

Eliminating the Carbon Emissions in Hotels Due to Energy Use in the Island of Crete, Greece. A PESTEL Analysis

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ABSTRACT: Hotels require energy for meeting their energy demand in heat, cooling and electricity. They mainly utilize fossil fuels and grid electricity while the use of sustainable energies is rather limited. The island of Crete, Greece is a well-known and popular global tourism destination hosting more than six million tourists every year. The elimination of carbon emissions due to energy use in hotel buildings increases their environmental sustainability and their attractiveness to environmental conscious visitors. Solar energy is abundant in Crete, Greece while it is broadly used in several sectors for heat production with solar thermal systems and electricity generation with solar photovoltaic systems. The use of solar thermal energy, solar photovoltaic energy and low-carbon energy technologies can replace the conventional energy sources used in hotels and eliminate their carbon emissions due to energy use. Additionally, hotels can offset any remaining carbon emissions with the existing offsetting mechanisms. A PESTEL analysis regarding the decarbonization of the hotel industry in Crete has been implemented indicating the external factors which affect the elimination of their carbon emissions. The political, economic, social, technological, environmental and legal factors which impact positively or negatively their decarbonization have been identified. The results of the current study could be useful to hotel owners, to public authorities in Crete and to energy companies dealing with installation of benign energy systems.

KEYWORDS: Carbon emissions, Crete-Greece, decarbonization, energy, hotels, renewable energies

1. INTRODUCTION

Hotel buildings consume large amounts of energy compared to other types of commercial buildings while they emit harmful greenhouse gases (GHGs) [1], [2], [3], [4]. Climate change is a severe global environmental problem and its mitigation is necessary. Mitigation of climate change in hotel facilities can be achieved with the reduction of their energy consumption and the replacement of fossil fuels with zero-carbon energy sources [5], [6], [7]. Additionally, any remaining carbon emissions can be offset with the existing mechanisms [8], [9]. The tourism industry in the island of Crete, Greece is nowadays well-developed while the island is a well-known global destination. Cretan hotels mainly use conventional fuels for meeting their energy requirements while the use of renewable energies is rather limited [1]. Political, Economic, Social, Technological, Environmental and Legal (PESTEL) analysis is a methodological tool which helps organizations to make rational strategic decisions [10]. It examines the impacts of the abovementioned external factors to organizations' performance. PESTEL analysis has been used in several cases in tourism industry [11], [12], [13].

The aim of the current work is to conduct a PESTEL analysis regarding the elimination of carbon emissions due to operational energy use in hotels in the island of Crete, Greece.

The text is structured as follows: After the literature survey the tourism industry in Crete is analyzed followed by a short survey of energy consumption and carbon emissions in hotels. In the next two sections the decarbonization of tourism industry in Crete is presented followed by a description of PESTEL analysis in the tourism sector. After that, a PESTEL analysis regarding hotels' initiative to eliminate their carbon emissions in Crete is made while the text ends with discussion of the findings, the conclusions drawn and the citation of the references used.

The text is innovative since there are limited studies so far regarding PESTEL analysis of the tourism industry in Crete while it fills the gap regarding the analysis of external factors influencing the elimination of carbon emissions in Cretan hotels. The results could be useful to hotel owners, to policy makers, to energy companies and to several stakeholders of the local tourism industry.

2. LITERATURE SURVEY

The energy consumption and the use of renewable energies in five summer operating hotels in Crete have been evaluated [1]. The author stated that the average annual energy consumption was 149 kWh/m² (19.4 kWh per night spent) and their mean carbon emissions at 12.1 kgCO₂ per night spent (p.n.s.). The energy use in hotel chains examining 45 international hotel chains has been studied [2]. The authors identified various key factors which affect the

energy consumption in hotel chains. A report regarding the energy use in European hotels has been published [3]. The report stated that the average annual energy consumption in EU hotels is in the range 305-330 kWh/m². It is also mentioned that the annual CO₂ emissions is in the range 160-200 kgCO₂ per m². The energy consumption and the carbon emissions in three small-scale hotels in Crete have been estimated [4]. The author stated that these hotels utilized several renewable energy and low-carbon energy technologies including, solar-PV systems, solar thermal systems, electric batteries, solid biomass burning systems and high efficiency heat pumps. He also mentioned that one hotel had negative carbon emissions, the second zero carbon emissions while the third low carbon emissions. The decarbonization of the tourism sector in Baltic states has been studied [5]. The authors stated five decarbonization factors which indicate the degree of decarbonization including: a) air-travel GHG emission intensity, b) tourism GHG intensity, c) tourism energy intensity, d) share of trips by train, and e) dependence of distant origins. They mentioned that Estonia had the best results in decarbonizing its tourism sector. The carbon emission reduction in hotels' transformation has been calculated [6]. The authors stated that the construction of hotels has the largest share in their life-cycle carbon emissions while the high-star hotels have more carbon emissions than low-star hotels. A report regarding the decrease of GHG emissions in hotels located in Greece, Cyprus, Germany and EU has been published [7]. The report stated that there are several technologies which can be used in hotels reducing their carbon emissions. These include: a) solar thermal systems, b) solar-PV systems, c) heat pumps, d) heat recovery systems, e) LED lighting, and f) buildings' insulation. The role of carbon offsets in achieving carbon neutrality in hotels has been explored [8]. The author stated that there is a large number of carbon offset providers in the unregulated carbon offset market. She also stated that hotels need to know how carbon offsets can be used effectively in achieving carbon neutrality. The use of carbon offset programs in hotels has been examined [9]. The authors stated that several hotels in many countries have introduced carbon offset programs as an important environmental sustainability measure. They also mentioned that various hotels offer voluntary carbon offset programs for their guests while the programs offered by hotels include reforestation and renewable energy projects in developing countries. A PESTEL analysis to identify the key barriers in developing smart cities in India has been implemented [10]. The authors stated that social and political factors are the key barriers for the development of smart cities in India. They also mentioned that environmental and legal factors were the least important for the development of smart cities in this country. A PESTEL analysis regarding tourism destinations focusing on the development of business tourism in Croatia and Qatar has been realized [11]. The author stated that Croatia has the potential for business

tourism but it should develop its infrastructure for business travelers. She also mentioned that Qatar is a destination that is already positioned as a tourism destination for business tourism. A PESTEL analysis of the tourism sector in the city of Mugla, Turkey has been conducted [12]. The analysis was realized with the support of 150 top managers of 3-star, 4-star and 5-star hotels in the city. The results indicated that legal factors were the most important while social factors were the least important for the development of the tourism sector in Mugla. A PESTEL analysis regarding the development of virtual tourism in Crete, Greece has been realized [13]. The author analyzed the political, economic, social, technological, environmental and legal factors affecting virtual tourism in Crete. He stated that economic factors play a critical role in shaping the growth of virtual tourism in the island. The business dynamics in tourism industry have been studied [14]. The author stated that social and technological factors are the most influential affecting the business models in tourism industry. The travel and tourism competitiveness index in Egypt has been examined [15]. The author stated that Egypt has different indexes than other countries in Middle East and North Africa region. He also mentioned that Bahrain and Saudi Arabia have better indexes including labor market and human resources, ICT readiness and T&T prioritization. The macro environmental factors influencing the development of rural tourism in Lithuania have been analyzed [16]. The authors stated that five groups of macro environmental factors have been identified including: a) economic, b) socio-cultural, c) natural-ecological, d) political-legal, and e) technological. The economic indicators in the hotel industry in Crete surveying 160 hotels in the island have been examined [17]. The authors stated that for most hotels the payroll cost and the operating cost per bed is lower than those found in the literature. They also stated that the occupancy rate above which the hotel generates profit is particularly high in the level of 41-45%. The energy efficiency opportunities in hotels in Egypt have been explored [18]. The authors stated that the improvement of energy efficiency in hotels results in many benefits. They mentioned that the energy efficiency measures in hotels are low cost with low payback period. The reduction of carbon emissions in a medium-size hotel in Rhodes Island, Greece has been studied [19]. The authors introduced a solar-PV system with the net-metering regulations in the hotel estimating that its carbon emissions were reduced by 31% at an optimized cost. The gap between carbon offsetting attitudes and behaviors has been examined [20]. The authors stated that knowledge, trust and credibility impact tourists' attitudes in different manner and degrees. They also mentioned that objective knowledge has more significant impacts on attitudes than subjective knowledge. A study regarding the use of renewable energies in hotels has been implemented [21]. The study stated that five renewable energy technologies were promoted in hotels including:

solar thermal, solar passive, solar-PV, biomass and geothermal energy. These technologies were promoted in five EU regions while technical assistance was offered in 200 hotels for adopting these benign energy systems. The use of renewable energies in hotels has been reviewed [22]. The authors reviewing 61 articles stated that many hotels have adopted renewable energy technologies to promote their sustainability. They also mentioned that the clients have positive perceptions towards hotels using renewable energies. The adoption of renewable energies in hotels in Portugal has been explored [23]. The author stated that although hotel owners have positive perceptions regarding the use of renewable energies in hotels their adoption is low. He also mentioned that the reason for this gap is the unfavorable market conditions. A report regarding decarbonization in hotels has been published [24]. The report stated that hotels account for around 1% of the global carbon emissions. It is also mentioned that energy costs correspond at around 3-6% of their operating cost while they create around 60% of their total carbon emissions. A SWOT analysis regarding the elimination of carbon emissions due to energy use in Cretan hotels has been implemented [25].The analysis indicated that the elimination of carbon footprint in hotels has many benefits while it revealed various weaknesses and threats.

3. THE TOURISM INDUSTRY IN CRETE

Crete, the largest and most populous of the Greek islands, stands as a cornerstone of Greece's tourism industry. With its rich tapestry of history, culture, natural beauty and hospitality, Crete attracts millions of visitors each year. The island's economy is deeply intertwined with tourism, making it both a vital source of income and a driver of development for local communities.The allure of Crete lies in its diverse offerings. Historically, the island is home to the ancient Minoan civilization, considered the oldest in Europe. The ruins of the Palace of Knossos near Heraklion, dating back over 3,000 years, are among the most visited archaeological sites in Greece. Beyond history, Crete's traditional villages, vibrant local culture, and authentic

cuisine provide tourists with immersive and memorable experiences. Natural attractions further bolster Crete's appeal. The island boasts stunning beaches such as Elafonissi and Balos, crystal-clear waters, and dramatic mountain ranges. Hikers and nature lovers are drawn to the Samaria Gorge, one of the longest canyons in Europe, as well as other natural reserves and coastal paths. These features make Crete suitable not only for mass tourism but also for eco-tourism, adventure tourism, and wellness retreats. The infrastructure on the island has evolved to support its thriving tourism sector. Crete is serviced by two international airports—Heraklion and Chania—offering connections to major European cities. Numerous hotels, resorts, and short-term rentals accommodate a wide range of budgets. Additionally, efforts have been made in recent years to improve accessibility, upgrade transportation networks, and promote sustainable tourism practices. Tourism contributes significantly to Crete's GDP and provides employment for a large portion of its population, from hotel staff and tour guides to artisans and local farmers who supply the food and crafts demanded by visitors. The multiplier effect of tourism also supports related sectors such as agriculture, retail, and construction. However, challenges remain. The seasonal nature of tourism in Crete means that most economic activity is concentrated in the summer months, leaving periods of inactivity in winter. Over-tourism in some coastal areas has led to environmental degradation and strain on local resources. Moreover, the increasing presence of large hotel chains can threaten small, family-run businesses and disrupt traditional ways of life. To ensure the long-term sustainability of its tourism industry, Crete is embracing more responsible tourism strategies. These include promoting lesser-known inland destinations, encouraging off-season travel, investing in green technologies, and preserving cultural heritage sites. By balancing growth with conservation, Crete aims to maintain its unique character while continuing to welcome visitors from around the world. Table 1 indicates the characteristics of the tourism industry in Crete.

Table 1. Characteristics of the tourism industry in Crete

Surface of Crete	8,336 km ²
Length of coastline	1,040 km
Residents in Crete (Census 2021)	617,360
Hotels in Crete (2021)	1,644
Rooms in Crete (2021)	98,547
Beds in Crete (2021)	193,928
Beds in Crete/ beds in Greece (2021)	22.1 %
Average revenue per bed (2021)	13,943 Euro
Arrivals in Crete (2023)	6,327,366 tourists
Arrivals to Crete/arrivals to Greece (2023)	17.7 %
Overnight staying in Crete (2023)	34,342,891 bed-nights
Overnight staying in Crete/overnight staying in Greece (2023)	23.3%
Average days staying in Crete (2023)	5.43 days

Number of airports for tourists’ arrivals	3
Tourism intensity (2023)	55.63 bed-nights per resident
Tourism density (2023)	4,000 bed-nights per km ²

Sources: [4], [17]

4. ENERGY CONSUMPTION AND CARBON EMISSIONS IN HOTELS IN CRETE

Among the most pressing issues related to hospitality in Crete are high levels of energy consumption and the resulting carbon emissions. These challenges are particularly important in the context of climate change and sustainable tourism. Hotels are among the most energy-intensive buildings in the service sector. In Crete, energy demand in hotels is driven primarily by air conditioning, lighting, water heating, laundry services, and recreational amenities like swimming pools and spas. The warm Mediterranean climate, especially during the peak tourist season in summer, increases the need for cooling systems and water use. As a result, hotel operations consume large amounts of electricity and fossil fuels, especially when occupancy rates are high. The majority of Crete’s energy grid is still powered by oil-fired plants, although there is an increasing shift toward renewable energies. This reliance on fossil fuels means that most of the energy used by hotels results in substantial carbon dioxide emissions. Luxury and all-inclusive resorts, in particular, tend to have a much larger environmental impact due to more intensive services and amenities. Additionally, many hotels in Crete are older buildings that lack modern insulation or energy-efficient systems. Outdated infrastructure leads to excessive energy consumption for heating and cooling. Furthermore, because tourism is highly seasonal, most hotels operate at full capacity only during a few peak months, leading to inefficiencies in energy management during off-season periods. Several studies suggest that the average annual energy use by hotels is in the range 305-330 kWh/m² while their annual carbon emissions are in the range 160-200 kgCO₂/m² [3]. It has been reported that energy costs can represent around 3- 6% of a hotel's total operating budget while they account for about 60% of its carbon footprint [24]. Despite these challenges, there is growing awareness within the industry about the need to reduce energy use and carbon emissions. Some hotels have begun investing in solar panels for water heating, LED lighting systems, smart thermostats, and energy-efficient appliances. The adoption of green building certifications and participation in eco-label programs such as Green Key or ISO 14001 are encouraging steps in the right direction. Moreover, the integration of renewable energy sources—particularly solar and wind power—has great potential in Crete. With abundant sunshine and strong seasonal winds, the island is well-positioned to develop clean energy solutions that could power hotel operations with lower environmental impact.

5. DECARBONIZING TOURISM IN CRETE: ADDRESSING ENERGY USE FOR A SUSTAINABLE FUTURE

The growth of the tourism industry has come at an environmental cost, primarily due to the high levels of energy consumption associated with transport, accommodation, and other services. As the world confronts the climate crisis, decarbonizing the tourism sector in Crete is becoming a strategic and ethical necessity.

5.1 The Carbon Footprint of Tourism in Crete

The tourism sector in Crete is heavily dependent on fossil fuels. The most significant contributor to emissions is transportation, especially air travel. Most international tourists arrive via direct flights to Heraklion and Chania airports, and many rely on rental cars or coaches for local travel. In addition, hotels and resorts consume vast amounts of electricity for air conditioning, lighting, heating, water treatment, and leisure facilities such as pools and spas. In summer, when tourism peaks, Crete's energy grid is under considerable pressure. Much of the island’s electricity is still generated using oil-fired power plants, though there has been a gradual shift toward renewable energy. The seasonal and high-volume demand of the tourism industry intensifies greenhouse gas emissions during the most ecologically sensitive time of year, when heatwaves and water shortages are also most likely. A study in five small-scale summer operating hotels in Crete, Greece has indicated that their average annual energy consumption was at 149 kWh/m² (19.4 kWh/p.n.s.) while their average carbon emissions at 12.1 kgCO₂/p.n.s. [1]. In another study the energy consumption and the carbon emissions in three small-size hotels in Crete have been evaluated [4]. It was found that one hotel has negative carbon emissions, one zero-carbon emissions while the third has substantially reduced its carbon emissions at 1.68 kgCO₂/p.n.s. while it could zero them with the use of solar energy technologies.

5.2 The Need for Decarbonization

Decarbonization refers to reducing carbon dioxide emissions through low- or zero-carbon emission technologies and practices. For Crete, decarbonizing tourism is not only a matter of meeting international climate goals but also a pathway to preserving the very environment that draws visitors in the first place. Unchecked emissions contribute to rising temperatures, increased risk of wildfires, and loss of biodiversity—developments that directly threaten Crete’s long-term viability as a tourist destination. Beyond environmental concerns, the transition to cleaner energy and sustainable tourism models can also enhance the island’s image, attracting eco-conscious travelers and boosting the resilience of its economy.

5.3 Strategies for Reducing Operational Energy Use and Emissions

Use of energy saving techniques: Several energy saving techniques can be used in hotels. These include the insulation of the building envelope, the use of double-glazed doors and windows, the use of LED lighting, the use of motion sensor detectors, the use energy management systems, the recycle of rejected heat from various equipment et cetera.

Renewable Energy Integration: One of the most effective paths to decarbonization is the expansion of renewable energy infrastructure. Crete is well-suited for solar and wind energy generation while the connection of the island to mainland Greece’s grid through submarine cables is under development. Hotels and resorts can invest in on-site solar panels, energy-efficient appliances, and smart energy systems to reduce their reliance on fossil fuels.

Sustainable Transport Options: Promoting the use of electric vehicles (EVs), public transport, and non-motorized options like bicycles is essential. The installation of EV charging stations and incentives for car rental agencies to offer electric or hybrid models can lower the carbon footprint of tourist transportation. Additionally, improving public transportation systems to better serve popular tourist areas can reduce dependence on private vehicles.

Green Building Design: New hotel developments should follow green building principles, incorporating passive cooling, natural lighting, and insulation to reduce energy demands. Retrofitting existing buildings with energy-efficient technologies such as LED lighting, smart thermostats, and low-energy HVAC systems is equally important.

Behavioral Change and Awareness: Educating both tourists and tourism operators about energy conservation can have a measurable impact. Encouraging practices like towel reuse in hotels, switching off lights and air conditioning when not in use, and choosing eco-friendly activities helps reduce energy consumption. Tour operators can also design low-impact tours and promote destinations that are accessible without excessive travel.

5.4 Challenges and Opportunities

The path to decarbonizing tourism in Crete is not without obstacles. Initial costs of installing renewable systems and retrofitting buildings can be high, particularly for small, family-run businesses. There may also be resistance to change, especially if short-term profitability is perceived to be at risk. However, the long-term benefits are substantial. Not only does decarbonization help protect the natural environment, but it also aligns Crete with global trends in sustainable travel. Increasingly, tourists are seeking destinations that reflect their values regarding climate action and environmental responsibility.

6. PESTEL ANALYSIS AND ITS USE IN THE TOURISM INDUSTRY

The tourism industry is one of the most dynamic and multifaceted sectors of the global economy. Influenced by a wide range of external factors—from political shifts and economic trends to environmental concerns and technological innovation—tourism operators must constantly monitor and adapt to changes in the external environment. One of the most effective strategic tools for understanding these external influences is PESTEL analysis. This framework examines six key macro-environmental factors: Political, Economic, Social, Technological, Environmental, and Legal. By analyzing each of these dimensions, businesses in the tourism industry can make informed decisions, mitigate risks, and seize emerging opportunities.

6.1 Political Factors

Political conditions have a direct and often immediate impact on tourism. Government policies on travel, taxation, infrastructure investment, and safety can significantly influence tourist flows and business operations. Stability and security are vital in attracting visitors, as tourists tend to avoid destinations perceived as politically unstable or unsafe. For instance, countries experiencing conflict or political unrest often see sharp declines in tourism. On the other hand, government-led campaigns to promote tourism—such as visa liberalization, improved diplomatic relations, or investment in airport infrastructure—can greatly enhance a destination’s appeal. In this regard, PESTEL analysis helps tourism organizations assess the political climate of regions they operate in or plan to enter, guiding decisions on market entry, partnerships, or crisis preparedness.

6.2 Economic Factors

Economic trends shape both the supply and demand sides of tourism. Exchange rates, inflation, employment levels, and disposable income all affect how much people are willing and able to spend on travel. In times of economic prosperity, leisure travel increases, while economic downturns typically lead to reduced bookings, shorter stays, or shifts toward more budget-friendly options. For tourism operators, PESTEL analysis enables forecasting and strategic planning based on macroeconomic indicators. It helps determine pricing strategies, marketing targets, and investment timing. For example, tour companies might focus more on domestic travelers during global economic slowdowns or adjust offerings in response to fluctuations in foreign currency exchange rates.

6.3 Social Factors

Social and cultural trends heavily influence tourism patterns. Changes in demographics, consumer preferences, education levels, and lifestyle expectations all affect what tourists seek in a destination. There is growing interest in sustainable tourism, cultural authenticity, and personalized experiences, especially among younger and more educated travelers.

Understanding these social dynamics through PESTEL analysis allows tourism businesses to tailor their services accordingly. For example, a hotel chain may introduce eco-friendly practices to attract environmentally conscious travelers, or a tour operator might design experiences that align with cultural immersion trends.

6.4 Technological Factors

Technology has transformed nearly every aspect of the tourism industry. From online booking systems and mobile apps to virtual tours and AI-powered customer service, technological innovation offers new ways to enhance customer experience, streamline operations, and boost profitability. PESTEL analysis encourages businesses to stay ahead of technological trends, adopt digital tools, and consider tech-driven shifts in consumer behavior. For instance, social media platforms now play a vital role in destination marketing, while data analytics help personalize offerings and improve customer retention. Meanwhile, the integration of smart technologies in hotels—such as keyless entry, smart energy systems, and contactless payments—has become a competitive necessity.

6.5 Environmental Factors

Environmental concerns are increasingly important in tourism. Climate change, biodiversity loss, water scarcity, and pollution all have direct implications for the industry. Destinations that fail to manage environmental impact may suffer long-term damage to their natural assets, leading to a decline in tourism appeal and reputation. Tourism businesses use PESTEL analysis to evaluate environmental risks and align with sustainability goals. Eco-tourism, green certifications, and carbon footprint reduction strategies have become essential parts of the industry. For example, hotels may adopt energy-efficient systems and source food locally, while tour operators might focus on low-impact travel experiences. Moreover, climate-related considerations—such as rising sea levels or extreme weather events—affect long-term investment decisions and destination planning.

6.6 Legal Factors

The tourism industry is subject to a broad array of legal regulations, including labor laws, health and safety standards, consumer protection laws, environmental regulations, and international travel agreements. These laws vary significantly by country and must be continuously monitored to ensure compliance. Using PESTEL analysis, businesses can stay informed about legal changes and minimize regulatory risks. For example, the introduction of stricter visa requirements or health protocols can affect tourist arrivals, while updates in labor laws may influence staffing and operations. In the post-COVID-19 era, legal regulations surrounding hygiene, vaccination, and public health have taken on added significance for hotels, airlines, and other travel-related services.

6.7 Strategic Implications of PESTEL in Tourism

The value of PESTEL analysis lies in its holistic and forward-looking approach. By evaluating each factor, tourism businesses gain a comprehensive understanding of the external landscape in which they operate. This insight is critical for strategic planning, risk management, and long-term sustainability. In practice, a hotel group may use PESTEL analysis before expanding into a new region, assessing the political risks, market potential, consumer trends, legal requirements, and environmental concerns. Similarly, a destination marketing organization might apply the framework to design promotional campaigns that resonate with the current social climate or prepare contingency plans for economic or environmental disruptions.

7. PESTEL ANALYSIS OF DECARBONIZATION IN CRETAN HOTELS

The political, economic, social, technological, environmental and legal factors affecting the elimination of carbon emissions in Cretan hotels are presented below in tables 2, 3, 4, 5, 6 and 7.

Table 2. Political factors affecting the elimination of carbon emissions in hotels in Crete

1	Crete should comply with national and EU policy regarding the achievement of net-zero carbon emissions until 2050
2	The government supports the investment in solar energy as well as in other renewable energies which facilitate the decarbonization of hotels in Crete
3	The governmental foreign policy affects the incoming tourism from various countries which might impact positively hotels’ occupancy rate and profitability discouraging the realization of green energy investments
4	De-carbonization of hotels in Crete aligns with some of UN sustainable development goals
5	Wars, pandemics or political instability in countries located near Greece might decrease the number of visitors in Cretan hotels and the profitability of sustainable energy investments in them

Source: Own estimations

Table 3. Economic factors affecting the elimination of carbon emissions in hotels in Crete

1	The investment cost of sustainable energy systems which support hotels’ decarbonization is affordable while in many cases is subsidized by the government and by EU structural funds
2	The payback period of several sustainable energy investments in hotels in Crete is attractive
3	Hotels investing in low- or zero-carbon emission energy systems producing their own energy will not be

	affected by future increases in the price of fuels
4	Future economic recession in EU countries and Greece might adversely affect the number of visitors in Crete and the profitability of sustainable energy investments in hotels
5	Increasing tourism competition from other Mediterranean countries might affect the number of visitors in Crete and the profitability of sustainable energy investments in hotels
6	Cretan hotels might not have the financial resources required for the sustainable energy investments
7	There are many financing instruments supporting the green energy investments in hotels
8	Appreciation or depreciation of Euro compared to other currencies might affect hotels' occupancy rate and profitability discouraging the realization of green energy investments

Source: Own estimations

Table 4. Social factors affecting the elimination of carbon emissions in hotels in Crete

1	Local residents in Crete approve the sustainable operation of local tourism facilities
2	The water scarcity in Crete results in conflicts among hotels, farmers and local residents. Sustainable operation of hotels in Crete reduces these conflicts
3	Many visitors in Crete prefer to stay in environmental conscious accommodations while occasionally they might pay an extra fee for staying in these green accommodations
4	Sustainable energy investments in hotels result in local jobs creation that increases the prestige of hotels in local societies
5	Hotel owners and managers might not understand the concept of net-zero emission hotel and the potential benefits
6	Environmental conscious visitors to Crete affect positively the decarbonization of local hotel facilities
7	The lack of specialized technicians in the field of sustainable energies might delay the decarbonization of hotels in Crete

Source: Own estimations

Table 5. Technological factors affecting the elimination of carbon emissions in hotels in Crete

1	There are many mature and reliable low carbon energy technologies which can be used in Cretan hotels' decarbonization
2	New technology innovations in sustainable energy technologies, such as solar cooling, could promote their future use in hotels in Crete
3	Innovative semi-transparent solar photovoltaic panels allow their use in hotels in Crete
4	Solar thermal and solar photovoltaic systems are broadly used in Crete for hot water and electricity production. Heat pumps are also broadly used in hotels in Crete.
5	Installation of commercial li-ion batteries combined with solar electricity generation in hotels improves their energy management, their energy security and climate change adaptation

Source: Own estimations

Table 6. Environmental factors affecting the elimination of carbon emissions in hotels in Crete

1	The high solar irradiance in Crete favors the use of solar energy for hot water and electricity production
2	The necessity for climate change mitigation requires the replacement of fossil fuels with zero carbon energy sources in hotels
3	On-site generation of heat and electricity with renewable energies in hotels increases their adaptation to climate change
4	The rich solid biomass resources in Crete facilitates their use in hotels particularly in those located in rural areas
5	The high wind potential in various locations in Crete favors their use for power generation in nearby located hotels

Source: Own estimations

Table 7. Legal factors affecting the elimination of carbon emissions in hotels in Crete

1	Hotels are allowed to participate in energy cooperatives generating green energy for their needs
2	Local heritage protection and zoning may restrict visible roof-mounted solar panels, especially in protected or architectural zones, limiting solar-PV deployment in some areas

3	Bureaucratic procedures regarding licensing of sustainable energy investments in hotels do not facilitate the promotion of clean energy systems in them
4	The net-billing initiative allows the on-site solar electricity generation offsetting the grid electricity use in hotels

Source: Own estimations

8. DISCUSSION

A PESTEL analysis regarding the decarbonization of Cretan hotels due to operational energy use has been conducted. The political, economic, social, technological, environmental and social factors which might affect the elimination of carbon footprint in Cretan hotels have been identified. It has been indicated that there are many parameters which affect positively or negatively the decarbonization of hotel facilities in the island. Knowing these factors Cretan hotels can better navigate their way to environmental sustainability and to clean energy renovation. Our analysis is based on our personal and subjective views and cannot avoid our personal bias. It does not also prioritize the abovementioned factors according to their importance neither quantifies them. Further work should expand the current PESTEL analysis including the views of several stakeholders of the local tourism industry including local hotels’ associations. The local stakeholders of tourism industry might have more objective views on these issues. It should also compare our present results with the results of SWOT analysis which has been already realized on Cretan hotels’ decarbonization.

9. CONCLUSIONS

A PESTEL analysis regarding the elimination of carbon emissions due to energy use in hotels in the island of Crete, Greece has been conducted. Energy consumption and carbon emissions in hotels are a major sustainability concern in Crete. The hospitality sector must accelerate the shift toward energy efficiency and renewable energy to meet environmental goals and maintain the island’s appeal as a responsible, eco-friendly destination. The decarbonization of tourism in Crete is both an urgent necessity and an opportunity to future-proof one of Greece’s most treasured destinations. The Political, Economic, Social, Technological, Environmental, and Legal factors which affect hotels’ decarbonization have been identified. As decarbonization becomes mainstream, the interplay of PESTEL forces underscores that success requires coordinated action across policy, investment, technology, behavior, and regulation. Our results indicate that there are currently many external factors which favor the elimination of carbon emissions in Cretan hotels and various others which discourage that.

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