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Use of soft measures for achieving decarbonization in hotels

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Abstract

The global hospitality industry is growing steadily nowadays reflecting the increase in the global income and the willingness of many people to travel to several destinations. However, it accounts for around 6% in the global greenhouse gas emissions. Taking into account the global policies for climate change mitigation hotels and other tourism enterprises should reduce their carbon emissions replacing the use of fossil fuels with zero-carbon energy sources and technologies. Several studies have already indicated that the energy technologies required for the elimination of carbon emissions in hotels are mature, reliable and cost-efficient. However, hotels willing to eliminate their carbon footprint, apart from using green energy technologies in their properties, should use various low cost soft measures complementing their green energy investments. These soft measures, which do not involve energy investments, include energy monitoring, energy auditing, energy benchmarking, behavioral changes of the guests and the staff as well as offsetting of carbon emissions. These soft measures facilitate the elimination of the carbon footprint in hotels reducing the cost of the required clean energy investments. The results of this study could be useful to hotels' owners, to energy service providers and to various stakeholders of the hotel industry.

Keywords: *audit, behavioral change, benchmarking, decarbonization, hotels, monitoring, offset*

1. Introduction

The decarbonization of the hotel industry is an important priority in the current era of climate crisis. Energy use in hotels accounts for around 3-6% of their operating cost and around 60% of their carbon footprint [1]. It has been indicated the the required energy technologies for hotels' decarbonization are mature, reliable and cost-effective[1], [2], [3]). They include energy saving technologies, renewable energy technologies, high-efficiency energy technologies and energy storage technologies. All of them are related with investments in benign energy systems. However, apart from these technologies hotels' decarbonization requires several soft measures additional to energy investments. Soft measures facilitate the clean energy transition in hotels achieving their optimum way towards carbon neutrality. These soft measures include: a) energy monitoring, b) energy auditing [4], [5], c) energy benchmarking [6], [7], [8], d) behavioral changes of the guests and the staff [9], [1-10], [11], and e) offset of carbon emissions [12], [13], [14]. Energy monitoring provides accurate, real-time insight into how, when, and where energy is used, energy audit identifies opportunities for improvement while energy benchmarking compares energy consumption with hotel peers and recognized patterns.

The aim of the current study is the presentation of various soft measures which facilitate the elimination of carbon emissions due to energy consumption in hotels.

The paper is structured as follows: After the literature survey the energy consumption and the carbon emissions in hotels are stated. In the following three sections the energy monitoring, the energy auditing and the energy benchmarking in hotels are presented. Next, the behavioral changes of hotels' guests and the staff are descussed followed by the presentation of carbon offsetting measures in hotels. The text ends with discussion of the findings, the conclusions drawn and the citation of the literature used.

The text is innovative since there are not many studies regarding the use of the abovementioned soft measures in hotels' decarbonization while it covers an existing gap in hotels' decarbonization. It could be useful to hotels' owners and hotels' associations as well as to policy makers and those involved in the decarbonization of the economy in the next decades.

2. Literature survey

A report on decarbonizing the hotels for a sustainable future has been published [1]. The report stated that energy costs

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represent 3% - 6% of hotels' operating costs and create around 60% of their carbon footprint. It is also mentioned that the embodied carbon accounts for 30%-70% of hotels' life-cycle carbon emissions. Additionally, it is stated that substantial energy renovation measures in existing hotels could reduce their carbon emissions up to 75% decreasing their initial carbon emissions from around 60-70 $kgCO_2$ per m^2 per year to around 15-20 $kgCO_2$ per m^2 per year. A report regarding the reduction of GHG emissions in the hotel sector has been published [2]. The report describes the opportunities for energy savings and decrease of CO_2 emissions in hotels. The measurement of the carbon footprint and the methodology for decreasing it are also mentioned. A report regarding the transformation of existing hotels to net-zero carbon hotels has been published [3]. The report stated that energy consumption represents between 3% and 6% of the operating cost in hotels while it is responsible for around 60% of their carbon emissions. Energy audits in 4-star and 5-star hotels in Nairobi, Kenya have been conducted [4]. The authors studied 10 hotels and stated that all of them have adopted energy conservation measures. However, they mentioned, during the last three years only 55.83% of hotels have improved their energy performance although their energy saving potential is high. The eco-efficiency and the energy audits in hotels located in Bali-Indonesia have been studied [5]. The authors stated that energy audits and eco-efficiency significantly affect the environmental performance in hotels. A data analysis to benchmark the energy consumption in hotels located in Nigeria has been realized [6]. The authors stated that more than 70% of the electricity was used in heat, ventilation and air-conditioning (HVAC) systems while grid-supplied electricity accounted for most of the hotels' energy needs. An energy benchmarking methodology for hotel buildings. Has been developed [7]The authors conducted an analysis of 50 hotels located in Da Nang, Viet Nam stating that their average annual energy intensity was 87.4 kWh/m^2 (8,628.6 kWh/room). They also mentioned that the occupancy rate had no significant impact on the energy intensity. The carbon, energy and water indexes for hotels have been explored [8]. For harmonizing the data the authors selected the following units. a) energy in kWh/m^2, b) water in liters, c) floor area in m^2, and d) greenhouse gases (GHG) in $kgCO_2eq$. The sustainable behavior of guests in hotels has been reviewed [9]. The authors analyzed 9 papers comprising 13 studies. They found several interventions increasing sustainable behavior including towel reuse, environmental appeals, messages for promoting conservation, donation to charities, social norms and nudges. The attitudes, behaviors and practices of tourists and the staff regarding hotels' sustainability have been examined [10]. The authors stated that there are improvements in hotels' sustainability related to technological approaches. However, there is lack of systematic long-term studies related to behavioral interventions, their impacts on hotels' sustainability and the reduction of their emissions. The factors that affect the environmental sustainability behavior in Malaysian hotels have been studied [11]. The authors collected and analyzed 234 qestionnaires from hotels in Malaysia. They stated that personal values, environmental awareness and environmental attitudes had a significant relationship with environmental sustainability behavior. The use of carbon offsetting programs in hotel industry have been studied [12]. The authors stated that hotels located in many countries have introduced carbon offset programs. They also mentioned that individual hotels which are not part of a global hotel chain are also using carbon offset programs. The role of carbon offsets in acheiving carbon neutrality in hotels has been explored [13]. The author stated that, in theory, carbon markets assist hotels in reducing the carbon footprint by purchasing carbon offsets. She mentioned that the claim "carbon neutral" is used often to attract green consumers while the claims of carbon neutrality in hotels can be exaggerated. A report on sustainable carbon credits strategy for the hospitality industry has been published [14]. It is stated that carbon emissions during hotels' operation are in the range 160-200 $kgCO_2e$ per m^2 per year while hotels have to pay around 10-12 per m^2 to completely offset their carbon emissions if they purchase carbon credits at the price of EU emissions trading system in 2023. The literature regarding the benchmarking of energy consumption in hotels has been reviewed [15]. The author stated that the main metric to measure energy consumption was the energy consumption divided by the floor area. He also mentioned that the average energy intensity in 1,494 hotels was 273.9 kWh/m^2. Benchmarking of the energy performance of hotel buildings in Hong Kong has been conducted [16]. The authors stated that it is difficult to evaluate the energy performance in hotel buildings bacause they have different buildings' design and operational characteristics and requirements. They also mentioned that hotels have many opportunities to improve their energy efficiency. The energy efficiency indicators in hotel buildings have been examined [17]. The authors stated that the main indicator to measure the energy intensity in hotels is kWh/m^2 year. They also mentioned that hotels in the tropics consume more energy than hotels in temperate zones while 4-star and 5-star hotels consume the most energy. The energy audit as a method for energy conservation in hotels has been studied [18]. The authors stated that energy audits are necessary before using various sustainable energy technologies in hotels. They also mentioned that luxury hotels consume significantly higher amounts of energy compared to low star hotels. The enhancement of energy efficiency in hotels has been examined [19]. The authors examined the use of smart HVAC systems, the energy management technologies and the use of renewable energies in hotels. They stated that these strategies reduce the energy consumption and the carbon emissions in hotels while they achieve significant financial savings. The energy consumption intensity indicators for conducting benchmarking in hotel industry interviewing several stakeholders' groups have been studied [20]. The authors proposed the use of several metrics such as: energy use intensity, energy use per guest night and energy use per net revenue. They also stated that the primary energy consumption in kWh must be calculated. The benchmarking data for Indian hotels have been analyzed [21]. The authors used data from 133 hotel buildings while 131 variables were collected. They conducted a regression analysis in these hotels

*Corresponding Author: Vourdoubas John

using a depended variable - the energy consumption in kWh - and as independed variables the climate zone, the stars of the hotel, the number of rooms and the covered area per room. The hotels' sustainability practices and the guests' attitudes and behaviors in Kazakhstan have been explored [22]. The authors stated that social and environmental factors play a positive role in guests' satisfaction while the economic factors and familiarity are likely to improve their satisfaction. The use of green management tools for promoting sustainability in a hotel located in Czechia has been investigated [23]. The authors reported several measures which improved the sustainability in the hotel comprising: collaboration with suppliers near the hotel, choosing local employees, training the staff, minimizing the packaging, recycle of the organic wastes in local farms, recycle of fried vegetable oils, use of LED lamps and use of various water saving measures. The impacts of sustainability practices on satisfaction of young guests in hotels in India have been examined [24]. The authors analyzed data from 505 young professionals traveling for work and staying in mid-priced hotels. They stated that these guests revisited and recommended hotels which have sustainable operation maintaining a satisfactory comfort level. The energy consumption and the use of renewable energies in hotels in Crete, Greece have been estimated [25]. The author analyzing data from five summer operating hotels in Crete stated that their average annual energy consumption was at 149 kWh/m^2 while their average carbon emissions were at 12.1 kgCO_2 per night spent (p.n.s.). An analysis on energy use by European hotels has been published [26]. It is stated that for most hotels the annual energy use falls in the range of 200-400 kWh/m^2 while the average annual energy use falls in the range of 305-330 kWh/m^2. It is also mentioned that their carbon emissions due to energy use vary in the range 160-200 kgCO_2/m^2 year. The energy consumption and the carbon emissions in three small- size hotels using clean energy technologies in their properties have been evaluated [27]. The author stated that these hotels use several benign energy sources and technologies such as: solar thermal, solar photovoltaic, solid biomass burning, heat pumps and electric batteries. He also mentioned that one hotel had negative carbon emissions, the second zero-carbon emissions while the third low-carbon emissions. The carbon reduction strategies by the hospitality sector in Zimbabwe have been studied [28]. The author analyzed 165 accommodation entities stated that their main sources of GHG emissions came from diesel-powered generators, transport and electricity use. A global hotel decarbonization report has been published [29]. The report stated that the global hotel industry will need to reduce its GHG emissions per room per year by 66% from 2010 levels by 2030 and 90% by 2050. It is also mentioned that hotel industry should be more efficient, more renewable and more electrified while the necessary technologies to fully decarbonize the hotel sector exists to day. The carbon emissions of staying in a hotel have been calculated [30]. Calculations in 38 different countries have been conducted indicating that hotels in Asia have the highest carbon emissions per night spent. It is also mentioned that the highest emissions are in Maldives' hotels at 152.2 kgCO_2e per hotel room per night while the lowest in Costa Rica's hotels at 4.7 kgCO_2e per hotel room per night.

3. Energy consumption and carbon emissions in hotels

Hotels operate 24 hours a day, seven days a week, making them one of the most resource-demanding segments of the commercial building sector. This high energy use translates into significant carbon emissions, especially when electricity and heat are generated from fossil fuels. As the urgency to combat climate change grows, understanding and addressing the relationship between hotels' energy consumption and carbon footprint is essential. The construction of hotels requires energy (embodied energy) and results in carbon emissions (embodied carbon). It is estimated that the embodied carbon corresponds at around 30-70% of the life-cycle carbon emissions in hotels [1].

Although exact figures vary by location, size, hotel category, type of construction and service level, current research identifies some common patterns:

a) Heating, Ventilation, and Air Conditioning (HVAC): 40–50% or even higher of total energy consumption in many hotels. Maintaining comfortable temperatures in rooms, lobbies, and meeting spaces is often the single largest demand.
b) Lighting: 15–25%, depending on the efficiency of fixtures and the level of natural daylight available.
c) Water Heating: 10–15%, especially in properties with extensive laundry operations, spas, or pools.
d) Kitchen Operations: 5–10%, including cooking, refrigeration, and dishwashing.
e) Other Loads: Laundry facilities, elevators, office equipment, and entertainment systems contribute the remainder.

It has been reported that for most hotels, energy use falls in the range 200-400 kWh/m^2 year [26]. A "meta-analysis" (combining data from all the various studies) suggests that average energy use by hotels is in the range 305-330 kWh/m^2 year. Most of this energy is derived from fossil sources, and the hotel sector's contribution to global warming and climate change, is estimated to include annual releases between 160 and 200 kg of CO_2 per m^2 of room floor area, depending on the fuel mix used to provide energy [26].

Luxury hotels and resorts tend to have significantly higher energy consumption per guest than budget hotels, due to larger room sizes, more extensive amenities, and higher service standards. The environmental impact of hotels' energy use during their operation depends largely on the carbon intensity of their energy sources. In many regions, electricity is generated primarily from coal, oil, or natural gas, which emit significant amounts of carbon dioxide (CO_2) per kilowatt-hour. On-site fuel use, such as natural gas for boilers, adds to direct emissions. According to current estimations the accommodation sector contributes roughly 21% of tourism-related carbon emissions. Without targeted action, this share is likely to rise as tourism grows. If the electricity grid remains

*Corresponding Author: Vourdoubas John

fossil-fuel-based, every kilowatt-hour saved through efficiency or renewable energy adoption directly reduces emissions. Table 1 indicates the energy consumption and the carbon emissions in hotels.

Table 1. Energy consumption and carbon emissions in hotels

Reference	Country, year	Annual energy use (kWh/m^2)	CO_2 emissions
Hotel Energy Solutions	EU countries, 2011	200-400	160-200 $kgCO_2/m^2$ year
Schick	Various countries, 2024	273.9	
Decarbonizing hotels for sustainable future	2024		60-70 $kgCO_2/m^2$ year
Circular economy	Several countries, 2023		4.7 - 152.2 $kgCO_2$ per room per night
Nguyen et al	2019, Viet Nam	87.4	
Vourdoubas	2016, Greece	149	12.1 $kgCO_2$ per night spent

Source: various authors

4. The Role of Energy Monitoring in Decarbonization of Hotels

One of the most impactful strategies to achieve decarbonization is the systematic monitoring of energy consumption, enabling hoteliers to understand, manage, and ultimately reduce their carbon footprint. Energy monitoring refers to the continuous collection, measurement, and analysis of energy usage data within a facility. In hotels, this process involves tracking the consumption of electricity, gas, water heating systems, and sometimes renewable energy outputs. Modern energy monitoring systems typically consist of:

a) Smart meters**:** Measure electricity and gas consumption in real-time.
b) Sensors**:** Track environmental conditions and occupancy.
c) Data management platforms**:** Aggregate and visualize data for analysis.
d) Automated controls**:** Integrate with building management systems (BMS) to adjust operations based on energy insights.

The purpose is not just to measure but to translate raw data into actionable insights that support carbon reduction strategies. Energy monitoring plays a critical role in hotel decarbonization for several reasons including baseline establishment. To reduce emissions, hotels must first know their starting point. Monitoring establishes an accurate baseline for:

a) Total energy use (kWh or MJ).
b) Carbon intensity (kg CO_2e per occupied room night or per m^2).
c) Seasonal patterns and peak loads.

Without these baselines, targets are speculative and progress cannot be quantified. Hotels often suffer from "hidden" energy waste such as:

a) HVAC running in unoccupied rooms.
b) Inefficient lighting in low-traffic areas.
c) Kitchen equipment left on outside service hours. Monitoring highlights these inefficiencies, enabling corrective actions.

Sustainability commitments require year-on-year verification. Energy monitoring provides auditable data, proving that interventions (e.g., LED retrofits, solar photovoltaic installation) are delivering expected emission reductions. Energy monitoring is not simply a technical add-on; it is the strategic backbone of hotel decarbonization. By providing accurate, real-time insight into how, when, and where energy is used, hotels can target interventions that yield measurable carbon reductions, operational savings, and competitive advantages.

5. The role of energy audits in the elimination of carbon emissions in hotels

One of the most effective strategies in the clean energy transition in hotels is the energy audit**,** a systematic process of evaluating a building's energy use to identify opportunities for improvement. Energy auditing serves as a diagnostic tool to pinpoint inefficiencies, recommend cost-effective measures, and create a roadmap toward carbon-neutral operations. In the context of hotels, energy audits play a pivotal role in both reducing operational costs and minimising carbon footprints, ultimately contributing to the elimination of emissions over the long term. An energy audit is a systematic inspection, analysis, and evaluation of energy flows in a building, process, or system, with the objective of understanding energy consumption patterns and identifying opportunities for improvement. In hotels, the goal is to achieve optimal energy efficiency while maintaining or enhancing guest comfort. Energy audits typically follow three levels:

a) Preliminary Energy Audit

It involves quick assessments to identify major problem areas while it is often based on utility bills, visual inspections, and basic measurements.

b) General Energy Audit

It includes detailed data collection and analysis of energy consumption while it Identifies savings opportunities with estimated costs and benefits.

*Corresponding Author: Vourdoubas John

c) Detailed Energy Audit

It involves comprehensive monitoring, simulations, and economic evaluations while it forms the basis for large-scale investment decisions, such as renewable energy systems or HVAC replacements.

Energy auditing stands as one of the most powerful tools available to hotels seeking to eliminate carbon emissions. By identifying inefficiencies, enabling renewable integration, and providing a structured pathway toward sustainability, energy audits offer both environmental and financial rewards**.**

6. The role of energy benchmarking in the decarbonization of hotels

Energy benchmarking is the process of measuring a building's energy use, normalising it for variables such as size, climate, and occupancy, and comparing it with:

a) Historical performance (internal benchmarking).
b) Industry peers (external benchmarking).
c) Recognised performance standards (standard-based benchmarking).

By contextualising these figures, hotels can understand how efficient they are relative to themselves over time and to similar properties in comparable markets. Several key metrics are used in hotel energy benchmarking that directly tie into decarbonization such as:

a) Energy Use Intensity**:** Energy consumed per square metre or per available room.
b) Carbon Intensity**:** Kilograms of CO_2 equivalent emitted per m^2 or occupied room night.
c) Utility consumption breakdowns: Electricity, gas, heating oil, or renewable energy contributions.

Energy benchmarking is a cornerstone of hotel decarbonization. By measuring, normalising, and comparing performance, it provides the insight necessary to identify inefficiencies, prioritise interventions, and verify progress towards carbon reduction goals. For hotels, benchmarking offers a strategic advantage: it not only drives environmental performance but also improves profitability, enhances brand reputation, and ensures compliance with evolving regulations.

7. The role of behavioral changes of tourists and employees in the decarbonization of hotels

Behavioral changes from both tourists (guests) and employees represent a powerful, often underestimated, lever for reducing carbon footprints. Technical upgrades in hotels such as solar photovoltaic panels, LED lighting, and efficient HVAC systems are essential, but they require capital investment and time to implement. Human behavior, by contrast, can change rapidly and often at low cost. For example:

a) A guest deciding to reuse towels instead of requesting daily laundering can save both water and energy.
b) An employee diligently turning off unused equipment can avoid "phantom loads" and unnecessary energy waste.

Behavioral changes matter because even in a high-tech, energy-efficient hotel, improper use by guests or staff can undermine performance. Conversely, conscious behavior can amplify the benefits of existing technologies.

Tourists often treat hotel stays as an escape from routine, which can lead to less sustainable behavior—leaving lights on, taking long showers, or overusing air conditioning. Overcoming this "vacation indulgence" mindset is a challenge but not insurmountable.

Low-Carbon Practices for Tourists include: a) Energy-conscious use of amenities, b) Water conservation, c) Food-related choices, d) Mobility choices, and e) Waste minimization.

Hotels can facilitate these changes by making sustainable choices more convenient than unsustainable ones. For example:

a) Installing keycard systems that automatically cut electricity when the guest leaves.
b) Providing reusable bottles and clear water refill stations.
c) Offering appealing vegetarian dishes in prominent menu positions.

Employees interact with hotel systems daily—housekeeping, kitchen, maintenance, and front desk operations all influence energy and resource use. Staff can either uphold sustainability standards or undermine them through neglect or outdated habits. To encourage lasting behavioral change, management should:

a) Train employees in sustainability principles and link them to job performance metrics.
b) Recognize and reward staff who consistently demonstrate low-carbon practices.
c) Empower employees to suggest improvements and innovations for reducing resource use.

Behavior change is most impactful when tourists and employees reinforce each other's actions. Behavioral changes, when supported by infrastructure, policy, and culture, can produce rapid, low-cost emissions reductions while also fostering a deeper sense of shared responsibility. Decarbonizing the hotel sector is not solely a matter of installing solar panels or retrofitting HVAC systems—it is also about shaping the everyday actions of the people who use and operate these spaces. Tourists' decisions—whether to take a shorter shower, switch off a light, or choose a vegetarian meal—aggregate into significant carbon savings. Employees' diligence in efficient housekeeping, energy management, and guest engagement ensures that sustainability goals are met consistently.

*Corresponding Author: Vourdoubas John

8. The role of carbon offsetting in the decarbonization of hotels

Among various sustainability strategies, carbon offsetting has emerged as a pivotal tool for mitigating greenhouse gas emissions. In particular, hotels, which are energy-intensive operations, are turning to carbon offsetting as a pathway to environmental responsibility.

Carbon offsetting can be realized in two markets, the voluntary and compliance markets. The voluntary market allows companies, organizations, or individuals to purchase carbon credits on their own initiative, usually to demonstrate climate responsibility, enhance reputation, or meet internal sustainability goals. Participation is optional, and standards vary across certifiers. In contrast, the compliance market is regulated by governments under schemes like the EU Emissions Trading System or the Kyoto Protocol. Here, companies must offset emissions to meet legally binding caps, and only credits from approved projects are valid. Thus, compliance offsets are mandatory and strictly regulated, while voluntary offsets are flexible and market-driven.

Carbon offsetting is the process of compensating for emissions by funding projects that reduce or remove carbon dioxide (CO_2) or other greenhouse gases elsewhere. Common offsetting projects include reforestation**,** renewable energy development**,** methane capture**,** and energy efficiency improvements in developing regions. The idea is simple: while some emissions are currently unavoidable, hotels and other businesses can neutralize their environmental impact by investing in these projects. Carbon offsetting is often categorized into voluntary and compliance markets. Hotels generally participate in the voluntary carbon market (VCM)**,** motivated by corporate social responsibility (CSR), brand image, and growing consumer expectations for sustainability.

Carbon offsetting offers hotels a valuable but limited tool for addressing their environmental impact. When used responsibly—alongside aggressive emission reductions and transparency—offsetting can help hotels move toward carbon neutrality and contribute to global climate goals. However, it is not a silver bullet**.** The hospitality industry must resist the temptation of easy solutions and commit to deeper, systemic changes in operations, infrastructure, and culture. To maximize effectiveness and integrity, hotels should follow best practices: a) Prioritize Emission Reduction First**,** b) Choose High-Quality, Verified Projects**,** c) Communicate Transparently**,** and d) Engage Guests and Employees. For carbon offsetting to be truly effective, it must be treated not as the end goal but as a bridge to a low-carbon future, where sustainable practices are embedded into every facet of the hotel experience. Only then can hotels authentically claim leadership in the fight against climate change.

According to several studies carbon emissions in tourism facilities vary in the range of 20-60 $kgCO_2$ per night spent. The cost of carbon offsetting in the voluntary market falls in the range 4-7 $ per $tonCO_2$ with average price in the begining of 2025 at 4.80 $/$tonCO_2$. Therefore the current cost of carbon offsetting in tourism facilities in the voluntary market is rather low falling in the range of 0.08-0.42 $/p.n.s. The cost of carbon offsetting for various types of projects in the voluntary market is presented in table 2 while, regarding the compliance market, the price of carbon credits in the EU emissions trading system in table 3.

Table 2. Cost of carbon offsetting for various types of projects in the voluntary market

Type of project	Cost ($ per ton of CO_2)
Reforestation	6-24
Development of renewable energy project (solar, wind, hydro, et cetera)	2-6
Methane (CH_4) capture	3-10

Source: various authors

Table 3. Price of carbon credits in the EU emissions trading system

Date	Price (Euros per ton of CO_2)
1/2021	34.92
1/2022	85.42
1/2023	81.50
1/2024	78.80
1/2025	75.94

Source: [31]

9. Discussion

Several soft measures which facilitate the decarbonization of hotels have been analyzed. These include energy monitoring, energy audit, energy benchmarking, changes in the behaviour of the staff and the guests and the offset of carbon emissions. These soft measures should complement the investments in several sustainable energy technologies which are necessary for the elimination of carbon emissions in hotels. Energy monitoring, energy audit and energy benchmarking are necessary for starting the decarbonization procedure in hotels. In fact their implementation is necessary in the beginning of the decarbonization procedure. Their realization will depict their actual energy consumption comparing it with existing benchvalues facilitating the management to make rational decisions. Behavioral changes of the staff and the guests can decrease the energy consumption and carbon emissions in hotels reducing the required sustainable energy investments in them. Lastly, offsetting any remaining carbon emissions with the existing offsetting schemes can achieve total elimination of hotels' carbon footprint. The abovementioned soft measures are low-cost while they can facilitate the decarbonization of hotels and the reduction of the necessary sustainable energy investments in them. Our study does not quantify the impacts of the abovementioned soft measures in hotels' decarbonization but rather it points out their usefullness in the decarbonization procedure. Future research should be focused on the implementation of case studies in

*Corresponding Author: Vourdoubas John

hotels which are willing to eliminate all their carbon emissions examining the role of the abovementioned soft measures in the decarbonization effort.

10. Conclusions

Several soft measures which facilitate the elimination of carbon emissions due to energy consumption in hotels have been analyzed. These include energy monitoring, energy auditing, energy banchmarking, changes in the behavior of the guests and the staff as well as the possibility of offsetting carbon emissions. These soft measures are useful for eliminating the carbon footprint in hotels and complement the green energy investments in them including investments in energy saving technologies, in renewable energy technologies, in low carbon emission energy technologies and in energy storage technologies. Our study indicates that hotels willing to eliminate their carbon footprint should monitor their energy use, conduct energy audits and benchmark their energy data with the existing standards. They should also try to alter the behavior of the guests and the staff promoting a more sustainable behavior. Additionally, they can offset any remaining carbon emissions, which for technical or economic reasons can not be eliminated with the implementation of clean energy investments, with the existing offsetting mechanisms.

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