BUILDING ENVELOPE DESIGN FOR CLIMATE CHANGE MITIGATION: A CASE-STUDY OF HOTELS IN GREECE

Ifigenia Farrou[*1], Maria Kolokotroni[2], Mat Santamouris[3]

1 Brunel University
Howell Building, Mechanical Engineering
School of Engineering and Design
Uxbridge, Middlesex
UB8 3PH, UK
** Corresponding author: ifarrou@hotmail.com*
3 National and Kapodistrian University of Athens
Physics Department
Group Building Environmental Research
Panepistimioupolis, 15784 Athens, Greece

2 Brunel University
Howell Building, Mechanical Engineering
School of Engineering and Design
Uxbridge, Middlesex
UB8 3PH, UK

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. (Ch. Giannakopoulos et al 2009; Committee for the Study of the Climate Change Impact 2011; CIBSE 2006a; 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. (Ch. 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; Mark F. Jentsch et al 2008, Kolokotroni et al 2012, Giannakidis, G 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, Hacker, and Powell 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.

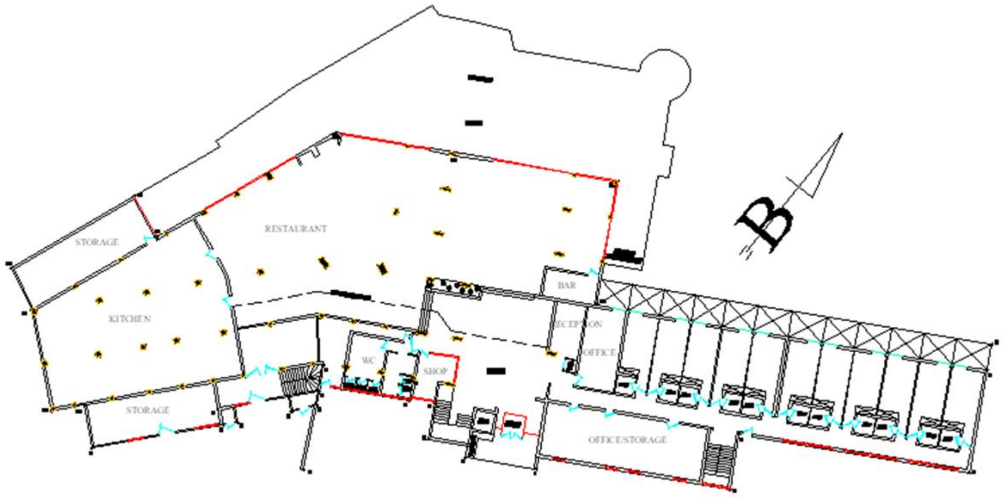

Figure 1 Ground floor

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	3.00

	Ufr: 7.00	
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	1^{st} and 2^{nd} floor	3rd and 4^{nd} 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; M.F. Jentsch 2010; Mark F. Jentsch, Bahaj, and James 2008). The tool uses the 'morphing method', developed by Belcher et al. (Belcher, Hacker, and Powell 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 (Mark F. Jentsch, Bahaj, and James 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 (Mark F. Jentsch, Bahaj, and James 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 below:

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 TM1 41:

$$D_d = \frac{\sum_{j=1}^{24} \left(\theta_b - \theta_{o,j}\right)_{\left(\left(\theta_b - \theta_{o,j}\right) > 0\right)}}{24} \quad \text{HDD} \quad (4)$$

$$D_d = \frac{\sum_{j=1}^{24} \left(\theta_{o,j} - \theta_b\right)_{\left(\left(\theta_{o,j} - \theta_b\right) > 0\right)}}{24} \quad \text{CDD} \quad (5)$$

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. Only the positive values are taken. (CIBSE 2006a)

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/m2K, 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/m^2/yr			**COOLING LOADS kWh/m^2/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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