REPORT

Assessment of Cyprus and Greece hotels

Structural characteristics, energy and GHG emissions performance indicators

Hotels4Climate

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

European Climate Initiative EUKI

Assessment of Cyprus and Greece hotels

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OEB

The Cyprus Employers and Industrialists Federation (OEB) was founded in 1960 by 19 pioneering entrepreneurs. Today, its members are active in all sectors of the economy and employ more than 60% of the private sector's workforce. OEB is a Pancyprian, independent non-profit organization comprising of 60 of the main professional/sectoral Associations as well as hundreds of companies from the Manufacturing, Services, Commercial, Construction and Agricultural Sectors. In total, OEB has more than 15.000 Member/Enterprises.

In particular, the Energy & Environment Department of OEB was founded in 2016 and its goals are to be pioneer on the topics of energy, environment and sustainability, through actions that can improve the competitiveness of renewable energy technologies, to remove administrative or other barriers for the promotion of energy efficiency, to support Cypriot manufacturers to maintain their global position in the installation of domestic solar thermal systems, to promote clean technologies for environmental protection and the 2030 targets for circular economy and climate change, to provide education and training, to promote efficient use of energy, to provide technical advisory support on sector related issues, to promote cooperation between academia and industry in the fields of energy and environment and in the development of research and innovation.

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OEB operates in environmentally friendly manner. Since 2017 OEB is EMAS certified as well as produces on site renewable electricity through PV net metering system.

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INSETE

INSETE is a non-profit organisation founded in early 2013, on the initiative of the Greek Tourism Confederation (SETE), by four partners with intense activity in critical areas of the Greek tourism market: SETE (principal partner), the Hellenic Hoteliers Federation (HHF), the Hellenic Association of Travel & Tourist Agencies (HATTA) and the Confederation of Entrepreneurs of Rented Rooms and Apartments (SETKE).

The mission of INSETE is to contribute with well-substantiated ideas to promoting both public and private policies that will support, modernise and improve the Greek tourism sector and any other service sector which is directly or indirectly associated with it.

Specifically, INSETE supports the Greek Tourism Confederation with:

- documented and thought out interventions in social and public dialogue (positions, proposals, etc.) aimed at promoting policies to support, modernise and improve Greek tourism.
- implementing actions to research, inform and disseminate knowledge, to develop human resources and improve and certify quality of enterprises and the skills of professionals and workers in Greek tourism.

Furthermore, the main activities of INSETE are:

- To research, safeguard and promote the position and contribution of tourism to sustainable economic, social and cultural growth and development at both a national and European level.
- To support and promote entrepreneurship (both conventional and social) in the tourism sector, and in any other service sector which is directly or indirectly associated with it.
- To enhance Human Resources development policies and tools for the tourism sector and any other service sector which is directly or indirectly associated with it.
- To provide scientific, technical or other form of documentation and support to SETE on issues relevant to its activities and operations, and to help it achieve its objectives.

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adelphi

adelphi is a leading independent think tank and public policy consultancy on climate, environment and development. Our mission is to improve global governance through research, dialogue and consultation. We offer demand-driven, tailor-made services for sustainable development, helping governments, international organizations, businesses and non-profits design strategies for addressing global challenges.

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CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DHW	Domestic hot water
EC	European Commission
EE	Energy efficiency
EMAS	Eco-Management and Audit Scheme
EPBD	Energy Performance of Building Directive
EPC	Energy performance certificates
EU	European Union
EUKI	European Climate Initiative
GDP	Gross Domestic Product
GHG	Greenhouse gas
INSETE	Institute of the Association of Greek Tourist Enterprises
ISO	International Standardization Organization
Kg	Kilograms
$KgCO_2e$	Kilograms CO_2 equivalent
kW	Kilowatt
kWh	Kilowatt-hours
LED	Light emitting diode
M^2	Meters squared
OEB	Cyprus Employers and Industrialists Federation
PMD	Plastic, metal and drink cartons
PV	Photovoltaic
RES	Renewable energy source
SME	Small & medium-sized enterprises
YR	Year

1. Executive summary

Main aim of this report is the assessment and evaluation of the energy performance and GHG emissions of Cyprus and Greece hotels, with the use of an integrated methodology that includes design of questionnaires, hotels' on-site visits, data collection, data analysis and results reporting. For the scope of this report, 20 Cyprus hotels and 20 Greece hotels were assessed. The study visits and data collection started in February 2020 and were completed in December 2020. However, the 2020 was not a representative year for the hotel sector due to COVID-19 pandemic and for that reason, the baseline year for the data collection in both countries was 2018 and in some cases 2019.

Tourism sector is one of the most important economic sectors both for Greece and Cyprus, with a total GDP contribution accounting for 21,2% and 22,7% in 2019, respectively (Knoema, 2019). The continuously increasing number of tourists in both countries results in higher energy demand and consequently, in growing GHG emissions generated by the hotel industry. The analysis outlined in this report will focus on the evaluation of the specific energy demands and identification of the most energy-intensive activities/segments of the hotels.

The hotels surveyed were divided in four main categories in both Greece and Cyprus:

- Four-star seasonal
- Four-star non-seasonal
- Five-star seasonal
- Five-star non-seasonal

Most of the participating hotels, both in Cyprus and Greece, are located in coastal areas and they were constructed before 2007, when there were no energy performance requirements. As a result, the energy situation of most hotels that did not have any energy renovation, can be characterized as poor to moderate.

Reinforced concrete frames and bricks are among the most common materials used for hotels' construction in the two countries, while for those that have thermal insulation, the main insulating materials used are polystyrene and stonewool. Around 85% of the participating hotels have double-glazed windows.

During the last decade there has been an increasing number in accreditation awards and certification schemes, with that being a sign of an upward trend in sustainability for the hotel sector in both countries. Almost all participating hotels have been certified with at least one green certification scheme, including Eco-Management and Audit Scheme (EMAS), International Organization for Standardization's (ISO) 14001 Environmental Management System, Travelife and Green key. ISO14001 and Travelife constitute the predominant certificates with more than 70% of the participating hotels being certified with one of these or with both. However, in terms of the total number of four-star and five-star hotels in Cyprus, only 24 out of 94 are certified with Travelife.

Significant investments have been made in energy efficiency improvement in lighting and cooling systems, while not considerable investments were made in heating systems, with the majority of the participating hotels in both countries still using high energy-consuming and polluting systems.

The predominant system used for the **production of hot water** in Cyprus and Greece is fuel-fired boiler. It is worth mentioning that almost half of the participating hotels in the two countries have **solar thermal panels** in place that contribute to the production of hot water at a great extent. Moreover, a big proportion of the Cyprus participating hotels (85%) use heat recovery from the chiller, for the production of hot water. In Greece this percentage is lower (10%) as many hotels still use split units or decentralised systems. All participating hotels have proceeded to the energy upgrade of their lighting, replacing a high proportion (>70%) of their conventional lighting (halogen, Incandescent) with **LED technology**. Around half of the participating hotels in Cyprus have a **PV system** in place, whereas in Greece only one participating hotel has a PV system installed.

Based on the survey results, the following key performance indicators were extracted in order to make the results comparable among the participating hotels and assess their energy and environmental performance:

- Energy consumption per unit area
- Energy consumption per guest-night
- Energy consumption per guestroom
- GHG emissions per guest-night
- Solid waste per guest-night

The average values of these key performance indicators for the four categories (seasonal four-star, non-seasonal four-star, seasonal five-star and non-seasonal five-star) of the participating hotels are shown in the table below:

Table 1: Average values of key performance indicators (KPIs)

	Average value							
	Four-star				Five-star			
	Seasonal		Non-Seasonal		Seasonal		Non-Seasonal	
	Cyprus	Greece	Cyprus	Greece	Cyprus	Greece	Cyprus	Greece
Total Energy per unit area (kWh/m²/year)	150,6	122	247,1	165,1	-	146,7	352,9	240,1
Total Energy per guest-night (kWh/guest-night/year)	22,9	13,5	29,8	23,1	-	19	39,5	23,9
Total Energy per guestroom (kWh/room/year)	7.454	4.276	11.263	8.145	-	6.866	17.293	12.968
GHG emissions (kgCO²eq./guest-night/year)	30,2	21,01	30,2	30,26		25,31	31,05	30,26
Solid Waste (kg/guest-night/year)	2,6	2,2	2,6	2,2	-	2,8	3,2	2,8

The overall higher energy consumption of the five-star hotels can be partially explained from the mandatory requirements/services for five-star hotels (set by the law on the establishment and operation of hotels and tourist accommodations[1]), which are optional for four-star hotels. Area of guestrooms, lobby area and other common areas of five-star hotels have higher minimum requirements compared to four-star hotels. Also, five-star hotels normally have higher number of restaurants, bars and they offer more luxurious services, corresponding to higher energy consumption.

Some of the main factors that affect the energy consumption of hotels are the following:

- **Number of kitchens, bars, restaurants, shops.**
- **Hotels' policy regarding the operation of saunas and steam baths. (on demand or non-stop).**
- **On site laundry service.**
- **High-level facilities and conveniences.**
- **Existence of jacuzzi for public use or private jacuzzi and jet pumps or fountains.**
- **Variety of facilities and services, areas of leisure.**
- **Conference rooms.**
- **Seasonality.**
- **Climate zone.**

According to the analysis, the per unit energy needs for cooling and heating in hotels with no central heating and cooling systems was higher compared to the hotels using a central system. In individual systems such as split units, the end user has the control of the set temperature, however in central systems the temperature as well as the operating time, can be set centrally by the chief engineer.

Also, it was observed that the higher the occupancy rate of a hotel, the lower the energy consumption per guest-night. This is mainly because of the operation of basic loads regardless the number of guests. These loads include:

- **Lighting in lobby and other common areas.**
- **Outdoor lighting.**
- **Cooling, heating and ventilation in common areas, bars, restaurants.**
- **Pool pumps.**

Now, regarding the most energy intensive segments of the hotels, these are as follows:

- **Process equipment** and **HVAC systems** (Cooling, Heating & Ventilation) are the largest energy consumers in all hotel categories in both countries. Consumption of process equipment is normally between 30% and 40% of the hotel total energy consumption, while HVAC systems consumption accounts for around 35% of the hotel total energy consumption.
- **DHW production** has also a large percentage on the hotel total energy consumption, accounting for around 20%.
- **Lighting** is not considered as a large consumer, with its proportion in the total energy consumption being around 5%. This is due to the wide use of LED technology in all hotels.

Such energy analyses are considered very helpful tools as they essentially assist a hotel group or company to comprehend the energy consumption areas and implement specific energy-saving measures.

[1] Source: http://www.tourism.gov.cy/tourism/tourism.nsf/All/902E993A5CE7B50CC225847B003F4319/$file/Peri_Xenodoxeion_kai_touristikon_katalymaton_genikoi_kanonismoi_2019.pdf?OpenElement

2. Introduction

Tourism constitutes one of the most important economic sectors both for Greece and Cyprus, with a total GDP contribution accounting for 21,2% and 22,7% in 2019, respectively (Knoema, 2019). Touristic activities have increased in the previous years, with Greece having welcomed about 31,3 million tourists in 2019, contributing approximately €17,8 billion to the economy (INSETE, 2020). Similarly, tourism in Cyprus experienced a rapid growth during the last five years, both in arrivals and revenue. In 2019, Cyprus welcomed around 4 million visitors with total revenue estimated at €2,7 billion. This development in both countries results in higher energy demand and consequently, in growing GHG emissions generated by the hotel industry.

In order to address the issue of rising emissions, the EU has set targets under the 2030 climate and energy framework, including a 40% reduction of GHG emissions (in comparison with 1990 levels), a 32% share of renewables, and at least 32.5% improvement in energy efficiency (European Commission, 2020). In order to achieve these ambitious GHG emission reduction targets, non-EU emissions trading system (ETS) sectors, including hotels, will be required to reduce emissions by 30% until 2030 (in comparison with 2005 levels), which has already been translated into binding legislative targets in the EU Member States. In an attempt to boost the energy performance of buildings specifically, the EU has established a legislative framework that includes the Energy Performance of Buildings Directive (EPBD) 2010/31/EU and the Energy Efficiency Directive (EED) 2012/27/EU, along with their amendments. The hotel industry has not only the obligation but also a massive potential to lower energy consumption and GHG emissions, and therefore to improve their energy efficiency and become more sustainable.

Aim of this report is to assess the structural characteristics, the energy performance and GHG emissions of Cyprus and Greece hotels, using an integrated methodology which includes design of questionnaires, hotels' on-site visits, data collection, data analysis and results reporting. From these results, important conclusions can be drawn regarding the potential of hotels for energy savings and GHG emissions reduction. For the scope of this report, 20 Cyprus hotels and 20 Greece hotels were assessed. In order to make the results comparable among the participating hotels, key energy performance indicators were defined.

As part of the "Hotels 4 Climate" project, a platform (https://www.oeb.org.cy/hotels4climate/) that demonstrates the 10 best practices in the participating hotels of each country (Greece, Germany and Cyprus) was developed. These good practices can demonstrate potential approaches for other hoteliers and for that reason, it is very important to be highlighted and presented.

This report "Assessment of Cyprus and Greece hotel industries" has been developed as part of the "Hotels4Climate" project, funded by the European Climate Initiative (EUKI).

2.1 General information about Cyprus hotels

In Cyprus, out of 820 hotels and hotel apartments, there are 29 five-star and 65 four-star hotels (Deputy Ministry of Tourism, 2020), with the average space of all hotels and hotel apartments accounting for 2.734m^2 (Energy Service, Ministry of Energy, Commerce and Industry, 2020). One of the most energy intensive segments of the majority of the hotels is that of heating and cooling, amounting to 30-40% of the hotel total energy consumption. This percentage depends on various factors including the seasonality of the hotel, the existence of roof or wall insulation and obviously the heating and cooling system used. In Cyprus, the most common heating system used in hotels is central heating system with oil-fired boiler, while the predominant system used for cooling in Cyprus hotels is chiller. Tables Table 2 and Table 3 show the proportion of heating and cooling systems used in Cyprus hotels[2].

[2] Source: Economidou, M. (2017). Long-term strategy for mobilizing investments for renovating Cyprus national building stock.

Table 2: Heating Systems used in Cyprus hotels

Heating System	Source	Percentage of hotels
Central heating system with oil-fired boiler	Oil	43%
Central heating system with a condensing boiler	Oil or liquefied gas	2%
Central heating system with a liquefied gas boiler	Liquefied gas	10%
Heat pump	Electricity	40%
Independent air-conditioners	Electricity	4%
No or other heating equipment	N/A	1%

Table 3: Cooling Systems used in Cyprus hotels

Cooling System	Source	Percentage of hotels
Central system with a heat pump	Electricity	62%
Independent air-conditioners	Electricity	28%
No or other air-conditioning equipment	Electricity	10%

Residential buildings in Cyprus **is estimated to account for 18% of the final energy consumption, whereas commerce, hotels and services (i.e. mostly office buildings) account for around 12%.** The different political, economic and social conditions that prevailed for many years did not favour the implementation of energy-saving measures in building construction, resulting in the creation of a particularly energy-intensive building stock. The first organised effort to implement energy-saving measures in buildings was made in 2004 through the grant schemes of the Fund for Renewable Energy Sources (RES) and Energy Saving (ES), while the implementation of mandatory measures in new buildings and buildings larger than 1.000 m^2 that undergo major renovation took place for the first time in 2007 upon the adoption of the ‘Regulation of the Energy Performance of Buildings (Minimum Energy Performance Requirements) Decree of 2007’ (Energy Service, Ministry of Energy, Commerce and Industry, 2020).

The minimum energy performance requirements for existing buildings must be applied when they undergo major renovation and when elements of their envelope are replaced or retrofitted. The latest minimum energy performance requirements (applicable from 1 July 2020) require all residential buildings undergoing major renovation to be of energy class A, and all other buildings, including hotels, to be of energy category B+. All newly constructed buildings, including hotels, have to be of energy category A. The minimum requirements for newly constructed hotels, renovated hotels and hotel building elements that are added or replaced, are shown in Tables Table 4, Table 5 and Table 6, respectively[3].

[3] Source: http://www.cylaw.org/KDP/data/2020_1_121.pdf

Table 4: Minimum requirements for newly constructed hotels (Cyprus)

	New hotel building
Energy efficiency rating in EPC	A
Maximum primary energy consumption for hotel buildings	220 kWh/ m^2/yr
Mean heat transfer coefficient for walls (U- Value)	0,40 W/m^2K
Mean heat transfer coefficient for horizontal structural elements (U- Value)	0,40 W/m^2K
Mean heat transfer coefficient for thermopanes (U- Value)	2,25 W/m^2K
The above U-Values may be exceeded in case the maximum mean U-Value of the total elements of the building envelope is not greater than:	0,65 W/m^2K
Maximum mean shading factor of thermopanes	0,63
Minimum RES share of the total primary energy consumption	9%

Table 5: Minimum requirements for hotels undergoing renovation (Cyprus)

	Renovated hotel building
Energy efficiency rating in EPC	B+ or higher

Table 6: Minimum requirements for hotel building elements that are replaced or installed subsequently (Cyprus)

	Added or replaced hotel building elements
Mean heat transfer coefficient for walls (U- Value)	0,40 W/m^2K
Mean heat transfer coefficient for horizontal structural elements (U- Value)	0,40 W/m^2K
Mean heat transfer coefficient for thermopanes (U- Value)	2,25 W/m^2K

2.2 General information about Greece hotels

In Greece, out of 9.971 hotels, there are 610 five-star and 1.664 four-star hotels[4]. The highest energy consumption in Greece hotels is usually observed in cooling systems (as most of them operate mainly during summer period), while hot water production and the use of equipment have a significant contribution to the hotel total energy consumption.

In total of 15.869 energy certificates for temporary residence buildings, that were issued between 2011 and 2019 in Greece, the majority (9.527) were of energy class C and D, while many (4.425) were of energy class E and F and fewer (1.917) were of energy class A and B.

The building stock in Greece is responsible for 34% of total energy consumption and 65% of the total electricity consumption in the country. The minimum required energy classification of the building units in Greece, is as follows:

a) New residential buildings, of which the building permit is issued until 31 May 2021, must be classified at least in energy category B. The addition of a building unit to existing buildings should be classified in energy category B+. Existing buildings or building units that are subject to radical renovation should be classified in energy category B.
b) New residential buildings, of which the building permit is issued after 31 May 2021 must be buildings of almost zero energy consumption, therefore they should be classified at least in energy category A. The addition of a building unit (as well as the radical renovation) to these buildings, should be classified in the same energy category.
c) New tertiary buildings (including hotels), of which the building permit application was submitted until 31 December 2020, must be classified at least in energy category B. The addition of a building unit (as well as radical renovation) to these tertiary sector buildings must be classified at least in energy category B.
d) New tertiary sector buildings (including hotels), of which the application for building permit was submitted from 1 January 2021 onwards, must be almost zero energy energy consumption buildings, therefore they must be classified at least in energy category A. The addition of a building unit (as well as radical renovation) to these buildings, should be classified in the same energy category.
e) The new buildings (including hotels) that belong to the State or the broader public sector, as of 1 January 2019, must be "Nearly Zero Energy Buildings (nZEBs)" and be classified at least in energy category A. The addition of building unit (as well as radical renovation) in these buildings, should be classified in the same energy category.

The minimum requirements for newly constructed hotels and renovated hotels in Greece, are shown in Tables Table 7 and Table 8, respectively[5].

[4] Source: Greek Hotel Association https://www.grhotels.gr/wp-content/uploads/2020/02/2019-Hotels_total.pdf

[5] Source: 2021 guidelines from the Technical Chambers of Greece.

Table 7: Minimum requirements for newly constructed hotels (Greece)

Energy efficiency rating in EPC	**A**			
Climate Zone	A	B	C	D
Maximum primary energy consumption for hotel buildings	185 kWh/ m^2/yr	114 kWh/ m^2/yr	119 kWh/ m^2/yr	82 kWh/ m^2/yr
Examples of maximum U-values for various building elements				
Maximum (U- Value) for horizontal surfaces in touch with external air	0,45 W/m^2K	0,40 W/m^2K	0,35 W/m^2K	0,30 W/m^2K
Maximum (U- Value) for external walls in touch with external air	0,55 W/m^2K	0,45 W/m^2K	0,40 W/m^2K	0,35 W/m^2K
Maximum (U- Value) for external walls in touch with heated area	1,10 W/m^2K	0,80 W/m^2K	0,65 W/m^2K	0,60 W/m^2K
Maximum (U- Value) for external walls in touch ground	3,20 W/m^2K	3,00 W/m^2K	2,80 W/m^2K	2,60 W/m^2K
Maximum (U- Value) for external windows	2,80 W/m^2K	2,60 W/m^2K	2,40 W/m^2K	2,20 W/m^2K
Minimum RES or solar production for DWH	60%	60%	60%	60%

Table 8: Minimum requirements for hotels undergoing renovation (Greece)

	Renovated hotel building
Energy efficiency rating in EPC	B

3. Methodology development & conduction of the survey

3.1 Questionnaire design

The consortium developed a detailed and well-structured questionnaire for the collection of the required data. The questionnaire was sent to the chief engineer of each participating hotel and then a meeting between the chief engineer and the Cyprus and Greece energy team was arranged in order to obtain all required data. The questionnaire was structured in such a way to make the process of information collection more efficient and as straight-forward as possible.

The questionnaire used in this study can be found in **Appendix** and its overall structure is as follows:

- General Information (e.g., contact person, hotel's name & address)
- General Description (e.g., year of construction, area of covered spaces, number of rooms and guests, months of operation)
- Electricity from renewable energy sources (e.g. scheme, RES technology, power)
- Typical Characteristics of the Building (e.g. Type of building, walls, glazing, roof, shading)
- Transport (e.g. number of vehicles, fuel type and consumption)
- Technical Characteristics of HVAC Systems
  - Cooling (e.g. type of cooling system, model, cooling input, operating time)
  - Heating (e.g. type of heating system, model, heating input, operating time)
  - Mechanical Ventilation (e.g. type of ventilation, input power, operating time)
- Hot Water Use (e.g. type of hot water source, fuel if applicable)
- Lighting (e.g. type of lighting, quantity, input power, operating time)
- Electrical and Electronic Equipment in kitchens, offices, guest rooms, laundry, gym, saloon and other areas of the hotel (e.g. type of equipment, quantity, input power, operating time)
- Electromechanical Equipment (e.g. type of equipment, quantity, input power, operating time)
- Actual Energy Consumption per month for the baseline year (electricity and fuels consumption)
- Waste & Wastewater (e.g. quantity of wastewater and solid waste, wastewater and solid waste treatment strategies, % of solid waste recycled)

The last section comprises of some quality questions that aim to evaluate their perception for the importance of implementing GHG reduction measures and the barriers prohibiting the implementation of such measures.

3.2 Information/Data collection

Energy consumption data were collected from 20 hotels in Cyprus and 20 hotels in Greece. Performing energy audits in the hotel sector revealed to be more difficult than expected, even if the hotels were pre-alerted and the questionnaire was sent to them in advance. Very often the process of data collection was very time-consuming as they were not fully prepared at the day of the audit or many data were missing. Several calls and emails were needed in order to obtain all the data, and in some cases multiple visits were required. The whole process of data collection was adversely affected by the pandemic of Covid-19, since all hotels in both countries were forced to shut down for a long period of time. Reference year for the data collection was either 2018 or 2019, depending on which year was more representative.

Since direct measurement of energy consumption was not feasible, simplified energy audits were carried out. The main scope was to collect the necessary information regarding the hotel building, the process equipment, the HVAC systems and other general information about the hotel. The methodology that was implemented comprises of the following steps, presented in Figure 1:

- Design of the questionnaire.
- Distribution to participating hotels.

- On-site visits.
- Data collection.
- Data analysis.
- Results reporting.

Figure 1: Implemented methodology

3.3 Analysis of results

For the analysis of the data, an energy tool was developed using Microsoft Excel. The energy tool was designed in such a way to come in line with the questionnaire and facilitate the data filling process. More specifically, a separate excel sheet was dedicated to every section of the questionnaire (i.e. one sheet for the General Information, one sheet for the General Description and so on). A snapshot of the excel spreadsheets is shown in Figure 2 and Figure 3.

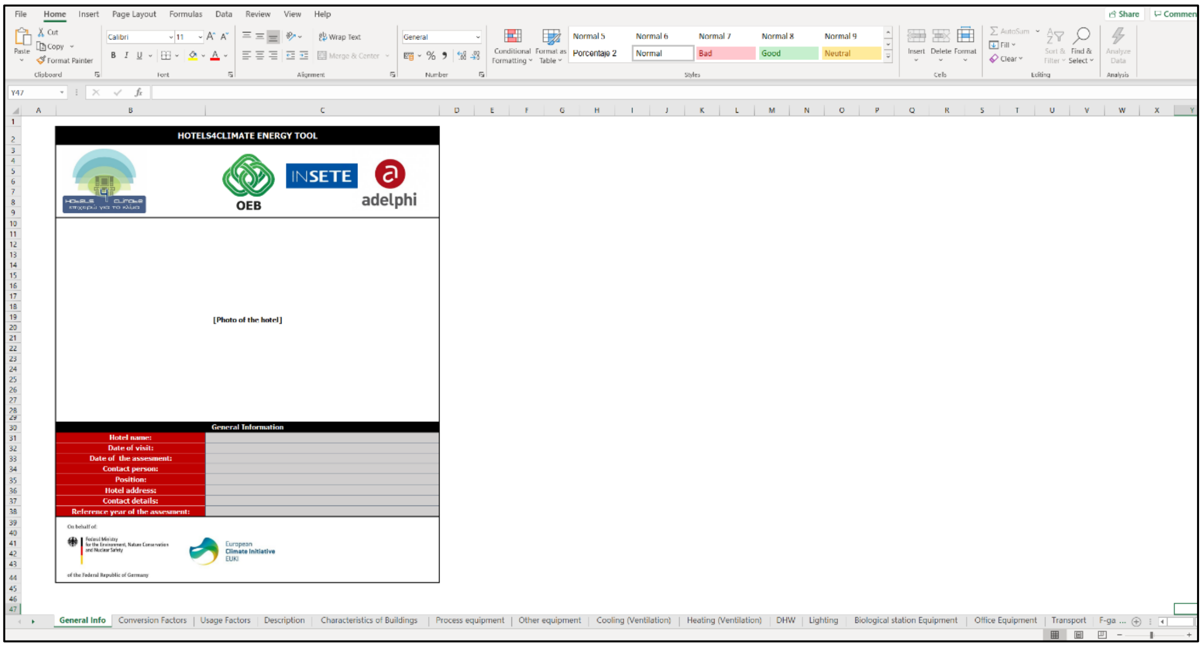

Figure 2: Snapshot of the Excel Energy Tool

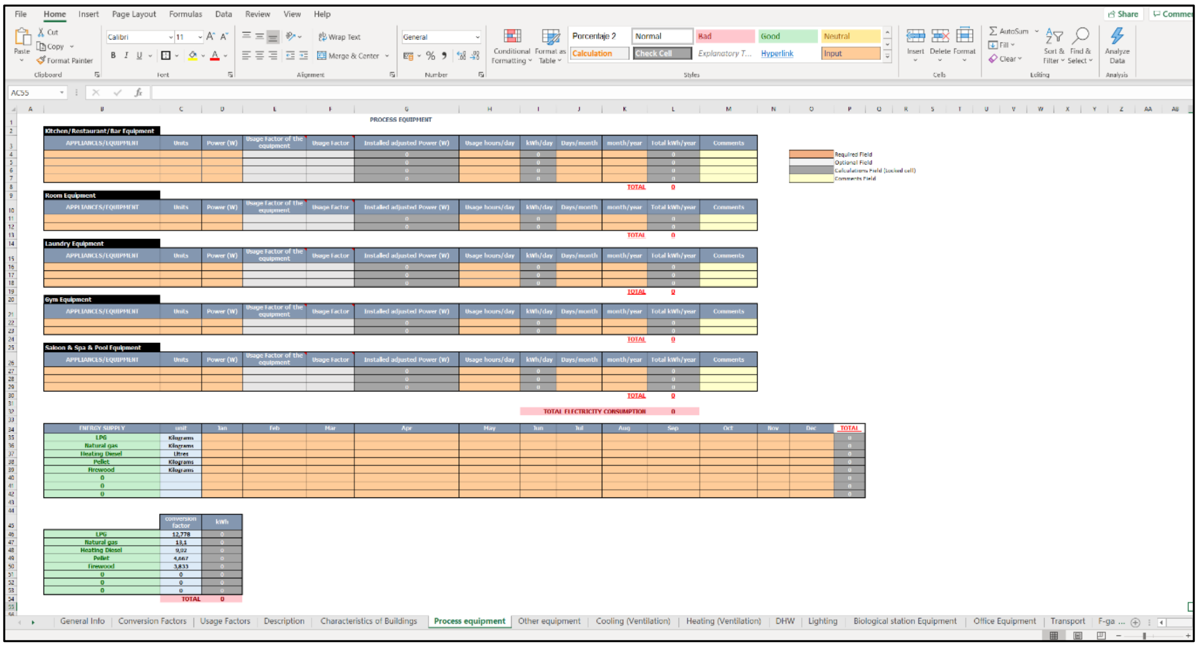

Figure 3: Snapshot of the Excel Energy Tool

All data gathered during the hotel visits, as well as additional data provided at a later stage were added in this energy tool. Once all data were filled in the respective spreadsheets of the energy tool, the total CO_{2eq} emissions, the final energy consumption, as well as various KPI's were automatically calculated and illustrated in a separate spreadsheet. The main KPI's calculated in the energy tool (Figure 4) are the following:

- Total annual energy consumption per unit area (kWh/m^2/year)
- Total annual energy consumption per guest-night (kWh/guest-night/year)
- Total annual energy consumption per guestroom (kWh/room/year)
- Total annual GHG emissions per guest-night (kg CO_2-equivalent/guest-night/year)
- Total annual solid waste per guest-night (kg/guest-night/year)

In addition, various graphs are automatically created and illustrated in order to present the main outcomes in a more user-friendly way (Figure 5).

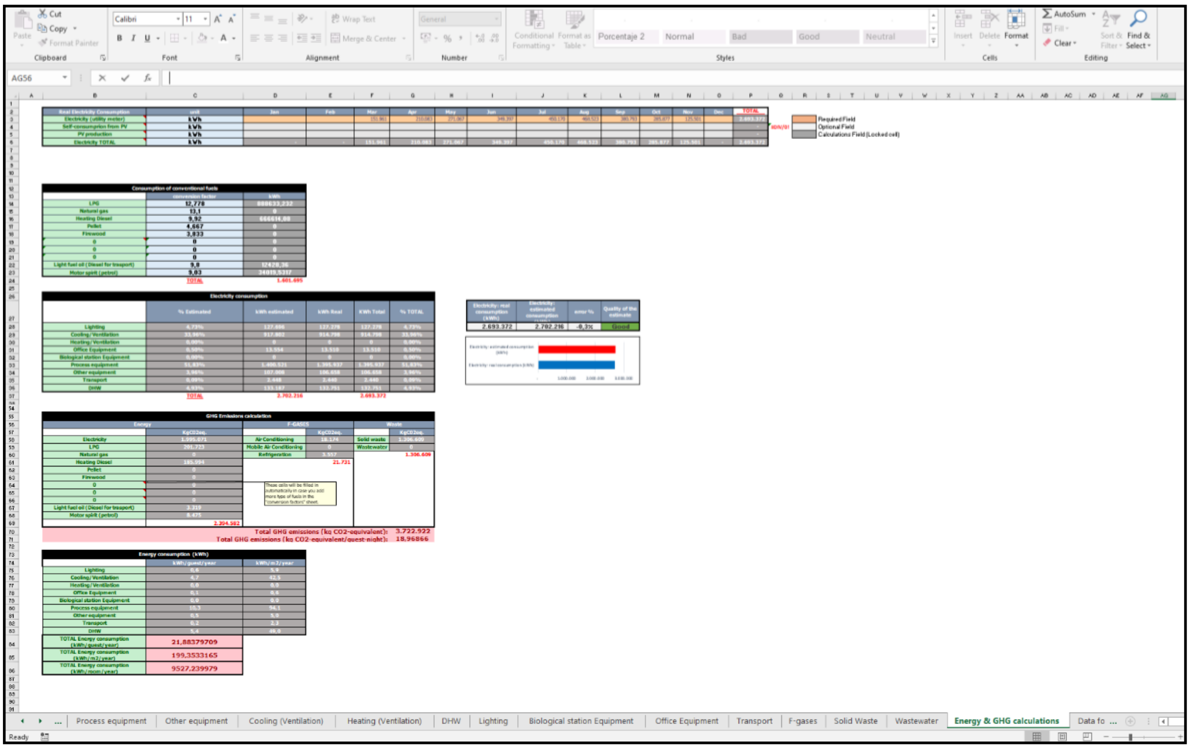

Figure 4: Main KPI's automatically calculated in the Excel Energy Tool

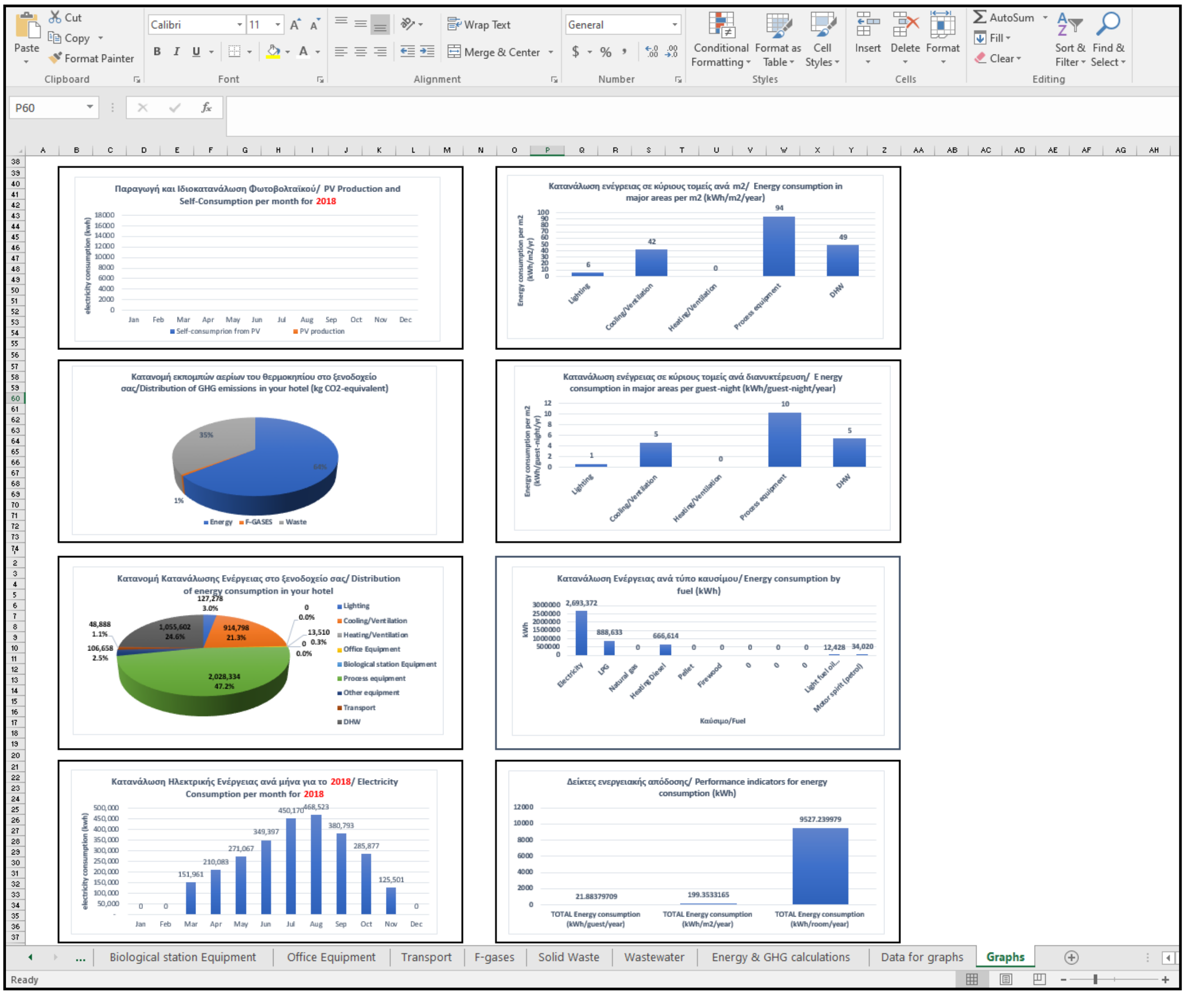

Figure 5: Graphs automatically created in Excel Energy Tool

4. General and structural characteristics of the hotel industry in Cyprus and Greece

4.1 Building characteristics

4.1.1 Cyprus

In general, the building stock in Cyprus can be divided in 5 chronological periods according to their construction year: before 1959, from 1960 to 1974, from 1975 to 1990, from 1991 to 2006 and from 2007 onwards. Regarding the hotel industry, a large number of hotels was constructed after the Turkish invasion of Cyprus in 1974. Eleven out of the twenty hotels that participate in this project were constructed between 1975 and 1990, while seven hotels were built between 1991 and 2006. During these two periods, the tourism industry of Cyprus experienced a rapid growth, especially on the seaside areas, and that is reflected on the large number of new hotels constructed along the coastline. A categorization of the hotels participating in the project, according to their construction period and climate zone, is shown in Table 9 and Table 10, respectively.

Table 9: Number of participating hotels in Cyprus according to the period of construction

Period of construction	Number of hotels
Before 1959	0
From 1960 to 1974	0
From 1975 to 1990	11
From 1991 to 2006	7
From 2007 to 2020	2

Table 10: Number of participating hotels in Cyprus according to the climate zone

Climate zone	Number of hotels
Coastal Area	19
Low Land Area	0
Semi Mountainous Area	0
Mountainous Area	1

Almost all hotels in Cyprus were developed between 1974-2006 and were constructed without any requirements for thermal insulation or any other energy efficiency requirements, similarly to the majority of the buildings in the tertiary sector in Cyprus. Consequently, the energy situation of the vast majority of the hotels in Cyprus can be characterized as poor to moderate.

Through the Energy Performance of Buildings Directive (EPBD), specific measures and policies have been implemented in Cyprus to improve the EE of buildings and consequently reduce the GHG emissions. For example, since 2007 mandatory EE requirements were implemented for new and existing buildings which underwent major renovations. From 2007 until today, the requirements have become stricter.

Regarding the hotel sector, a big proportion of the Cyprus hotels were built before the first legislation (2007) for energy performance requirements. In general, it can be assumed that the hotels' sector follows the structure and construction materials of the residential and tertiary sectors in Cyprus, as well as the same period of development. It is worth noting that the first minimum energy performance requirements specifically for hotels came into force on the 1st of July 2020. These include requirements regarding the primary consumption per square meter, the share of renewable energy sources (RES) in the total consumption, the level of insulation of the building envelope etc. More specifically, the new regulation sets that new hotel buildings should consume a maximum of 220 kWh/m^2/yr. and the minimum RES contribution in the primary energy consumption should be at least 9%. The chronological development of energy performance requirements in Cyprus, is outlined in Figure 6.

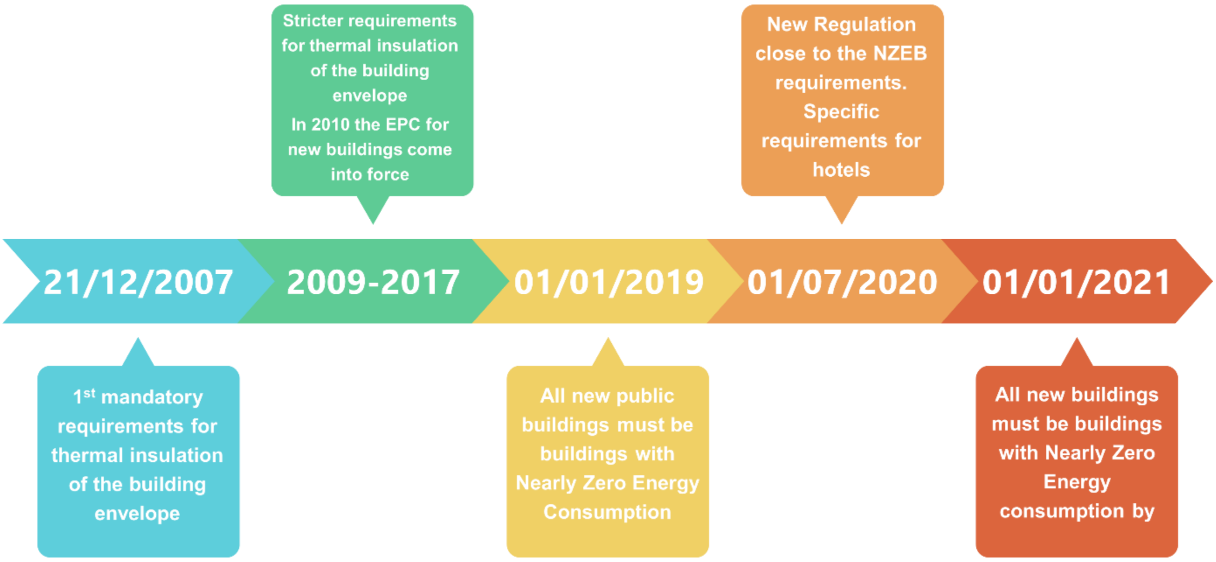

Figure 6: Development of buildings energy performance requirements in Cyprus

Reinforced concrete frames and bricks are among the most common materials used for hotels' construction in Cyprus, while for those that have thermal insulation, the main insulating materials used are polystyrene and stonewool. During the last five years, three out of the twenty Cyprus hotels proceeded to deep renovation of their building envelope including thermal insulation on external walls and roof. The structural characteristics of the Cyprus hotels participating in this project are outlined in the table below:

Table 11: Overall structural data of the Cyprus hotel buildings participating in the survey

	Construction Materials	Thermal Insulation [Yes/No/%]
External Walls	Bricks with indoor and outdoor plaster (25-30cm width), cement and iron	5 (25%) of the participating hotels have external walls' thermal insulation.
Exposed Roof	Cement and iron with waterproof layer	8 (40%) of the participating hotels have roof thermal insulation.

	Construction Materials	Thermal Insulation [Yes/No/%]
Windows	Single-glazed or double-glazed windows with aluminium frame	10 (50%) of the participating hotels have double-glazed windows without thermal break. 7 (35%) of the participating hotels have double-glazed windows with thermal break. 3 (15%) of the participating hotels have both single-glazed and double-glazed windows without thermal break.

4.1.2 Greece

Hotel industry in Greece was developed in different periods of time and in different areas as well. In the first place, the areas of Rhodes and Crete played a leading role in the hotel industry, followed by a similar proliferation throughout the whole country. More precisely, during the period 2015-2019, there was an ongoing tendency of upgrading the hotels in terms of star rating. In 2019, 50% of the hotel units in Greece belonged to the top three categories, over a percentage of 43% in 2015.

Between 2015 and 2019, the hotel units increased by 2,5%, while the average number of hotel rooms increased by 2,7%. When it comes to star rating, the most considerable growth in the number of hotels (48%) between 2015-2019 was observed in five-star hotels, while at a regional level the most significant rise in the number of hotels was observed in the Southern Aegean Sea (11%), followed by Epirus (10%) during the same period.

In 2019, the seasonal hotels were accounting for 59% of the total number of hotels in Greece, raised by 5% since 2015. More than 50% of the hotels are located in the island region of the country and 79% of the hotels have a capacity of up to 50 rooms. The above information emerges from the study of the Hellenic Chamber of Hotels[6].

A categorization of the Greece hotels participating in the project, according to their construction period and climate zone, is shown in Tables Table 12 and Table 13.

Table 12: Number of participating hotels in Greece according to period of construction

Period of construction	Number of hotels
Before 1959	0
From 1960 to 1974	3
From 1975 to 1990	8
From 1991 to 2006	3
From 2007 to 2020	6

[6] Source: https://www.itep.gr/wp-content/uploads/2020/12/itep-hotel-evolution-2015-19-short.pdf

Table 13: Number of participating hotels in Greece according to the climate zone

Climate zone	Number of hotels
Coastal Area	16
Low Land Area	4
Semi Mountainous Area	0
Mountainous Area	0

Similarly to Cyprus, reinforced concrete frames and bricks are among the most common materials used for hotels' construction in Greece, while for those that have thermal insulation, the main insulating materials used are polystyrene and stonewool. During the last five years, many Greece hotels proceeded to deep renovation of their building envelope including thermal insulation on external walls and roof. The structural characteristics of the Greece hotels participating in this project are outlined in the table below:

Table 14: Overall structural data of the Greece hotel buildings participating in the survey

	Construction Materials	Thermal Insulation [Yes/No/%]
External Walls	Bricks with indoor and outdoor plaster (25-30cm width), cement and iron	9 (45%) of the participating hotels have external walls' thermal insulation. Half of these hotels were thermally insulated as part of a deep renovation of the hotel. 4 (20%) of the participating hotels have double stud walls with thermal insulation in between them.
Exposed Roof	Cement and iron with waterproof layer	8 (40%) of the participating hotels have roof thermal insulation.
Windows	Single-glazed or double-glazed windows with aluminium frame	14 (70%) of the participating hotels have double-glazed windows without thermal break. 4 (20%) of the participating hotels have double-glazed windows with thermal break. 2 (10%) of the participating hotels have both single-glazed and double-glazed windows without thermal break.

4.2. Hotels' general information

For the scope of the project, 20 hotels were surveyed in each country. For Cyprus, the sample consisted of six five-star and fourteen four-star hotel units, while for Greece, the sample was comprised of nine five-star and eleven four-star hotel units.

In general, the indoor area of five-star hotels compared to four-star hotels, in both countries, is higher mainly due to larger guestrooms and common areas, as well as increased number of restaurants and leisure areas. Despite the fact that small differences were observed regarding the annual occupancy rates between four-star and five-star hotels, the daily average guest-nights of five-star hotels compared to four-star hotels was higher mainly because of the higher number of guestrooms. Table 15 provides an overview of the characteristics and occupancy rates of the participating hotels.

Table 15: Common building characteristics and average occupancy rates of the hotels participating in the survey

		Number of hotels		Mean Indoor Area (m^2)	Number of guestrooms		Annual occupancy rate (%)	Average guest-nights per day
		seasonal	Non-seasonal		Range	Mean		
Greece	Four-star hotels	10	1	7.280	16 – 446	173	70% – 92%	317
	Five-star hotels	6	3	14.025	157 – 561	280	70% – 97%	515
Cyprus	Four-star hotels	7	7	14.950	144 – 330	231	60% – 87%	391
	Five-star hotels	0	6	18.680	155 – 424	268	70% – 88%	477

4.3 Energy and Environmental Management Systems

During the last decade, there has been an increasing number in accreditation awards and certification schemes, with that being a sign of an upward trend in sustainability hotel sector in Cyprus and Greece.

According to Schneider *et al.* (2020), more than one third of all (93) four-star and five-star hotels in Cyprus have been certified with some sort of green certification scheme, such as Eco-Management and Audit Scheme (EMAS), the International Organization for Standardization's (ISO) 14001 Environmental Management System and Travelife (Travelife 2020). Certification is also common in Greece, with more than 380 establishments certified with the Green Key, 153 certified with Travelife, and two hotels using the EMAS system (Green Key 2020; Travelife 2020; and EMAS 2020).

Based on the data collected from the twenty participating hotels in Cyprus, 14 have been certified with ISO14001, 10 with Travelife, 2 with EMAS and 1 with Green Key (Table 16). Regarding EMAS certification, hotels have the opportunity to use a Government support scheme that offers a grant sponsorship of 70% (with a maximum amount of €2.000) of the total eligible costs for the establishment of EMAS, and a maximum amount of €500 for the verification and validation of the system.

With regards to Greece hotels that participated in the survey, 10 have been certified with ISO14001, 14 with Travelife, 6 with ISO50001, 1 with EMAS and 14 with Green Key (Table 16).

As outlined by the EU's Energy Efficiency Directive (EED), all non-small and medium enterprise (SME) companies – including hotels – are obliged to perform an energy audit once every four years. This obligation was transposed into national legislation in both Cyprus (Law 31(I)/2009) and Greece (Law

4342/2015). As shown in Table 16, 6 out of 20 hotels in Cyprus underwent an Energy Audit, with 4 of them being obliged to do so to comply with Law 31(I)/2009. Similarly, 6 out of the 20 participating hotels in Greece underwent an Energy Audit. Energy audit can be a useful tool that allows hoteliers to see areas and equipment with high energy consumption and where cost savings can be achieved. Despite the fact that there is a support scheme in Cyprus that provides grants to SME's for energy audits since 2019, it has not been exploited be the SME's (including hotels) mainly due to the low grant offered.

Table 16: Number of green certified hotels participating in the survey

	Number of Cyprus hotels		Number of Greece hotels	
	Four-star	Five-star	Four-star	Five-star
Eco-Management and Audit Scheme (EMAS)	2	0	1	0
ISO14001 Environmental Management System	9	5	3	7
ISO50001 Energy management System	2	1	0	6
Travelife	7	3	7	7
Green Key	0	1	5	9
EPC	0	1	0	6
Energy Audit	2	4	0	6

4.4 Technical characteristics of HVAC systems and lighting

The main HVAC systems and lighting technologies used in the participating hotels are summarized in Table 17. Significant investments have been made in energy efficiency improvement in lighting and cooling systems, while not considerable investments were made in heating systems, with the majority of the hotels in both countries still using high energy-consuming and pollutant systems (oil-fired boiler).

The predominant system used for the production of hot water in Cyprus and Greece is fuel-fired boiler. It is worth mentioning that almost half of the participating hotels both in Cyprus and Greece have solar thermal panels in place that contribute to the production of hot water at a great extent. Moreover, a big proportion of the Cyprus participating hotels (85%) use heat recovery from the chiller, for the production of hot water. In Greece this percentage is lower (10%) as many hotels are still using split units or decentralised systems.

All participating hotels have proceeded to the energy upgrade of their lighting, replacing a high proportion (>70%) of their conventional lighting (halogen, Incandescent) with LED technology. The fact that hotels are using LED technologies resulted to lower energy use for lighting which was not the case in previous years for Cyprus and Greece hotels.

The majority of the participating hotels in Cyprus are using central cooling (chiller, VRV) and heating systems (chiller, boiler) for the main hotel's areas and usually AC split units for the auxiliary areas (i.e. Offices, conference rooms etc.). In Greece, around half of the participating hotels are using central cooling (chiller, VRV) and central heating (chiller, boiler, VRV), while around 25% are using split units for heating and cooling in all areas.

Regarding the energy sources used in the participating hotels of both countries, electricity is predominant whereas liquid fuels like oil and LPG also being for hot water production. What is more, LPG constitutes the predominant energy source used in kitchen facilities, representing around 10% of the total energy consumption of the hotel.

Table 17: Main HVAC systems and lighting technology used in the hotels participating in the survey

	Cyprus	Greece
Space Heating	6 (30%) of the hotels are using oil-fired boiler with fan coil units in rooms and AHU in public areas. 2 (10%) of the hotels are using pellet boiler. One uses fan coil units in rooms and AHU in public areas, while the other uses panel radiators. 5 (25%) of the hotels are using heat pump chiller with fan coil units in rooms and AHU in public areas. 2 (10%) of the hotels are using VRV with fan coil units in rooms and AHU in public areas. 5 (25%) of the hotels do not require space heating due to their seasonality.	1 (5%) of the hotels is using oil-fired boiler with fan coil units in rooms and AHU in public areas. 1 (5%) of the hotels is using firewood pellet boiler with fan coil units in rooms and AHU in public areas. 2 (10%) of the hotels are using heat pump chiller with fan coil units in rooms and AHU in public areas. 3 (15%) of the hotels are using VRV with fan coil units in rooms and AHU in public areas. 3 (15%) of the hotels are using both heat pump chiller and VRV with fan coil units in rooms and AHU in public areas. 5 (25%) of the hotels are using AC split units in all areas. 5 (25%) of the hotels do not require space heating due to their seasonality.
Cooling	5 (25%) of the hotels are using heat pump chiller for the main hotel's areas and usually VRFs and split units in auxiliary areas (i.e. Offices, conference rooms etc.) 13 (65%) of the hotels are using chiller for the main hotel's areas and usually VRFs and split units in auxiliary areas (i.e. Offices, conference rooms etc.) 2 (10%) of the hotels are using solely VRV for the main and auxiliary hotel's areas.	8 (40%) of the hotels are using heat pump chiller for the main hotel's areas and usually VRFs and split units in auxiliary areas (i.e. Offices, conference rooms etc.) 2 (10%) of the hotels are using chiller for the main hotel's areas and usually VRFs and split units in auxiliary areas (i.e. Offices, conference rooms etc.) 3 (15%) of the hotels are using solely VRV for the main and auxiliary hotel's areas. 7 (35%) of the hotels are using AC split units in all areas.
Domestic Hot Water	Main systems 18 (90%) of the hotels are using **boiler** as their main system for hot water production.	Main systems 15 (75%) of the hotels are using **boiler** as their main system for hot water production. • 9 (60%) of these hotels are using **oil-fired boiler,** 3 (20%) are using **LPG**

	• 15 (85%) of these hotels are using **oil-fired boiler** and 3 (15%) are using **pellet boiler**. 1 hotel (5%) is using **heat pump chiller (six-pipe chiller)**. 1 hotel (5%) is using **VRV system in combination with hydrofree system**. Auxiliary systems 9 (45%) of the hotels have **solar panels** in place that contribute to the hot water production. 17 (85%) of the hotels utilize **heat recovery** from the chiller operation.	**boiler,** 2 (14%) are using **natural gas boiler** and 1 (6%) is using **firewood boiler**. 1 hotel (5%) is using **electric water heater**. 4 hotels (20%) are using **heat pump chiller**. Auxiliary systems 8 (40%) of the hotels have **solar panels** in place that contribute to the hot water production. 2 (10%) of the hotels utilize **heat recovery** from the chiller operation.
Ventilation	All hotels use **AHU systems** in common areas (e.g. lobby, restaurants, spa, gym) to regulate and distribute the conditioned air. All hotels use **exhaust/supply fans** to discharge (supply) and admit (return) air directly to/from the guestrooms.	All hotels use **AHU systems** in common areas (e.g. lobby, restaurants, spa, gym) to regulate and distribute the conditioned air. All hotels use **exhaust/supply fans** to discharge (supply) and admit (return) air directly to/from the guestrooms.
Lighting	All hotels have replaced a large proportion (>75%) of their conventional lighting (halogen, Incandescent) with CFL and LED. On average, the hotels' lighting comprises of 85% LED, 12% CFL and fluorescent tubes and 3% conventional lighting.	All hotels have replaced a large proportion (>70%) of their conventional lighting (halogen, Incandescent) with CFL and LED. On average, the hotels' lighting comprises of 80% LED, 10% CFL and fluorescent tubes and 10% conventional lighting.

4.5 RES contribution

Photovoltaic (PV) panels for electricity production and solar thermal panels for hot water production are the main renewable energy systems used in many hotels, both in Cyprus and Greece. Due to the high solar irradiation and solar potential in these two countries, photovoltaic and solar panels can be very efficient, with considerably short payback periods.

4.5.1 PV systems

4.5.1.1 Cyprus

The Cyprus Government has released various support schemes for the promotion of RES. Those that can be exploited by the hotels are related to net-metering, net-billing and autonomous PV systems. The size of the PV system under the net-metering and net-billing scheme should not exceed 10kW and

10MW, respectively. Regarding the autonomous PV systems, there is no limit on their installed capacity. Although these schemes can be very beneficial for the hotels, they cannot be used on the desired extent mainly due to roof space limitation that prohibit the installation of large PV systems.

Based on data gathered from the participating hotels, 7 out of 20 hotels have an autonomous PV system in place that is used to cover a proportion of the electricity consumption of some pool pumps. The capacity of the autonomous PV systems in these 7 hotels ranges between 1,25kW and 17kW, with the average capacity accounting for 9,5kW.

Photo: Lordos Beach Hotel, Larnaca, Cyprus

One hotel is using a 20kW net-metering PV system, which has an annual production equal to around 1,2% of the hotel annual electricity consumption.

Two hotels have installed larger PV systems with capacities of 40kW and 100kW, under the net-billing scheme. The 40kW PV system produces electricity that is equal to around 5,2% of the hotel annual electricity consumption, while the production of the 100kW PV system accounts for around 6% of the hotel annual electricity consumption.

Table 18: PV systems installed in the Cyprus hotels participating in the survey

	Number of hotels	Power capacity (kW)	Share in total electricity demand (%)
Autonomous systems	7	1,25 - 17 kW	<1 %
Net-Metering scheme	1	20 kW	1,2 %
Net-Billing scheme	2	40 – 100 kW	5,2–6 %

4.5.1.2 Greece

Government schemes along with the existing legislation allow the installation of photovoltaic panels in buildings. The PV systems that can be exploited by the hotels in Greece are the net-metering and autonomous systems. However, the majority of Greece hotels do not utilize this potential. Among the hotels that underwent the energy-based inspections and diagnostics, only one was found to have photovoltaic panels installed. This system was installed on the rooftop of the hotel and it is operating under the net-metering scheme. Generally, due to architectural restrictions, the photovoltaic power plant installation within the hotel units in Greece has not yet sufficiently advanced.

Table 19: PV systems installed in the Greece hotels participating in the survey

	Number of hotels	Power capacity (kW)	Share in total electricity demand (%)
Autonomous systems	0	-	-
Net-Metering scheme	1	20	65%[7]
Net-Billing scheme	0	-	-

4.5.2 Solar thermal systems

Almost half of the participating hotels in Cyprus and Greece have solar thermal panels in place that contribute to the production of hot water at a great extent. In Cyprus and Greece, due to the high solar irradiation and solar potential, solar panels can be very efficient, with their payback period estimated at 3 to 5 years. The solar thermal panels have a lifespan of around 25 years.

Photo: Cavo Maris Hotel, Ammochostos, Cyprus

[7] The percentage is high due to the big size of the PV system in proportion to the small size of the hotel (35 rooms). Estimated annual energy production of the PV system is around 35.000kWh, while the hotel's annual electricity consumption is equal to 53.300kWh.

4.5.2.1 Cyprus

According to the data collected from the 20 participating hotels, 9 hotels have solar thermal panels installed on their roofs. Based on the available roof space, a typical hotel normally installs around 80 (appr. 160m^2) solar thermal panels and that is the case for the 8 out of the 9 hotels. The other hotel which is spread out, has enough available roof space for the installation of 361 solar panels.

Table 20: Data of the solar thermal systems installed in the Cyprus hotels participating in the survey

Number of hotels	Number of Solar panels	Average Number of Solar panels	Median Number of Solar panels	Median installed area of solar panels per room (m^2/room)
9	45-361	105	80	0,8

4.5.2.2 Greece

According to the data collected from the 20 participating hotels, 8 hotels have solar thermal panels installed on their roofs. Based on the available roof space, a typical hotel in Greece normally installs around 63 (appr. 130m^2) solar panels. The other hotel, which is spread out, has enough available roof space for the installation of 216 solar panels.

Table 21: Data of the solar thermal systems installed in the Greece hotels participating in the survey

Number of hotels	Number of Solar panels	Average Number of Solar panels	Median Number of Solar panels	Median installed area of solar panels per room (m^2/room)
8	12-216	63	43	1,09

Photo: Creta Maris Beach Resort, Heraklion, Crete

5. Energy and emissions performance indicators in hotels in Cyprus and Greece

5.1 Energy efficiency index

Based on the survey results, key performance indicators were extracted in order to assess energy and environmental performance of the hotels, differentiating four- and five-star, seasonal and non-seasonal hotels.

The results are related with energy consumption coming from electricity, fossil fuels (heating diesel, LPG, natural gas), biomass (pellet, wood chips or olive wood) and liquid fuels for transport (diesel, petrol). GHG emissions and waste generated by the hotels are also among the outcome results.

In order to analyse the results, various factors were taken into account including indoor area, guest-nights, occupancy rate, number of guestrooms, usage factor of each equipment, services provided and seasonality.

In order to make these results comparable among the participating hotels, the following key performance indicators (KPI's) were defined:

- Energy consumption per unit area
- Energy consumption per guest-night
- Energy consumption per guestroom
- GHG emissions per guest-night
- Solid waste per guest-night

In addition, the per unit energy consumption in different segments (heating, cooling, DHW and lightning) has been calculated and assessed.

5.1.1. Total annual energy performance indicators for the hotels participating in the survey

5.1.1.1. Cyprus

The main KPI's concerning the 19 hotels located in coastal areas are outlined in Table 22, Table 23 and Table 24. The corresponding results for the 1 **non-seasonal four-star** hotel that is located in **mountain area** are as follows:

- Total annual energy per unit area is 210kWh.
- Total annual energy per guest-night is 40,9kWh.
- Total annual energy per guestroom is 5.261kWh.

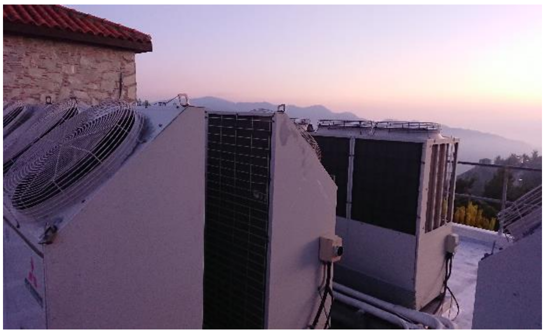

Photo: Mountain hotel in Cyprus

Table 22: Total energy consumption per unit area of Cyprus hotels participating in the survey

	Total Energy per unit area ($kWh/m^2/year$)		
	Four-star		Five-star
	Seasonal	Non-Seasonal	Non-Seasonal
Mean	150,6	247,1	352,9
Median	141,8	279	331,7
Range	123-199	163 – 321[8]	226 - 462

Table 23: Total energy consumption per guest-night of Cyprus hotels participating in the survey

	Total Energy per guest-night (kWh/guest-night/year)		
	Four-star		Five-star
	Seasonal	Non-Seasonal	Non-Seasonal
Mean	22,9	29,8	39,5
Median	21,5	28	38,0
Range	16,2 – 37,0[9]	23,4 – 37,9[10]	29,9 – 54,5

Table 24: Total energy consumption per guestroom of Cyprus hotels participating in the survey

	Total Energy per guestroom (kWh/room/year)		
	Four-star		Five-star
	Seasonal	Non-Seasonal	Non-Seasonal
Mean	7.454	11.263	17.293
Median	6.634	10.463	16.761
Range	4.670[11] – 12.265[12]	7.150 – 17.254[13]	12.068 – 23.261

The wide range on the per unit energy consumptions of hotels with same star rating, is mainly attributed to the fact that some hotels have an in-house laundry which is considered a large consumer and it increases the overall energy consumption of the hotel. On the other hand, the hotels that have solar thermal panels in place for the production of hot water, make significant energy savings and as a result

[8] Hotel with in-house laundry with high consumption of heating diesel (45.600 L/yr.) for the operation of the steam boiler.

[9] Hotel with spread out buildings.

[10] Hotel with in-house laundry with high consumption of heating diesel (134.400 L/yr.) for the operation of the steam boiler. Also, the hotel occupancy rate is very low (69%).

[11] Hotel with almost zero energy consumption for DWH production.

[12] Hotel with spread-out buildings.

[13] Hotel with in-house laundry with high consumption of heating diesel (45.600 L/yr.) for the operation of the steam boiler.

the overall energy consumption decreases. The type of hotel in terms of buildings' layout (compact or spread out) is another factor that affects the overall energy consumption. Through the analysis, it was observed that hotels with spread out buildings, have higher per unit energy consumption compared to the hotels with compact buildings. More specifically, the energy for heating and cooling comes to be higher in spread out buildings because of heat distribution losses (due to the longer distances) and thermal losses that result from the exposure of high number of walls to the external environment.

The overall higher energy consumption of five-star hotels can be partially explained from the mandatory requirements/services for five-star hotels, which are optional for four-star hotels. Area of guestrooms, lobby area and other common areas of five-star hotels have higher minimum requirements compared to four-star hotels. Also, five-star hotels normally have higher number of restaurants and bars, they offer more luxurious services, corresponding to higher energy consumption.

Obviously, there are various factors that affect the energy consumption of hotels, such as:

- **Number of kitchens, bars, restaurants, shops.**
- **Hotels' policy regarding the operation of saunas and steam baths (on demand or non-stop).**
- **High-level facilities and conveniences.**
- **Existence of jacuzzi for public use or private jacuzzi and jet pumps or fountains.**
- **Variety of facilities and services, areas of leisure.**
- **Conference rooms.**
- **Seasonality.**
- **Climate zone.**

The per unit energy needs for cooling and heating in hotels with no central heating and cooling systems was higher compared to the hotels using a central system. In individual systems such as split units, the end user has the control of the set temperature, however in central systems the temperature as well as the operating time, can be set centrally by the chief engineer.

The higher the occupancy rate of a hotel, the lower the energy consumption per guest-night. This is mainly because of the operation of basic loads regardless the number of guests. These can be:

- **lighting in lobby and common areas.**
- **outdoor lighting.**
- **cooling, heating and ventilation in common areas, bars, restaurants.**
- **pool pumps.**

5.1.1.2 Greece

The main KPI's concerning the 20 Greece hotels participating in the project, are outlined in the following tables.

Table 25: Total energy consumption per unit area of Greece hotels participating in the survey

	Total Energy per unit area (kWh/m^2/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasonal	Non-Seasonal
Mean	122	165,1	146,7	240,1
Median	98	165,1	149,2	294,2
Range	29,9 – 310,1	165,1	110,7 – 174,4	62,9 – 363,4

Table 26: Total energy consumption per guest-night of Greece hotels participating in the survey

	Total Energy per guest-night (kWh/guest-night/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasonal	Non-Seasonal
Mean	13,5	23,1	19	23,9
Median	12	23,1	16,4	29,5
Range	6,6 – 22,7	23,1	13,7 – 29	9 – 33,1

Table 27: Total energy consumption per guestroom of Greece hotels participating in the survey

	Total Energy per guestroom (kWh/room/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasonal	Non-Seasonal
Mean	4.276	8.145	6.866	12.968
Median	3.731	8.145	6.609	16.197
Range	1.945 – 5.290	8.145	4.523 – 10.287	3.809 – 18.897

The average energy consumption of Greece five-star hotels participating in the project, comes to be twice as much as the energy consumption of four-star hotels. Similarly to Cyprus hotels, this can be partially explained from the mandatory requirements/services for five-star hotels, which are optional for four-star hotels. Area of guestrooms, lobby area and other common areas of five-star hotels in Greece have higher minimum requirements compared to four-star hotels. Also, five-star hotels normally have higher number of restaurants and bars, they offer more luxurious services, corresponding to higher energy consumption. This difference is higher in seasonal hotels since five-star hotels are commonly selected for events, conferences and other activities. From the analysis it was also observed that non-seasonal hotels have higher consumption rates per guest-night. This is due to the fact that they have lower annual occupancy, while seasonal hotels typically operate for a shorter period of time but with higher occupancy. The corresponding comments in the previous subchapter referring to the Cyprus hotels, are equally applicable for Greece hotels participating in the project.

5.1.2. Breakdown of hotels' energy consumption

A breakdown of the share of each segment in the total energy consumption, has been made in order to examine which segments are the largest consumers in each hotel category and draw valuable conclusions. These segments are:

- **Cooling and Ventilation**
- **Heating and Ventilation**
- **DHW**
- **Lighting**
- **Process equipment**
- **Other**

The process equipment includes the energy consumption of kitchens, bars, restaurants, guestrooms, laundry, gym, saloon, spa (e.g. sauna and steam bath) and pool equipment (e.g. pumps). Process equipment does not include the energy consumption for cooling, heating, ventilation and lighting of the aforementioned areas.

Other equipment includes the energy consumption of IT (e.g. server, modems, music systems) and office equipment (e.g. computers, printers). It also includes the energy consumption of lifts, sewage pumps and water pressure booster pumps (for bathroom use and not for DHW).

Photo: Amavi Hotel, Paphos, Cyprus

5.1.2.1. Cyprus

The average share of each segment in the total energy consumption of the hotels in each category is illustrated in the following figures:

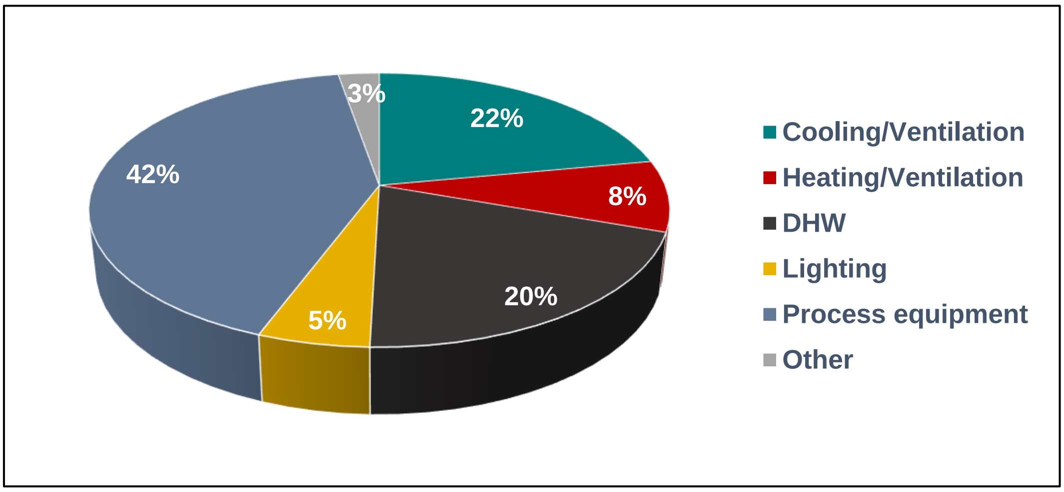

Figure 7: Cyprus non-seasonal four-star hotels

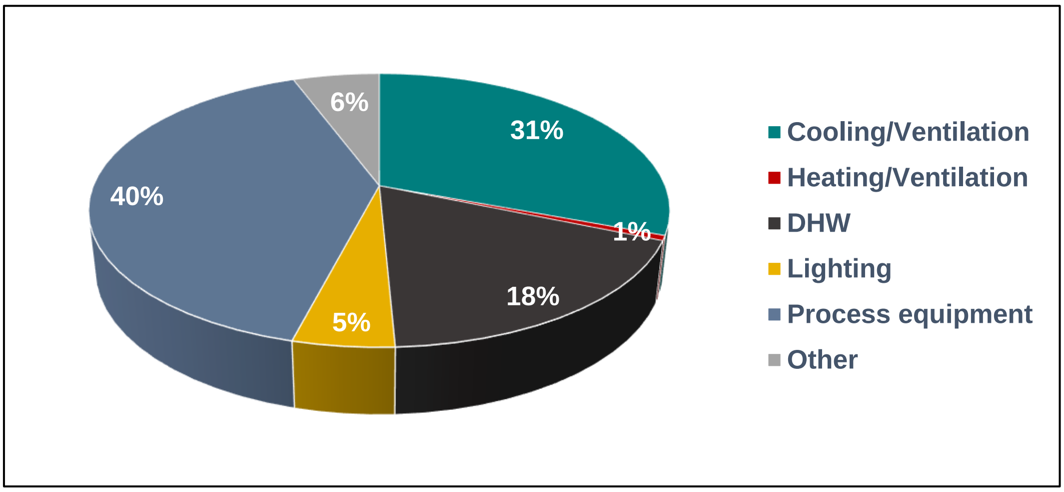

Figure 8: Cyprus seasonal four-star hotels

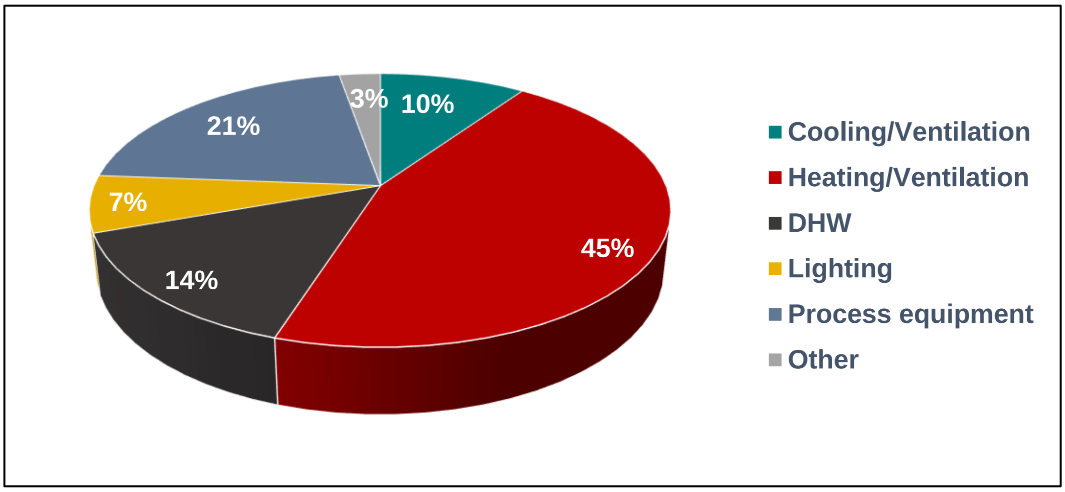

Figure 9: Cyprus non-seasonal four-star hotel in mountain area

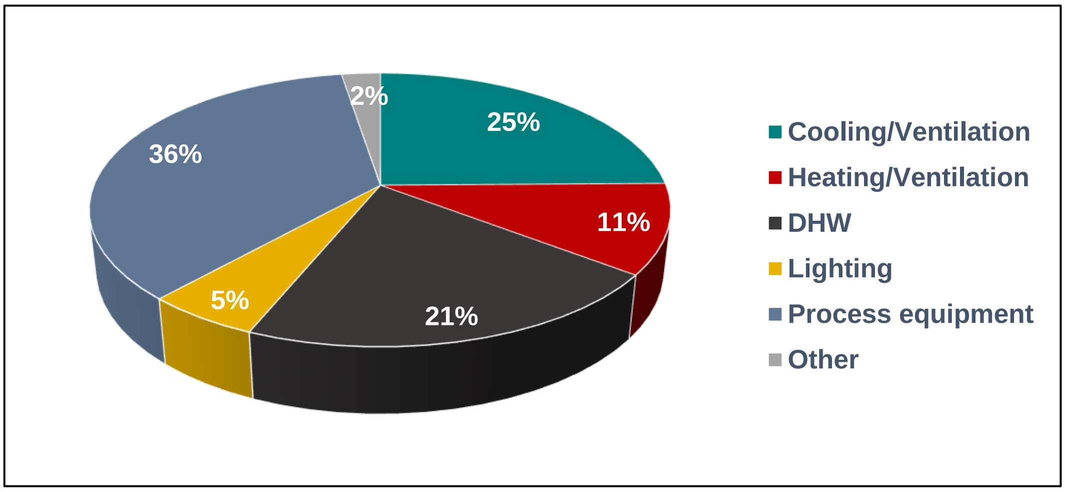

Figure 10: Cyprus non-seasonal five-star hotels

The most relevant conclusions of the analysis regarding the share of each segment in the total energy consumption of the Cyprus hotels, are highlighted below:

- **Process equipment** and **HVAC systems** (Cooling, Heating & Ventilation) are the largest energy consumers in all hotel categories accounting for around 40% and 35% respectively, totalling up to 75% share of total energy consumption of the hotels.
- Mountain hotels which are open throughout the whole year, have a significantly higher percentage of energy consumption for space heating compared to the coastal non-seasonal hotels, due to the lower temperatures in the mountain areas.
- Energy efficiency (SCOP, SEER), indoor temperature set-point, thermal insulation of the building envelope, floor area and weather conditions are among the main factors affecting energy consumption of the HVAC systems.
- **DHW production** has also a large percentage on the total energy consumption, accounting for around 20%.
- **Lighting** is not considered as a large consumer, with its proportion in the total energy consumption being around 5%. This is due to the wide use of LED technology in all hotels.
- **Other equipment** has the lowest contribution in the total energy consumption, with a share of up to 3%. Four-star seasonal hotels constitute an exemption, with the total share of other equipment in total energy consumption being equal to around 6%. This is mainly due to the fact that other equipment, which include the server and office equipment, are in operation throughout the whole year.
- It is observed that the energy consumption for heating in seasonal hotels, accounts only for 1% of the total energy consumption. This is attributed to the fact that during the seasonal hotels' operating months, the temperature in Cyprus rarely falls below 25 °C, so there is not much need for space heating.

The following table indicates the ranges of the final energy consumption in major areas of the Cyprus hotels, expressed in kwh/m^2/year.

Table 28: Final energy consumption per m^2 in major areas of Cyprus hotels participating in the survey

Energy carrier	Final energy consumption in major areas (kWh/m^2/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasonal	Non-Seasonal
Cooling/Ventilation	33,8 – 57,7	42,4 – 74,7	-	58,9 – 142,9
Heating/Ventilation	0,1 – 2,7	15,1 – 28	-	31,1 – 39,0
Lighting	3,6 – 8,5	7,9 – 13,8	-	8,4 – 17,7
Process Equipment	39,5 – 94,1	52,3 – 152,4	-	88,5 – 190,5

Non-seasonal five-star hotels compared to non-seasonal four-star hotels have higher energy consumption per unit area in all segments, mainly due to the reasons stated below:

- Five-star hotels offer some 24-hour services that require the continuous operation of HVAC systems, lighting and various process equipment.
- Full air-conditioning in all areas on five-star hotels results in higher thermal and electrical consumption related to cooling and heating needs.
- The number and operation hours of kitchen/restaurant/bar equipment are higher in five-star hotels, resulting in considerably higher energy consumption per unit area of the process equipment.

- Five-star hotels offer a variety of facilities and complexity of services which increase the energy consumption per unit area in all segments.
- The higher variety of foods served by a five-star hotel, results in higher energy consumption for their preparation.
- Five-star hotels normally have higher energy consumption per m^2 for lighting, mainly due to the installation of increased number of lights for the provision of a more stylish design (e.g. hidden lighting) in all areas.

As for the energy consumption for DHW, the analysis was on a per guest-night level, as it was regarded the most representative metric for comparisons.

Table 29: Final energy consumption per guest-night for DHW production in Cyprus hotels participating in the survey

Energy carrier	Final energy consumption for DHW (kWh/guest-night/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasonal	Non-Seasonal
Mean	4,5	6	-	8,5
Median	4,1	6	-	10,7
Range	0,4[14] – 10[15]	3,6 – 8[16]	-	3,2[17] - 12[18]

The most relevant conclusions of the analysis regarding energy consumption for DHW are highlighted below:

- Among the hotels analysed, those that use solely oil-fired boilers have the highest energy consumption per guest-night for DHW production.
- The hotels that replaced the oil-fired boiler with pellet-fired one show slightly lower energy consumption per guest-night for DHW production. This is mainly due to the higher energy efficiency of the new boiler.
- In general, the hotels which combine the main DHW heating system with solar thermal panels and heat recovery from the chiller, had significantly lower energy consumption per guest-night for DHW. Heat recovery technology recovers the waste heat discharged into the atmosphere during the operation of the chiller in cooling mode and as a result, “free” production of hot water is achieved. Seasonal and non-seasonal hotels with these systems (solar panels and heat recovery) in place have a typical annual energy consumption per guest-night of 3,2kWh and 5,5kWh respectively, while the corresponding average energy consumption for hotels without these systems in place was 4,3kWh and 7kWh.
- A typical hotel (based on the available roof space) can install around 80 solar panels (160m^2) and the energy saving for DHW production that can achieved is between 30-40%.
- Through the proper design and implementation of available technological solutions and systems, almost zero energy consumption for DWH production can be achieved. 2 out of 20 hotels that were surveyed managed to achieve that through combination of various systems as outlined below:

[14] Hotel which uses solar panels and heat recovery from VRF system in combination with hydrofree system.

[15] Hotel which uses solely oil-fired (34.700 L/yr.) boiler.

[16] The only non-seasonal four-star hotel that does not have solar panels in place.

[17] Hotel which uses oil-fired boiler in combination with solar panels and heat recovery.

[18] Hotel which uses solely oil-fired (107.900 L/yr.) and pellet (310 tn/yr.) boiler for the production of DHW.

- Hotel A (non-seasonal five-star) uses a new technology six-pipe simultaneous chiller that covers the hotels needs for space cooling and heating, producing at the same time domestic hot water with no additional energy consumption. That is achieved through highly efficient heat recovery. This system, in conjunction with the 45 solar thermal panels, can cover the total needs of the hotel for domestic hot water throughout the year.
- Hotel B (seasonal four-star) uses α VRF with hydrofree system. HydroFree, combined with the 3-pipe Set Free Sigma VRF system, offers the possibility to have “free” hot water production by recovering energy produced by the air conditioning system. 60 solar thermal panels installed on the hotel roof have significant contribution to the DHW production. The entire hotel needs for hot water are covered by these systems with minor additional electricity consumption.

5.1.2.2. Greece

The average share of each segment in the total energy consumption of the hotels in each category is illustrated in the following figures:

- **non-seasonal four-star hotels**[19]

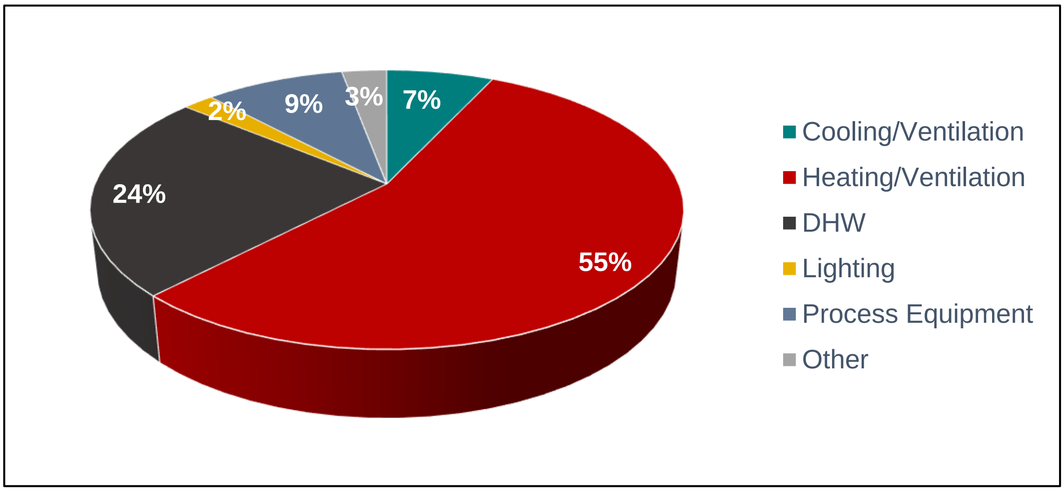

Figure 11: Greece non-seasonal four-star hotels

[19] The specific share of energy consumption is related to only one hotel in Greece which cannot be considered as a typical non-seasonal four-star hotel. Therefore, the share of the energy consumption of this graph should not be generalised.

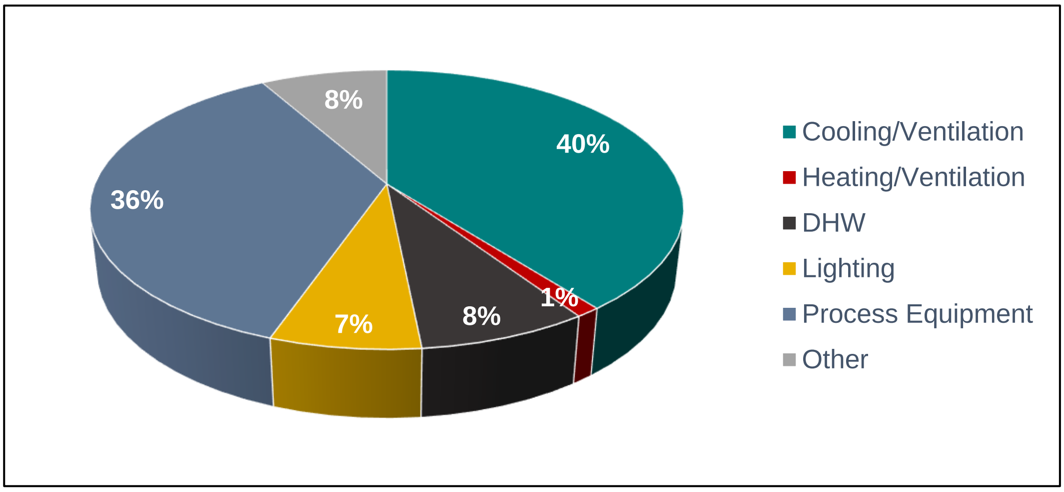

Figure 12: Greece seasonal four-star hotels

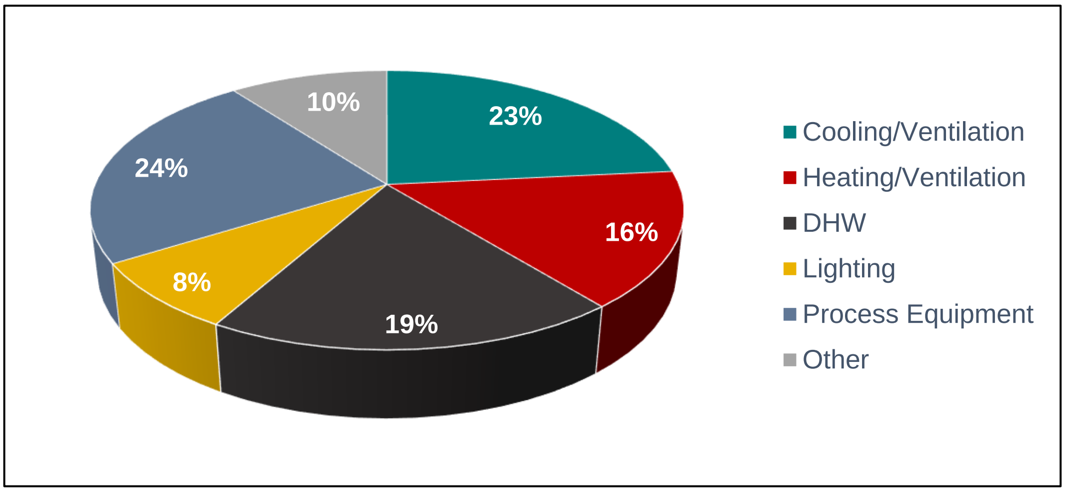

Figure 13: Greece non-seasonal five-star hotel

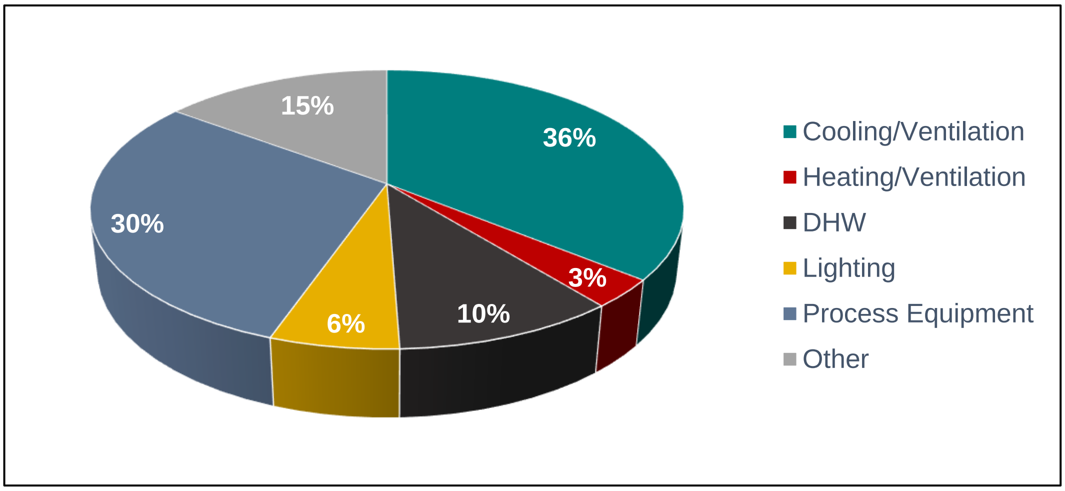

Figure 14: Greece seasonal five-star hotels

The most relevant conclusions of the analysis for Greece hotels are highlighted below:

- **Process equipment** and **HVAC systems** (Cooling, Heating & Ventilation) are the largest energy consumers in all hotel categories accounting for around 30% and 40% respectively, totalling up to 70% share of total energy consumption of the hotels. The process equipment percentage is higher to all-inclusive hotels
- **DHW production** has also a large percentage on the total energy consumption, accounting for around 20% in non-seasonal hotels and around 10% in seasonal hotels.
- **Lighting** is not considered as a large consumer, with its proportion in the total energy consumption being around 7%. This is due to the wide use of LED technology in all hotels.
- Energy consumption for heating in seasonal hotels is between 1-3% of the total energy consumption. This is explained by to the fact that during the seasonal hotels' operating months, the temperature in Greece rarely falls below 25 °C, so there is not much need for space heating.

The following table indicates the ranges of the final energy consumption in major areas of the Greece hotels, expressed in kwh/m^2/year.

Table 30: Final energy consumption per m^2 in major areas of Greece hotels participating in the survey

Energy carrier	Final energy consumption in major areas (kWh/m^2/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasonal	Non-Seasonal
Cooling/Ventilation	13,9 – 115	11,5	35,2 – 88,1	24,2 – 57,5
Heating/Ventilation	0 – 4	91,2	0 – 10,9	9,7 – 59,9
Lighting	1,3 – 14,4	3,3	5,9 – 12,2	7,1 – 29,5
Process Equipment	7,7 – 210,3	15	11,3 – 592,94	3,7 – 128

Table 31: Final energy consumption per guest-night for DHW production in Greece hotels participating in the survey

Energy carrier	Final energy consumption for DHW (kWh/guest-night/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasona l	Non-Seasonal
Mean	1,2	5,5	1,8	5,1
Median	1,0	5,5	1,9	4,6
Range	0,1 – 4,3	5,5	0,1 – 3,5	1,1 – 9,5

Photo: Creta Maris Beach Resort, Heraklion, Crete

5.2 GHG emissions performance indicators

The GHG emissions (kgCO_{2eq}./guest-night/year) outlined in Table 32, come from:

- The energy consumption (electricity and fuels) for the operation of the hotel.
- f-gases for the operation of air-conditioning and refrigerators.
- Waste, including solid waste and wastewater.

From the analysis, it was concluded that on average, around 75% of the total annual GHG emissions came from the energy consumption for the hotel operation, followed by the solid waste at around 24%. F-gases had the lowest contribution at around 1%.

One of the main factors for the increased total GHG emissions in some hotels is the existence of in-house laundry for which steam boilers are used, that require large amount of fossil fuels (heating diesel or LPG) for their operation. Also, the other factors that were mentioned in chapter 5 that result in increased energy consumption, will accordingly result in increased GHG emissions.

Table 32: GHG emissions per guest-night for the hotels surveyed in Cyprus and Greece

	GHG emissions ($kgCO_{2eq.}$/guest-night/year)			
	Cyprus		Greece	
	Range	Mean	Range	Mean
Four-star hotels	18,5 – 29,2	21,9	15,17 – 30,26	21,85
Five-star hotels	25,2 – 42,4	30,2	16,82 – 40,04	27,89

The increased amount of solid waste in five-star hotels is mainly due to the additional services and facilities they offer, the higher number of bars and restaurants, as well as the increased variety of foods they offer in their buffets that result in increased food waste.

Table 33: Solid waste per guest-night for the hotels surveyed in Cyprus and Greece

	Solid Waste (kg/guest-night/year)	
	Cyprus	Greece
Four-star hotels	2,6	2,2
Five-star hotels	3,2	2,8

The average weight of solid waste in the participating hotels in both countries is between 2,2 and 3,2 kg/guest-night/year. It was estimated that around 50% of the hotels' total solid waste concerns recyclable materials, 40-45% organic materials and the rest proportion other materials such as electrical and electronic equipment, batteries, bulbs etc. it is easy to realize that reducing organic waste can lead to significant decrease in solid waste and consequently to considerable decrease in GHG emissions.

Another worth-mentioned point from the evaluation of the results regarding solid waste is that the majority of the participating hotels recycle between 20% to 35% of their solid waste, including paper, PMD, glass, batteries, bulbs, toners, electrical and electronic equipment.

Photos: Nissi Beach Hotel, Ammochostos, Cyprus

6. Good Practices in the participating hotels

The majority of the hotels surveyed, have various practices and systems in place that contribute to their energy savings and GHG emissions reduction. In some hotels, the good practices in place have significant contribution to their energy savings, while in other hotels the contribution is not that significant. In any case, these good practices should be particularly highlighted in order to demonstrate potential approaches for other hoteliers. As part of the "Hotels 4 Climate" project, a platform[20] that demonstrates the 10 best practices in the participating hotels of each country (Greece, Germany and Cyprus) was developed.

Solar panels for DHW production can be considered the most common good practice in place both in Greece and Cyprus, with around half of the hotels having solar panels in place. Based on the available roof space, a typical hotel in Greece and Cyprus normally installs around 63 (appr. 130 m^2) and 80 (appr. 160 m^2) solar thermal panels, respectively. The energy saving for DHW production that can be achieved by such systems is between 30-40%.

Another common good practice in place in the Cyprus participating hotels is the **PV system**. Almost half of the Cyprus hotels surveyed have a PV system in place, however due to limited availability of roof space, their size is limited and their share in the total electricity demand is in most cases below 2%. Mainly due to architectural restrictions, the photovoltaic power plant installation within the hotel units in Greece has not yet sufficiently advanced. In some destinations, the installation of PV and solar panels is not permitted due to reasons of preserving the aesthetic of the scenery (traditional settlements, cultural heritage sites etc.).

The two most important good practices in place on participating hotels in Greece and Cyprus that have significantly high contribution to their energy savings and GHG emissions reduction, are outlined below:

6.1 Cyprus – Good Practices

6.1.1. Six-pipe simultaneous chiller & solar thermal panels

One of the participating hotels in Cyprus, which is a newly constructed non-seasonal five-star hotel, uses a **six-pipe simultaneous chiller** that covers the hotels needs for space cooling and heating, producing at the same time domestic hot water with no additional energy consumption. That is achieved through highly efficient heat recovery. This system, in conjunction with 45 **solar thermal panels** installed on the rooftop of the hotel, can cover the total needs of the hotel for domestic hot water throughout the year.

Figure 15: Six-pipe simultaneous chiller installed on the rooftop of the hotel

[20] https://www.oeb.org.cy/hotels4climate/

Figure 16: 45 solar thermal panels installed on the rooftop of the hotel

6.1.2. Voltage Optimizer

Five out of the twenty participating hotels in Cyprus have a voltage optimizer in place. This system cleans and conditions the incoming power supply. It optimises the incoming voltage by a set amount in order to match electrical equipment requirements on-site providing energy consumption savings.

In general, power from the electricity provider is supplied at a higher voltage than necessary as the electricity provider is required to ensure all buildings are supplied with voltage within set parameters. If a building is supplied at a higher voltage than necessary, it will likely result in a mass of wasted energy, excessive levels of carbon emissions, and higher than necessary electricity bills in addition to power quality issues, including increased wear and reduced lifespan of electrical equipment. In addition to reducing energy consumption, cutting carbon emissions and providing savings on electricity bills, voltage optimisation can also improve power quality by balancing phase voltages and filtering harmonics and transients from the network operators supply.

Voltage optimisation technologies are typically installed in series between the distribution transformer and the main low voltage distribution board, allowing the voltage optimization of the loads connected on the specific boards. It is estimated that voltage optimization can result in 7-9% reduction in the electricity consumption of the loads connected in the system.

Figure 18: Voltage Optimizer

Figure 17: Voltage Optimizer screen

6.2 Greece – Good Practices

6.2.1. Sea Water Air Conditioning (SWAC)

One hotel in Greece has installed a Sea Water Air Conditioning (SWAC) system. This system takes advantage of the sea water temperature to cool down the return of the circulation water before going through the chillers again. The measure exemplifies a high degree of innovation and has achieved significant reduction in the amount of the required energy for the operation of the four chillers. Theoretically, any hotel in close proximity to the sea could easily implement this technology, however it requires a considerably high amount of capital investment and there must be no special environmental restrictions applicable in each specific destination. The overall process for the operation of this systems is outlined in Figure 19.

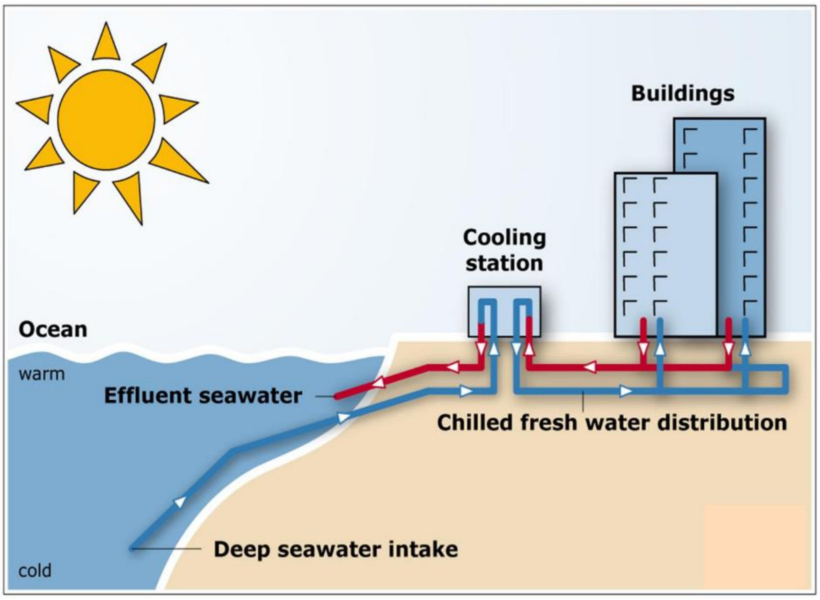

Figure 19: Sea Water Air Conditioning (SWAC) (Ecopower International, 2019)

6.2.2. Solar thermal Panels

A hotel in Greece has proceeded to the installation of around 500 solar panels (apr. 1.000m^2) for the production of DHW. The installation also combines a heat recovery system from the return of the Heating/Cooling system and is supported by two LPG-fired boilers in case of cloudy weather. Almost half of the solar panels were placed over the parking lot of the hotel providing shade for the parked cars, as shown in Figure 20. Although this technology is characterised by a low degree of innovation, it is considered extremely efficient and cost effective, especially in regions with high solar potential. Thus, as mentioned before it is already used on a large scale in hotels with adequate suitable space.

Figure 20: Solar panels placed on top of the parking lot

Figure 21: Solar panels placed on the rooftop of the hotel building

7. Conclusions

Significant conclusions regarding the energy performance and GHG emissions of Cyprus and Greece hotels were drawn throughout this study. The analysis and the report preparation required data collection and on-site visits to 20 hotels in Cyprus and 20 hotels in Greece, that took place between the end of 2019 and the end of 2020. For Cyprus, the sample consisted of six five-star and fourteen four-star hotel units, representing 22% of the total number (94) of five-star and four-star hotels in Cyprus. For Greece, the sample was comprised of nine five-star and eleven four-star hotel units, representing around 1% of the total number (2274) of four-star and five-star hotels in Greece.

The majority of the participating hotels, both in Cyprus and Greece, are located in coastal areas and they were constructed before 2007, when there were no energy performance requirements. As a result, the energy situation of most hotels that did not have any energy renovation, can be characterized as poor to moderate.

Reinforced concrete frames and bricks are among the most common materials used for hotels' construction in the two countries, while for those that have thermal insulation, the main insulating materials used are polystyrene and stonewool. Around 85% of the participating hotels have double-glazed windows.

Significant investments have been made in energy efficiency improvement in lighting and cooling systems, while not considerable investments were made in heating systems, with the majority of the participating hotels in both countries still using high energy-consuming and polluting systems.

Space Cooling

Space cooling constitutes one of the most energy-consuming segments of the participating hotels in both countries, with its total proportion on the total hotel energy consumption ranging between 20-40% (exempting the hotel located in mountain area). The main outcomes regarding space cooling in the participating hotels are outlined below:

- The majority of the participating hotels in Cyprus (90%) are using **chiller or heat pump chiller** for the main hotel's areas and usually AC split units and VRF systems for the auxiliary areas (i.e. Offices, conference rooms etc.).
- In Greece, around half of the participating hotels are using **chiller or heat pump chiller** for the main hotel's areas and usually AC split units and VRF systems for the auxiliary areas, while around 25% of the participating hotels are using **split units** for space cooling in all areas.
- The per unit energy needs for space cooling in hotels with no central cooling systems was higher compared to the hotels using a central system like chiller. In individual systems such as split units, the end user has the control of the set temperature, however in central systems the temperature as well as the operating time, can be set centrally by the chief engineer. The same applies to space heating systems.

DHW production

DHW production can also be considered a large consumer, accounting for around 10-20% of the total energy consumption of the participating hotels. The main results related to DHW production are as presented below:

- The predominant system used for the production of hot water in Cyprus and Greece is **fuel-fired boiler**.
- A big proportion of the Cyprus participating hotels (85%) use **heat recovery** from the chiller, for the production of hot water. In Greece, this percentage is lower (10%) as many hotels still use split units or decentralised systems.
- Almost half of the participating hotels in Cyprus and Greece have **solar thermal panels** in place that contribute to the production of hot water at a great extent.
- Among the hotels analysed, those that use solely oil-fired boilers have the highest energy consumption per guest-night for DHW production.

- In general, the hotels which combine the main DHW heating system with solar thermal panels and heat recovery from the chiller, had significantly lower energy consumption per guest-night for DHW. Seasonal and non-seasonal hotels with these systems (solar panels and heat recovery) in place have a typical annual energy consumption per guest-night of 3,2kWh and 5,5kWh respectively, while the corresponding average energy consumption for hotels without these systems in place was 4,3kWh and 7kWh.

Lighting

All participating hotels have proceeded to the energy upgrade of their lighting, replacing a high proportion (>70%) of their conventional lighting (halogen, Incandescent) with **LED technology**. Payback period for the replacement of conventional lighting with LED technology in Cyprus and Greece was estimated at 1-2 years.

General Conclusions

Some general worth-mentioned conclusions drawn from the analysis of the collected data, are outlined below:

- Usually, the higher the occupancy rate of a hotel, the lower the energy consumption per guest-night. This is mainly because of the operation of basic loads regardless the number of guests. These loads include:
    - lighting in lobby and common areas.
    - outdoor lighting.
    - cooling, heating and ventilation in common areas, bars, restaurants.
    - pool pumps.
- Energy consumption per guest-night is influenced by the occupancy rate and the services offered by the hotel (e.g. eating and leisure services, rooms and common areas size).
- The average energy consumption per guest-night of the participating hotels in Greece and Cyprus is illustrated in the table below:

Table 34: Average total Energy consumption per guest-night in the participating hotels

	Average total Energy per guest-night (kWh/guest-night/year)			
	Four-star		Five-star	
	Seasonal	Non-Seasonal	Seasonal	Non-Seasonal
Greece	13,5	23,1	19	23,9
Cyprus	22,9	29,8	-	39,5

- In general, the average total energy consumption per guest-night in the participating hotels in Cyprus is higher than the average total energy per guest-night in the participating hotels in Greece. This is mainly due to the higher number and variety of facilities offered by the participating four-star and five-star hotels in Cyprus.
- The overall higher energy consumption of the five-star hotels in both countries can be partially explained from the mandatory requirements/services for five-star hotels, which are optional for four-star hotels. Area of guestrooms, lobby area and other common areas of five-star hotels have higher minimum requirements compared to four-star hotels. Also, five-star hotels normally have higher number of restaurants, bars and they offer more luxurious services, corresponding to higher energy consumption.

- Cyprus hotels seem to consume less energy for space heating compared to the corresponding Greece hotels. This is mainly due to the slightly higher temperatures in Cyprus during Spring, Winter and Autumn, compared to Greece.
- On the other hand, Cyprus hotels usually consume more energy for space cooling in comparison to the corresponding Greece hotels. This can be attributed to the slightly higher temperatures in Cyprus during Summer, compared to Greece.

Comparison with European Hotels

Table 35 below summarizes the range of annual energy consumption per unit area (kWh/m^2) of the participating hotels in Greece and Cyprus, along with the corresponding consumption of hotels from various European countries (Buso, 2014) (Nigel Claridge, 2016). The star rating of the hotels in Slovakia, Latvia and Norway is not specified.

Table 35: Range of total energy consumption per unit area in hotels of various countries

	Energy consumption per unit area (kWh/m^2/year)
Greece participating 5 & 4* star hotels (Hotels4Climate) (2018-2019)	30 - 363
Cyprus participating 5 & 4* star hotels (Hotels4Climate) 5* & 4* (2018-2019)	123 – 462
Hotels in Slovakia (2006)	190 - 545
Hotels in Latvia (2010)	140 - 185
Hotels in Norway (2011)	220 - 296
4-star hotel in France (2015)	302

Practices to be avoided

During the on-site visits, it was observed that some hotels had various high energy-consuming equipment in continuous operation. Such operation, which can be considered as bad practice, results in high energy consumption that in most cases is not detected by the hoteliers. Some of the most worth-mentioned cases are outlined below:

- Continuous operation of a large toast griller with nominal power of 5kW. The specific electrical equipment was in operation for 20 hours per day, throughout the whole year. That is translated to approximately 2.700kWh of electricity consumption per month, corresponding to around 420 €/month.
- Continuous operation of a sauna with nominal power of 12kW. The sauna was in operation for 10 hours per day, throughout the whole year, resulting in around 3.200kWh energy consumption per month, which corresponds to approximately 500 €/month.

The continuous operation leads not only to energy and money waste, but it can reduce the lifespan of the equipment at a great extent. So, it would be preferable to operate the equipment according to the demand (on-demand operation), where this is possible.

Overall, such energy analyses are considered very helpful tools as they essentially assist a hotel group or company to comprehend the energy consumption areas and implement specific energy-saving measures.

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9. Annex

HOTELS ENERGY DATA COLLECTION QUESTIONNAIRE FOR CYPRUS AND GREECE

Work package (WP 1): Assessment of Cypriot and Greek hotel industry and its potential for GHG emission reduction

Output I: Assessment of the hotel market

*Baseline line year 2018 or 2019

*F-Gases data for 2019 are accepted

* Mandatory Fields

Date of completion:

A1.	GENERAL INFORMATION		
Contact person:			
Position			
Hotel name:			
Hotel address:			
Contact details:	Phone:	Fax:	Email:

A2.	GENERAL DESCRIPTION	
Year of construction		
Number of floors of the building		
Area of covered spaces		
Number of Rooms and Beds		
Number of guests		
Number of employees		
Annual average occupancy rate of the hotel (%)		
Months of operation		
Number of Swimming pools, Restaurants, Kitchens, Bars, Laundry, Gym, Saloon, Shops, Wellness center (Spa, Sauna)		
Electricity tariff		
EPC and energy class	Yes ☐ No ☐	If yes, Date:
Energy Audit (YES/NO)	Yes ☐ No ☐	If yes, Date:
Energy and Environmental Management Systems (e.g. ISO14001, ISO 50001, EMAS)		Since:

Inspection of Heating & Cooling Systems (YES/NO)	Yes ☐ No ☐
Energy/Environmental manager (YES/NO)	Yes ☐ No ☐

B	**RES ELECTRICITY**
Scheme	◻ **Net-metering** ◻ **Self-consumption/Net-Billing** ◻ **Feed-in tariff** ◻ **Other ....**
RES Technology (PV, Biomass, etc.)	
Power (kW)	
Contract Duration (In case of FiT)	
Feed-in price (€/kWh)	
Total electricity generated (kWh/year)	
Energy share/Self-consumption (%)	
GOs in kWh	
Date of installation/purchasing GOs	

C	**TYPICAL CHARACTERISTICS OF THE BUILDING**
Type of Building	Detached ☐ Semi-Detached ☐
Types of walls:	Without insulation ☐ With thermal insulation ☐ Construction materials: .... Comments: ....
Type of glazing:	Single glazing ☐ Double glazing ☐ Double glazing with thermal bridge ☐ Comments: ....
Columns and beams:	Without insulation ☐With thermal insulation ☐ Construction materials: .... Comments: ....
Roof type:	Horizontal ☐ Angled ☐ Thermal Insulation ☐ Construction materials: .... Comments: ....
Shading type:	Internal shading ☐ External shading ☐ Garden (trees deciduous/Evergreen) ☐ Comments: ....

D	TRANSPORT		
Fuel	**Diesel**	**Petrol**	**Electricity**
Number of vehicles			
Fuel Consumption (lt/yr)			
Battery capacity (kWh)			
Number of charges			
Mobile Air Conditioning			
Type of F-Gas:	**R-407C**	**R-410A**	**HFC-410a**
Charge (kg)			
Number of units (same charge)			
Comments/remarks:			

E	TECHNICAL CHARACTERISTICS OF HVAC SYSTEMS					
E1.1	**COOLING**					
E1.1.1	**SPLIT UNITS**					
Model						Server Room
Number:						
Cooling input (kW)						
Cooling output (kW)						
SEER						
Hours/day:						
Months/year:						
Type of F-Gas (e.g. R-407C, R 410A, HFC-32)						
Charge of F-Gas (kg/unit)						
Set Temperature Summer:	**°C**					
Comments/remarks:						
E1.1.2	**VRF**					
Model						
Number						
Cooling input (kW)						
Cooling output (kW)						

Number of Indoor Units						
Power of Indoor Unit (W)						
SEER						
Hours/day						
Months/year						
Type of F-Gas (e.g. R-407C, R 410A, HFC-32)						
Charge of F-Gas (kg/unit)						
Set Temperature Summer:	**ºC**					
Comments/remarks:						

E1.1.3	**CENTRAL COOLING (CHILLER/BOILER)**			
Model				
Fuel				
Number				
Cooling input (kW)				
Cooling output (kW)				
Fuel Consumption				
Mean of Distribution				
Number of AHU				
Power of AHU (kW)				
Number of Indoor Units				
Power of Indoor Unit (W)				
SEER				
Hours/day				
Months/year				
Type of F-Gas (e.g. R-407C R-410A, HFC-134a)				
Charge of F-Gas (kg/unit)				
Thermostat:	Central ☐ In zones ☐ Per room ☐	Yes ☐ No ☐	Central ☐ In zones ☐ Per room ☐	Yes ☐ No ☐
Timer:	Yes ☐ No ☐		Yes ☐ No ☐	
Consumption counter:	Yes ☐ No ☐		Yes ☐ No ☐	

Set Temperature Summer: ºC

Comments/remarks:

E1.1.4	FANS (WALL/FLOOR/CEILING)					
Number:						
Power (W)						
Hours/day						
Months/year						

Comments/remarks:

E1.2.	HEATING					
E1.2.1	**SPLIT UNITS**					
Model						
Number:						
Heating input (kW)						
Heating output (kW)						
SCOP						
Hours/day:						
Months/year:						
Type of F-Gas (e.g. R-407C, R 410A, HFC-32)						
Charge of F-Gas (kg/unit)						

Set Temperature Winter: ºC

Comments/remarks:

E1.2.2	VRF					
Model						
Number:						
Heating input (kW)						
Heating output (kW)						

Number of Indoor Units						
Power of Indoor Unit (W)						
SCOP						
Hours/day						
Months/year						
Type of F-Gas (e.g. R-407C, R 410A, HFC-32)						
Charge of F-Gas (kg/unit)						
Set Temperature Winter: ºC						
Comments/remarks:						

E1.2.3	**CENTRAL HEATING (CHILLER/BOILER)**			
Model				
Fuel				
Number				
Heating input (kW)				
Heating output (kW)				
Fuel Consumption:				
Mean of Distribution				
Number of AHU				
Power of AHU (kW)				
Number of Indoor Units				
Power of Indoor Unit (W)				
SCOP				
Hours/day				
Months/year				
Type of F-Gas (e.g. R-407C R-410A, HFC-134a)				
Charge of F-Gas (kg/unit)				
Thermostat	Central ☐ In zones ☐ Per room ☐	Yes☐ No ☐	Central ☐ In zones ☐ Per room ☐	Yes ☐ No ☐
Timer	Yes ☐ No ☐		Yes ☐ No ☐	
Consumption counter:	Yes ☐		Yes ☐	

	No ☐	No ☐
Set Temperature Winter: **ºC**		
Comments/remarks:		

E1.2.4	**FREE-STANDING HEATERS (WALL/FLOOR/CEILING)**					
Number						
Fuel						
Fuel Consumption						
Power (kW)						
Hours/day						
Months/year						
Comments/remarks:						

F	**HOT WATER USE**				
Type:	**Solar water heater**	**Electric water heater**	**Speed heater**	**Connect with Central Heating**	**Boiler**
Number of panels:					
Litres of cylinder:					
Total Power					
Hours/day					
Months/year					
Fuel					
Fuel consumption					
% of the total fuel consumptio used for DHW					
Comments/remarks:					

G	**MECHANICAL VENTILATION**			
	Exhaust fan	**Supply fan**	**WC fan**	
Number				

Power (W)				
Hours/day				
Months/year				
Comments/remarks:				

H	**LIGHTING**				
H1.	**INTERNAL LIGHTING**				
H1.1.	**LED**				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					
H1.2.	**CFL**				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					
H1.3.	**Fluorescence**				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					
H1.4.	**Halogen**				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					

H1.5.	Incandescent lamps				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					
H2.	OUTDOOR LIGHTING				
H2.1.	LED				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					
H2.2.	CFL				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					
H2.3.	Fluorescence				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					
H2.4.	Halogen				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					

H2.5.	**Incandescent lamps**				
Power					
Amount					
Hours/day					
Use of automation					
Comments/remarks:					

I	**ELECTRICAL AND ELECTRONIC EQUIPMENT**					
Kitchen Equipment:	**Number**	**Total power (W)**	**Typical Daily Operating Time**	**Energy label**	**Type of F-Gas (e.g. R-404A, HFC-134a)**	**F-Gas charge (kg)**

Fuel consumption of Kitchen equipment (e.g. LPG)						
Office Equipment:	**Number**	**Total power (W)**	**Typical Daily Operating Time**	**Energy label**	**Type of F-Gas (e.g. R-404A, HFC-134a)**	**F-Gas charge (kg)**
Tv						
Computer Monitor						
Computer						
Printer						
Photocopier						
Communications device Modem						
Server room						
UPS						
Room Equipment:	**Number**	**Total power (W)**	**Typical Daily Operating Time**	**Energy label**	**Type of F-Gas (e.g. R-404A, HFC-134a)**	**F-Gas charge (kg)**

Laundry Equipment:	**Number**	**Total power (W)**	**Typical Daily Operating Time**	**Comments**	**Type of F-Gas (e.g. R-404A, HFC-134a)**	**F-Gas charge (kg)**

Gym Equipment:	**Number**	**Total power (W)**	**Typical Daily Operating Time**	**Comments**	**Type of F-Gas (e.g. R-404A, HFC-134a)**	**F-Gas charge (kg)**
Saloon Equipment:	**Number**	**Total power (W)**	**Typical Daily Operating Time**	**Comments**	**Type of F-Gas (e.g. R-404A, HFC-134a)**	**F-Gas charge (kg)**
Other Equipment:	**Number**	**Total power (W)**	**Typical Daily Operating Time**	**Comments**	**Type of F-Gas (e.g. R-404A, HFC-134a)**	**F-Gas charge (kg)**

Biological station Equipment:	Number	Total power (W)	Typical Daily Operating Time	Comments

J	ELECTROMECHANICAL EQUIPMENT					
Equipment	**Number**	**Use (hours/day)**	**Use (days/month)**	**Use (months/year)**	**Power (kW)**	**Comments**
Compressed air						
Elevators						
Water pressure pumps						
Cooling (Chiller) pumps						
Heat recovery unit (pump)						
Circulation pumps						
Heating pumps						
Hot water circulation Pumps						
Sewage pumps						
Drainage pumps						
Pool pumps						
Sauna						
Stream bath						
Burner pump						
AHU pump						
Rainwater Pumps						

K	COGENERATION
Year of installation	
Form of energy produced	
Fuel consumption	
Electrical Power	

Efficiency	
Total electricity (kWh)	
Thermal Power	
Efficiency	
Total thermal energy produced (kWh)	
Comments/remarks:	

L	**ENERGY CONSUMPTION**					
Electricity Consumption	**Year 2017**		**Year 2018 (Baseline)**		**Year 2019**	
Period:	kWh:	€:	kWh:	€:	kWh:	€:
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Total year						

Fuel consumption:.............	**Year 2017**		**Year 2018 (Baseline)**		**Year 2019**	
Period:	............:	€:	............:	€:	............:	€:
January						

February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Total year						

Fuel consumption:............	**Year 2017**		**Year 2018 (Baseline)**		**Year 2019**	
	............:	€:	............:	€:	............:	€:
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Total year						

M	**WASTE & WASTEWATER**

Quantity of Wastewater (m3/yr)	
Wastewater treatment method	□ **On-Site** □ **Centralized/sewage**
	□ **Aerobic Treatment** □ **Anaerobic Treatment** □ **Both**
Quantity of Solid waste (m3/yr or tn/yr	
Solid waste treatment method	□ **On-Site (Press system)** □ **Central collection**
% of solid waste recycled	
Recycling Rate	□ **PMD ....** □ **Glass ....** □ **Paper ....** □ **Organic ....**

N	QUALITY QUESTIONS
Have you implemented any GHG reduction measures at your hotel? If yes, which were those measures?	
What are the main barriers that prevent you from implementing GHG reduction measures? (e.g. lack of financing, lack of technical knowledge etc)	
What do you think is the main energy consuming sector in your hotel?	
Is the reduction of GHG emissions at your hotel a top priority on your agenda?	
What is the maximum amount that you are willing to invest for GHG reduction measures?	