high in 2050 and 2080, meaning that the current technologies are not efficient enough to cope with the climate change in the long term future. Additionally, in terms of heating, optimum buildings are not very efficient in areas with severe climatic conditions. Therefore, for a better result the energy efficient building envelope design should be combined with the use of energy efficient plant.

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Appendix 9 - Infiltration calculation

INFILTRATION

Infiltration is calculated for each thermal zone (Table 1 & Table 2) based on default infiltration values for different type of openings as given in the Technical Chamber (TOTEE 20701-1/2010) (Table 3).

- **Year 2007 – before the renovation**

Table 1 Infilration for each thermal zone

A/A	Thermal zone	Area of openings (m^2)	Air Infiltration [m3/(m^2h)]	[m^3/h]	**Zone m^3**	**Air [m^3/h]**	**ACH**
1	Dining room	96	8.7	835.2	1899.7	835.20	0.44
2	Lounge	70.1	8.7	609.87	774.9	609.87	0.79
3	Kitchen	12.45	15.1	187.995	1355	188.00	0.14
4	Entrance-reception	16.32	8.7	141.984	527.5	141.98	0.27
5	Circulation area	6.8	8.7	59.16	222.3	59.16	0.27
6	Corridors to the rooms	16.25	6.8	110.5	219.45	110.50	0.50
7	Rooms	31.5	15.1	475.65	937.5	475.65	0.51
8	Office	2.86	8.7	24.882	101.25	24.88	0.25
9	Office & storage	4.8	8.7	41.76	216.6	41.76	0.19
10	WC	2.5	8.7	21.75	94	21.75	0.23
11	Storage (external area)					0.00	
12	Meeting room	7	8.7	60.9	310.65	60.90	0.20
13	Lobby of meeting room					0.00	
14	Office	2.86	8.7	24.882	176.25	24.88	0.14
15	Rooms (height 3.75m)	14.3	15.1	215.93	420	215.93	0.51
16	Rooms (height 2.85m)	17.16	15.1	259.116	393.3	259.12	0.66
17	Office & storage	4.8	8.7	41.76	266.25	41.76	0.16
18	Corridors to the rooms	15.75	6.8	107.1	342	107.10	0.31
19	Rooms (height 2.85m)	62.88	15.1	949.488	1489.7	949.49	0.64
20	Rooms (height 3.75m)	17.16	15.1	259.116	517.5	259.12	0.50
21	Corridors to the rooms	42.9	6.8	291.72	598.5	291.72	0.49
22	Office & storage	4.8	8.7	41.76	290.7	41.76	0.14
23	Rooms	37.18	15.1	561.418	1818.3	561.42	0.31
24	Room (study case)	2.86	15.1	43.186	64.7	43.19	0.67
25	Corridors to the rooms	42.9	6.8	291.72	598.5	291.72	0.49
26	Office & storage	4.8	6.8	32.64	290.7	32.64	0.11
27	Rooms	77.22	15.1	1166.022	1818.3	1166.02	0.64
28	Room (study case)	2.86	15.1	43.186	64.7	43.19	0.67
29	Corridors to the rooms	42.9	6.8	291.72	598.5	291.72	0.49
30	Lift					0.00	
	AVERAGE						0.4

- **Year 2008 – after the renovation**

A/A	Thermal zone	Area of openings (m^2)	Air Infiltration [m3/(m^2h)]	[m^3/h]	**Zone m^3**	**Air [m^3/h]**	**ACH**
1	Dining room	96	6.8	652.8	1899.7	652.8	0.34
2	Lounge	70.1	6.8	476.68	774.9	476.68	0.62
3	Kitchen	12.45	6.8	84.66	1355	84.66	0.06
4	Entrance-reception	16.32	8.7	141.984	527.5	141.984	0.27
5	Circulation area	6.8	8.7	59.16	222.3	59.16	0.27
6	Corridors to the rooms	16.25	6.8	110.5	219.45	110.5	0.50
7	Rooms	31.5	15.1	475.65	937.5	475.65	0.51
8	Office	2.86	8.7	24.882	101.25	24.882	0.25
9	Office & storage	4.8	8.7	41.76	216.6	41.76	0.19
10	WC	2.5	8.7	21.75	94	21.75	0.23
11	Storage (external area)					0	
12	Meeting room	7	8.7	60.9	310.65	60.9	0.20
13	Lobby of meeting room					0	
14	Office	2.86	8.7	24.882	176.25	24.882	0.14
15	Rooms (height 3.75m)	14.3	15.1	215.93	420	215.93	0.51
16	Rooms (height 2.85m)	17.16	15.1	259.116	393.3	259.116	0.66
17	Office & storage	4.8	8.7	41.76	266.25	41.76	0.16
18	Corridors to the rooms	15.75	6.8	107.1	342	107.1	0.31
19	Rooms (height 2.85m)	62.88	15.1	949.488	1489.7	949.488	0.64
20	Rooms (height 3.75m)	17.16	15.1	259.116	517.5	259.116	0.50
21	Corridors to the rooms	42.9	6.8	291.72	598.5	291.72	0.49
22	Office & storage	4.8	8.7	41.76	290.7	41.76	0.14
23	Rooms	37.18	15.1	561.418	1818.3	561.418	0.31
24	Room (study case)	2.86	15.1	43.186	64.7	43.186	0.67
25	Corridors to the rooms	42.9	6.8	291.72	598.5	291.72	0.49
26	Office & storage	4.8	6.8	32.64	290.7	32.64	0.11
27	Rooms	77.22	15.1	1166.022	1818.3	1166.022	0.64
28	Room (study case)	2.86	15.1	43.186	64.7	43.186	0.67
29	Corridors to the rooms	42.9	6.8	291.72	598.5	291.72	0.49
30	Lift					0	
	AVERAGE						0.38

Table 3 Infiltration values according to the national legislation

Opening	**Infiltration** (TOTEE 20701-1/2010, table 3.26, ppg 79)
	Opening ($m^3/h/m^2$)
Wooden frame	
Single glazing, not air-tight (sliding opening)	15.1
Double glazing, with certification (sliding opening) Double glazing , not certified (folding opening)	12.5
Double glazing , air-tight and certified	10.0
Aluminum or plastic frame	
Single glazing, not air-tight (sliding opening)	8.7
Double glazing, with certification (sliding opening) Double glazing , not certified (folding opening)	6.8
Double glazing , air-tight and certified	6.2