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The Management of Energy Leakage and Waste in Three and Four Star Hotels

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Abstract This paper aims to investigate the dimensions of the energy leakage and waste problem in three and four star hotels in Egypt. A questionnaire form and a checklist were designed and distributed to the 176 chief engineers in three and four star hotels in Cairo, Hurghada and Sharm-Elsheikh. The findings of the study showed that fossil fuels are the main sources for generating energy at three and four star hotels and the forms used are in a descending order, Electricity, Diesel oil, Liquefied petroleum gas, natural gas. The results clearly elucidated that only 39 of the investigated 176 three and four star hotels use solar energy for water heating only. The results showed that the HVAC systems consume more electricity and followed by the kitchen compared to other sectors. 80% of the respondents in the four star hotels and 67% in the three star hotels agree that staff wrong practices in using equipment and devices is the main cause that may lead to energy waste in their hotels. It is quite clear that there are several barriers that hinder improving and developing efficient system to reduce and manage energy leakage among which; shortage of financial resources, lack of technical services and skilled labor force. Loose legislations and ill staff practices in using equipment and devices are among other reasons. The entire population of the study is only interested in investing no, low and medium cost to minimize energy leakage. It was found also that only 5 hotels of the four star category that comply with the ISO 14001 certificate standards and the Green planet label. The current research concluded the indigence need to raise the level of hoteliers' awareness of the potential using of renewable energy. There is also essential to build up policy based on implementing feasible energy management program. Also benefiting from organic waste in the hotels by installing a station to gather and ferment the waste to produce methane gas to use it as a cooking fuel.

Keywords Energy Leakage and Waste, Energy Management Program, Environmental Quality System

1. Introduction

Energy resources as one of the assets of a hotel need from the manager to decide how best to use them to achieve the organization's objective. Especially nowadays as several studies such as[1],[2], and[3] indicated that the increasing prices of energy resources and growing pressure from governments and stakeholders provided increased motivation to lodging operators to enhance energy efficiency in their properties. With regard to the hotel industry as one of the major sectors of the hospitality industry, they need a base load of energy that forms a fixed cost to operate equipment such as heating, ventilation, cooling and lighting regardless of the number of guests staying at the hotel, in addition some studies like[4] and[5] indicated that hotels rank among the top five in terms of energy consumption in the commercial building sector.

Reference[6] differentiated between two types of losses of energy in the hospitality establishments, the first is energy waste that could happen due to turning on equipment on far in advance of its need to be used and being left on even though it is no longer needed i.e. air-condition and dishwasher or using it in half of its load i.e. ranges. The second is energy leakage due to poor insulation i.e. in hot water pipes. By considering these concepts,[7] stated that the cooking equipment and HVAC systems are the most wasters of energy as about 50% of the energy used to heat food is wasted and not properly maintained cooling system can require 10% more energy. According to some field studies conducted by[8] to assess the potential energy efficiency and measures in 3 and 4 star hotels it was found that all the investigated hotels still use normal incandescent bulbs that use more energy, there is no insulation for the hot water system and that could lead to waste of energy and the air-condition system is operated with On/Off control which means that the air-condition could work even if there is no guest in the room and consequently wastes energy.

In the studies of[9],[10], and[3], they revealed the aspects of energy leakage and waste in hotels and attributed them to lack of awareness of operators and engineers of the energy saving opportunities and concentration only on energy expenditure without attention to the specific consumption of energy of the different sectors in hotels. Therefore hotels

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need to apply energy management program that minimize wastes and improve proper practices. Such approach has been effectively implemented after OPEC oil embargo in 1973 as it was previously reported in the study of[11] and[7], who indicated that hotels started to show an immediate response to conserve and manage energy and consequently add a new dimension to the job of the chief engineer to make a significant savings of energy. In this respect,[12] as well indicated that the estimate of the percentage of energy saving that could be achieved by the application of energy efficiency improvement technologies especially in lighting, heating, ventilation and air-conditioning systems has ranged from 5% to 15% in Egyptian hotels.

It can be clear that there is a national benefit from energy conservation in hotels through saving capital investments needed for energy projects and reducing harmful emissions. Hotel management and guests also can benefit through increasing guest satisfaction at a lower cost, running the hotel efficiently and making reduction of the use of non-renewable energy resources. Although there is a great progress in the renewable energy technology applications like solar energy for water heating and cooking, wind energy for generating electricity, geothermal energy for warming and water heating and modern cooking equipment and systems that could save energy and conserve the environment,[13] referred to that the medium and small hotels are unlikely to achieve large savings of energy compared with large hotels which can undertake capital investments. Therefore the current study concentrates on identifying the aspects of the energy leakage and waste problem in three and four star hotels in Egypt.

2. Methodology

A questionnaire form was designed and distributed to the chief engineers in three and four star hotels. The questionnaire used for this study consists of nine questions dealing with the level of chief engineers' awareness of the energy leakage and waste management concept, identifying the causes of energy leakage and waste, ascertaining the barriers that hinder energy efficiency improvements in three and four star hotels, the levels of energy consumption of the different sectors and the extent of using renewable energy and the extent of complying with environmental quality systems related to energy usage efficiency.

The sequence of the questions was arranged in five groups as follows:

1- Group one is a multiple choices question to inquire about the sources of energy used in the hotel.

2- Group two includes a question to identify the level and percentage of energy consumption per different hotel sector.

3- Group three includes three questions were developed to inquire about the awareness of chief engineers to the energy leakage and waste management concept and the application of an energy management program, where the first question is a yes or no filter question to inquire about the awareness of respondents to the energy leakage and waste management concept, the second question is an open-ended multiple choices question to inquire about how the management of energy leakage and waste concept is applied in the hotel, the third question is a yes or no supplemental question to ask if the hotel implement an energy management program.

4- Group four includes two questions where the first question is an open-ended multiple choices question to ask the respondents about their opinions about the causes that may lead to energy leakage and waste in their hotels and the second question is a likert scale type question with a 1 to 5 rating where (1=strongly agree and 5= strongly disagree) to ask about the barriers of energy efficiency improvement in the investigated hotels.

5- Group five includes two questions where the first question is a yes or no filter question and the second question is a likert scale type question with a 1 to 5 rating where (1=strongly agree and 5= strongly disagree) to ask about the affiliation with energy efficiency labels and quality systems in the investigated hotels.

Field visits were conducted using a checklist to investigate the energy practices applied in the hotels, in addition to help interpreting the results of the survey.

The checklist consists of five groups of multiple choice questions to inquire about the practices applied in the main energy end-users in the hotel that include HVAC systems, lighting, kitchen, laundry and water heating.

3. Sample

3.1. Sampling frame

The frame of this study includes the three and four star hotels in Cairo, Hurghada and Sharm-Elsheikh as they represent about 51% and 66% respectively of the total number of the three and four star hotels in Egypt and the biggest number of hotel capacity according to[14].

3.2. Stratification

Table 1. Hotels' sampling frame

City	No. of four star hotels	No. of three star hotels
Cairo	12	27
Hurghada	34	29
Sharm-Elsheikh	43	31
Total	**89**	**87**

The hotels are divided into two strata by the classification of each hotel and a stratified sample was drawn from all

classified hotels (as shown in table 1). 176 classified hotels were selected randomly to fill the survey and the checklist was self-administered, from which 138 hotels responded (78.4% as a response rate). The questionnaire was distributed to chief engineers from February 10th to May 17th and the individuals were kindly asked to return completed forms at their earliest possible convenience.

The entire response rate is (78.4%) which is considered relatively low comparing with similar results conducted by[3] in all hotel categories where the rate in their study was (83.3%).

3.3. Pre-testing and Pilot Study

A sample of 25 questionnaire forms and checklist were pre-tested by academics and industry experts to validate and assume their appropriateness to the purpose by all respondents, according to[15]. The pre-testing resulted in many modifications in questions wording and sequence. In addition, the reliability coefficient (Cronbach's Alpha) was calculated to measure the internal consistency of the questionnaire and checklist as shown below.

Table 2. Reliability analysis results by using Cronbach's Alpha coefficient

Item measured	Cronbach's Alpha coefficient
Reasons that may lead to energy leakage and waste in hotels	0.64
Barriers to energy efficiency management	0.74
Energy efficiency labels and certificates	0.79
Checklist questions	0.81

4. Findings

4.1. Reliability Analysis by Using Cronbach's Alpha Coefficient

As shown in (table 2), the computed Cronbach's Alpha coefficient values for questions in 25 questionnaire forms and checklists in the pilot study are 0.64, 0.74, 0.79 and 0.81 respectively and they are acceptable measures for the reliability of the questionnaire and the checklist questions according to[16].

4.2. Energy sources used in three and four star hotels

The results obtained clearly indicated that 59.3% and 60.8% of the three and four star hotels respectively use gas (liquefied petroleum gas, LPG) mainly for cooking and it was observed that it is used for water heating in one hotel in Sharm El-sheikh. The respondents stated that gas is cheaper and has superior burning efficiency. This finding agrees with the result of[17], who found that most of the hotels visited use LPG for cooking for the similar reasons. On the other hand, poor transportation access, unsafe storage of gas and supply in winter represent a major problem that hinder using gas by 7% and 19% of three and four star hotels respectively.

The results indicated that 67.2% of the three star hotels and 81.1% of the four star hotels use diesel oil for water heating in the boiler and in emergency electricity generators, thus the diesel oil is widely used and that could be due to its cheapness and burning efficiency compared with electricity for water heating. In spite of that[18] stated that the cost of thermal energy is directly tied to fuel costs and the diesel oil as a fossil fuel has a significant environmental impact resulting from burning it. Therefore the hotels need a system to use this source efficiently without waste, this can be done through using of a combined heat and power unit that generates electricity and provide hot water according to[19] and[20].

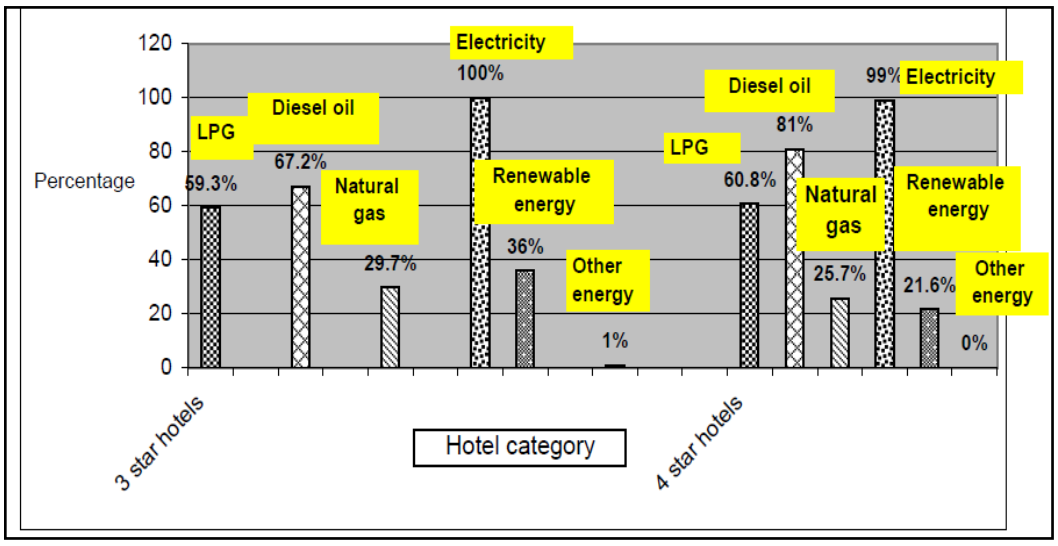

Figure 1. The profile of energy resources and their usage in 3 and 4 star hotels

The results obtained showed that 29.7% of the three star hotels and 25.7% of the four star hotels use natural gas for cooking or water heating, on the other hand 70.3% and 74.3% of the three and four star hotels respectively use LPG and Electricity for the same purpose as shown in (figure1).The field observation and the interview with the chief engineers revealed that 93% of three and four star hotels in Hurghada and 80% in Sharm El-sheikh have no access to natural gas resources because of the cost of the connection is charged on the hotel and that explains why natural gas usage is limited although it is considered a clean and cheap source of energy. This result agrees with what previously stated by[21],[22],[23] and[3] who indicated that energy consumption varies between different hotels according to the location that mainly affects the availability of energy supply options nearby the location.

The results obtained also revealed that 100% of the three star hotels and 99% of the four star hotels use electricity from grid connection for cooking, lighting and air-conditioning against 1% of the 4 star hotels that is not connected to the electricity system and depends on a diesel oil powered generator. That could be due to the accessibility of electricity across the country. Similar results were previously reported by[24] and[18].It was also observed from the field observation that only one four star hotel and it represents the rest 1.4% of the four star hotels.

The frequencies analysis showed that only 1% of the three star hotels use other energy sources like gasoline for electricity generators in contrast with 99% that do not use other energy sources beside electricity, LPG, natural gas and renewable energy, while there is no other energy sources used in the four star hotels as shown in (figure 1).

Figure 2. Solar water heater at one of the investigated four star hotels in Hurghada

The results of the cross-tabulation analysis indicated that out of 176 only 39 of the investigated three and four star hotels use solar energy for water heating as the only form of renewable energy as. This could be due to lack of knowledge regarding the potential of using solar energy particularly of the value of using solar energy especially in Cairo where hotels extend vertically and are surrounded by other buildings and the difficulty of depending on solar energy in winter due to decrease of sun rising hours. This argument is in accordance with that by[18] who indicated that the hotel location affects the climatic conditions and consequently the availability of energy supply options and[17] who stated that solar water heater is very expensive and the hotels do not see that as a viable investment in the short to medium term requirements. The interview clearly elucidated that the hotels use solar water heaters are convinced with its viability and cost effectiveness, similar results was previously illustrated by[25] and[26], who found in their study that solar water heater is cheaper, easier to maintain compared with other systems and lasts for longer periods.

4.3. The consumption of energy by the different operations in the hotels of the current investigation in a descending order of follow

Table 3. Profile of energy consumption of different operations in 3 and 4 star hotels in Cairo

Hotel category / City		3 star	4 star
Cairo	Operation	Energy consumption percentage	Energy consumption percentage
	HVAC	52%	52%
	Kitchen	45%	22.2%
	Laundry	16.3%	19%
	Water heating	17.5%	16.2%
	Lighting	23.3%	20%
	Other sectors	10%	15%

The profile of the consumption of different operations is shown in (table 3), (table 4) and (table 5). The heating, ventilation and air-conditioning systems (HVAC) consume 50% ±2 of hotel energy needed to run the operations, followed by the kitchen that consumes between 22.2% and 45%. That could be due to operating the air-condition, ventilation systems and the kitchen most of the day therefore their energy consumption is the highest compared with other operations and the lack of insulation techniques in most hotels in addition to the variance in facilities and size between hotels. It is noticed also that the kitchen in three star hotels in Sharm El-sheikh consumes 70% of hotel energy and that could be ascribed to depending on electricity as the main source of energy in the kitchen. Other operations include lighting, water heating; laundry and other sectors including water pumps and waste water treatment stations rank in the medium and low energy consumption levels. This

finding is in accordance to what previously stated by[12] and[7], who reported that the HVAC systems have the highest share of energy consumption and followed by the kitchen in hotels. Authors argue that could be explained by the fact that the employee are ill-equipped to how manage operations in the kitchen and poor control of air-condition systems.

Table 4. Profile of energy consumption of different operations in 3 and 4 star hotels in Hurghada

Hotel category / City		3 star	4 star
Hurghada	Operation	Energy consumption level	Energy consumption level
	HVAC	52%	48%
	Kitchen	45%	45%
	Laundry	17%	17.5%
	Water heating	15%	16.8%
	Lighting	21.2%	17.1%
	Other sectors	8%	15%

Table 5. Profile of energy consumption of different operations in 3 and 4 star hotels in Sharm Elsheikh

Hotel category / City		3 star	4 star
Sharm El-sheikh	Operation	Energy consumption level	Energy consumption level
	HVAC	50%	50%
	Kitchen	70%	24.8%
	Laundry	19.1%	17.7%
	Water heating	20%	20%
	Lighting	20%	20.4%
	Other sectors	15%	7.2%

However, the current results partially contradict with the results of the study of[17] as it was found that the HVAC and lighting are the highest operations of energy consumption in the 4 star hotels, while the kitchen and lighting are the highest operations of energy consumption in the 3 star hotels.

4.4. Following a Uniformed Energy Leakage and Waste Management Program in the Hotel

"Energy management includes all practices, measures and actions that aim to minimize energy waste"[27]; without adversely affecting the building's functional requirements. It is a multidimensions system[28] and[29] that covers developing an energy efficient culture, understanding and controlling the energy usage. In this respect the results of the current study have shown that most of respondents lack the awareness and knowledge of their hotels energy management policy. However, they mostly aware of necessary energy saving practices.

Although, there are 13 of 57 of the respondents in the three star hotels and 22 of 70 of the respondents in the four star hotels showed that they have an energy management program and indicated that they interpret the full concept of energy leakage and waste management.

4.5. Energy Leakage and Waste in Three and Four Star Hotels

Energy leakage and waste is quite remarkable in 3 and 4 star hotels due to different reasons as shown in (table 4). The ranking cause differs between two hotel categories except that staff poor practices in using equipment and devices occupied the top rank and using of low energy efficiency equipment came into the 7th rank for both hotel categories. Surprisingly enough that poor insulation of piping and duct systems was remarkable and highly ranked by the researcher, it came at the 9th ascending order cause of energy leakage and waste. Other causes ranked 3-6 categories for both 3 and 4 star hotels.

In similar studies[30],[31],[32] and[33] identified staff attitude problems, inadequate maintenance or personnel, poor design and insulation and uncomfortable work conditions as main causes of energy leakage and waste but they did not provide a particular arrangement for these causes.

4.6. Barriers to Energy Efficiency Improvement in the four Star Hotels

Figure (3) shows that high proportion of respondents (39.4% agree and 29.6% strongly agree) view that high cost and lack of financial resources as the limiting factor that hinder improving the efficiency of energy management. Similar findings were reported by[34] and[35]. The results also showed that (19.7% strongly agree and 21% agree) that lack of loans or economic subsidy provided by the government to increase energy efficiency is another barrier to improving energy efficiency. On the other hand,[18] reported contradicted view based on the abusing of the energy subsidy policy prices that lead to higher energy wastes. It could be noticed also that hotels could have loans from banks in addition to their flow of fund to finance their energy efficiency projects therefore the former results did not clarify exactly if it is really a barrier or not.

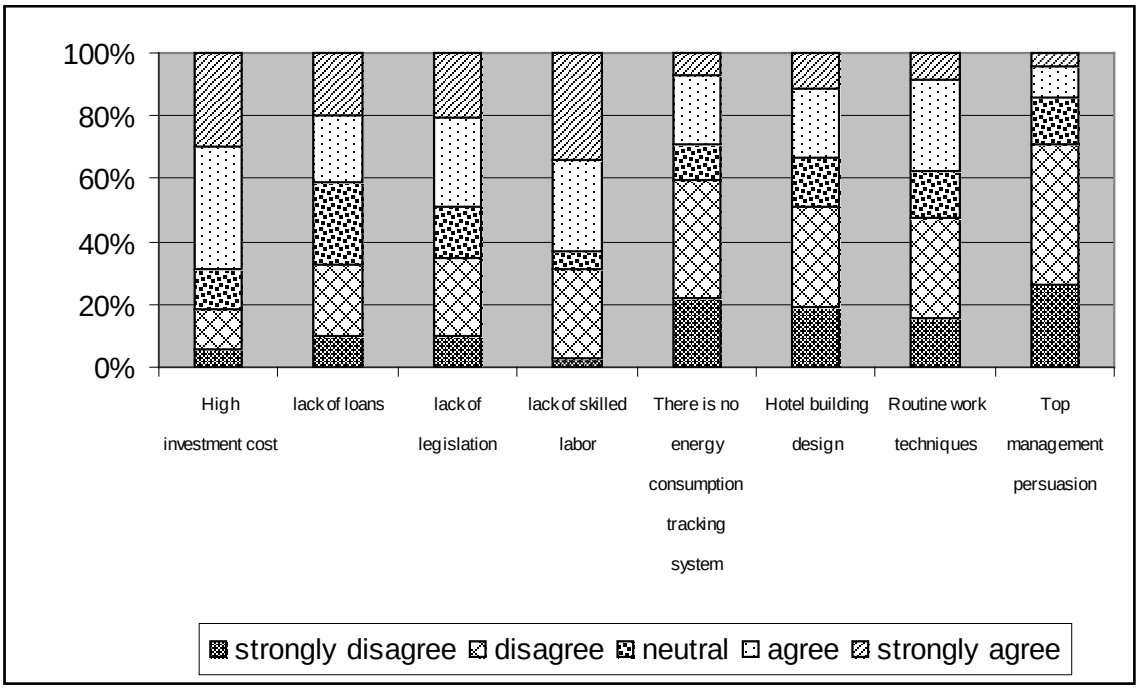

Figure 3. Frequencies of energy efficiency improvement barriers in the three star hotels

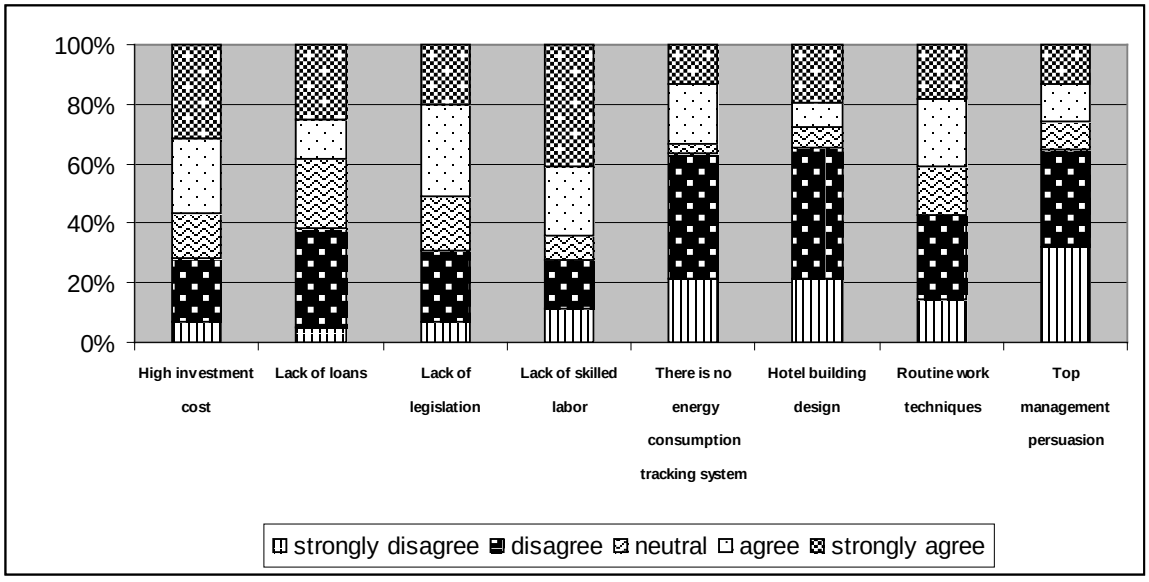

Figure 4. Frequencies of energy efficiency improvement barriers in the three star hotels

It was found also that high proportion of respondents (20.3%strongly agree and 29% agree) that lack of legislation in Egypt related to improving energy efficiency in hotels is a barrier to energy efficiency and consequently there is no definite law for hotels to improve their energy efficiency. On the other hand 10.1% of the respondents strongly disagree, 24.6% disagree and 15.9% are neutral. These results could be due to lack or absence of legislations in Egypt related to reducing energy leakage and waste in hotels. Reference[18] as well reported similar result.

Other results indicated that 34.2% strongly agree and 28.8% agree that lack of skilled personnel has a great negative impact and present a barrier to energy efficiency improvement in the four star hotels. Only 2.7% of respondents strongly disagree, 28.8% disagree and 5.5% are neutral. Hence it is well clear that this result confirm the former result saying that wrong practices of the staff could be a cause of energy leakage and waste. These results could be due to the absence of training programs related to improving energy efficiency and handling with new energy efficient equipments in these hotels. Similar result was previously reported by[35] as lack of motivation and knowledge of the staff is a barrier to improve energy efficiency.

In addition a high proportion of respondents (22.2% strongly disagree and 37.5% disagree) that nonexistence of a system to control energy consumption is a barrier to begin to

improve energy efficiency in the four star hotels. Therefore it could be clear that making readings of energy consumption is a routine work of considerable importance that could not form a barrier to improve energy efficiency in these hotels. This result disagree with what previously stated by[32] who viewed that little or no tracking of energy consumption is one of the main causes of energy problems in hotels.

The results showed that 19.4% strongly disagree and 31.9% disagree that poor design of a hotel is a barrier to energy efficiency improvement. On the other hand 11.1% of the respondents strongly agree, 22.2% agree and9 15.3 are neutral. Therefore it could be clear that hotel design is not a barrier of the first degree due to the fact that these hotels could adopt new systems to reduce energy leakage apart from their design. This result is disagreeing with[32],[33] and[36] who viewed that many of the buildings are wasting energy because of inefficient design and neglected operation and consequently could be a barrier to energy efficiency improvement.

The obtained results showed that 15.3% of the respondents strongly disagree and 31.9% disagree that monotonous or routine approach to perform work is a barrier to energy efficiency, while only 8.3% strongly agree, 29.2% agree and 15.3% are neutral. Hence it could be clear that routine work method is not a barrier to improve energy efficiency. This result could be due to that most of the chief engineers view that routine maintenance is a method to reduce energy leakage and waste.

According to the survey results, 26.4% of the respondents strongly disagree and 44.4% disagree that no conviction of the top management of the energy efficiency technologies is a barrier to energy efficiency. Only 4.2% strongly agree, 9.7% agree and 15.3% are neutral. Therefore it is clear that no conviction of the top management of the worthiness of energy efficiency technologies is not a barrier and that could be due to that the four star hotels may take up capital investments to promote energy efficiency. This result is not in accordance with what was reported by[31] which stated that no intention from top management to enhance energy efficiency could be a cause to energy leakage and waste and consequently a barrier to energy efficiency improvement.

4.7. Barriers to Energy Efficiency Improvement in the Three Star Hotels

Figure (4) shows that high proportion of respondents (31.7%strongly agree and 25% agree) that high cost of investment is a limiting factor that hinder improving energy in three star hotels, while only 6.7% of the respondents strongly disagree, 21.7% disagree and 15% are neutral. This result is in accordance with the former result in the four star hotels in that high cost and lack of availability of financial resources is a barrier to energy efficiency improvements.

The results showed that high proportion of respondents (20.3% strongly agree and 30.5% agree) that lack of legislation related to energy efficiency improvement in the three star hotels is a barrier as there is no definite law to organize energy usage and consumption in hotels. On the other hand a portion of respondents (6.8%) strongly disagree, 23.7% disagree and the rest (18.6%) are neutral. This result is in accordance with the former result in the four star hotels and what was reported by[18] as lack or weak legislation related to using energy resources hinder the activation of energy efficiency improvement in the hotels.

According to the survey results, 25% of the respondents strongly agree and 13.3% agree that lack of loans or economic subsidy provide by the government is a barrier to energy efficiency improvement in three star hotels whereas only 5% strongly disagree, 33.3% disagree and 23.3% are neutral. Hence it is clear that lack of loans or economic incentive systems from the government to enhance energy efficiency in the three star hotels is not a barrier as the total response of both agreement and disagreement is the same (38.3%) while 23.3% are neutral. This result is in accordance with the previous result in the four star hotels and that could be due to the possibility of taking up loans from banks to finance energy efficiency improvement projects in hotels regardless the oriented subsidy from the government to the energy resources. This result is not in accordance with what previously indicated by[18].

The results showed that the majority of respondents (41% strongly agree and 23% agree) that lack of skilled labor who are capable of maintaining new technological equipment is a barrier to energy efficiency improvement in the three star hotels. Whereas only 11.5% strongly disagree, 16.4% disagree and 8.2% are neutral. Thus, it could be clear that lack of skilled labor is a barrier to energy efficiency improvement in the three star hotels. This result is the same as in the four star hotels. Reference[35] as well indicated that lack of knowledge of the staff is a barrier to improve energy efficiency of buildings.

It was found also that high proportion of respondents (21.7%strongly disagree and 41.7% disagree) that they do not have any system for energy consumption tracking and therefore it is a barrier to energy efficiency improvement in the three star hotels. While 13.3% strongly agree, 20% agree and only 3.3% are neutral. This result is in accordance with the former result of the four star hotels in that most of the hotels make readings of energy consumption regularly and consequently it is not a barrier. On the contrary,[32] stated that little or no tracking of energy consumption is one of the main causes of energy problems in hotels.

The results indicated that 21.3% strongly disagree and 44.3% disagree that hotel building design is a barrier to energy efficiency improvement in the three star hotels, while only 19.7% strongly agree, 8.2% agree and 6.6% are neutral. This result is in accordance with the former result of the four star hotels in that hotel design is not a barrier to enhance energy use efficiency. This can be due to that respondents think that they can accommodate their operation to the hotel design without wasting energy. This result does not conform to what was previously stated by[33], who viewed that inefficient designed hotels could waste energy.

In addition, 18% of the respondents strongly agree and 23% agree that routine approach to perform work is a barrier

to energy efficiency improvement in the three star hotels, whereas 14.8% strongly disagree and 27.9% disagree and 16.4% are neutral. Therefore it is clear that monotonous approach of work may be a barrier to some hotels and reversely for the other as the percentage of agreement and disagreement is close to an extent. This result differ from the result in the four star hotels where routine work methods is not a barrier to energy efficiency and this can be due to that there are many routine procedures of work that the hotels could not dispense with it. In this respect,[36] reported that many buildings are wasting energy because of neglected operation.

Other results showed that 32.3% of the respondents strongly disagree and 32.3% disagree that no conviction of the top management that energy efficiency technologies are worthwhile is a barrier to energy efficiency improvement in the three star hotels. On the other hand, 12.9% strongly agree, 12.9% agree and 9.7% are neutral. Therefore it could be clear that this result is in accordance with the result in the four star hotels in that the conviction extent of the top management is not a barrier to energy efficiency improvement. On the contrary,[31] indicated that the top management negligence is a cause of energy waste and consequently hinder the commitment of energy efficiency improvement.

4.8. The Affiliation with Eco-labels Systems Related to Energy Efficiency in the Four Star Hotels

The results obtained of the frequencies indicated that there is lack of affiliation with energy efficiency labels in the four star hotels as there is only 5 hotels from the total 74 sharing hotels have the Green Planet award and the ISO 14001 certificate. And that can be due to lack of information about energy efficiency labels and how the hotel can comply with its standards. Similar result was previously stated by[1], who indicated that eco-friendliness ranks low in hotels due to lack of customer interest in addition to other economic, political and socio-cultural factors of a country. Reference[37] attributed the lack of affiliation with energy efficiency labels to hotels that are less influenced by stakeholders such as customers, suppliers and local authorities who are interested in the hotel environmental performance. On the other hand, there is no hotel of the total sharing 64 three star hotels has any energy efficiency label. This result is similar to an extent to the results of the four star hotels as there is lack of affiliation with eco-labels and that can be due to lack of information about energy efficiency labels and uninteresting to comply with their standards.

4.9. Checklist Analysis in the Four Star Hotels

4.9.1. Heating, Ventilation and Air-conditioning Practices

The statements used to assess the efficiency of heating; ventilation and air-conditioning practices in the four star hotels and rate of their application are shown in (table 6).

It was observed that the four star hotels tend to traditional low to medium cost practices to reduce energy leakage and waste as 93% of the hotels maintain insulation on pipes and ducts, 80% use key card (power saver card) and 49% of hotels fix double glazing on windows to prevent heat loss or gain while all of them do not use occupancy sensors in guest rooms or heat recovery system in the kitchen hood because of their high cost and unavailability, On the other hand 32% of hotels use other actions like control timers or thermostat in the air-condition and 5% use an energy management system to control air-condition. Similar result was previously stated by[38] and[35],who indicated that high capital cost and lack of awareness to some systems are the main barriers to tending to high cost actions. Although[6] indicated that low to medium cost actions to reduce energy leakage and waste lead to noticeable results. Reference[39] reported that installing heat recovery system can reduce energy waste by 10% to 25%. Reference[40] as well indicated that using occupancy sensors can save 2 to 3 billion kilowatt-hours annually in the U.S hotels.

Table 6. Frequency analysis of the first section responses in the checklist of the four star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Double glazing on windows is installed	74	36	49%	38	51%
Installing occupancy sensors to control temperature in guest rooms	74	0.0	0.0%	74	100%
Using key cards in guest rooms	74	59	80%	15	20%
Maintain insulation on piping and duct systems to prevent energy loss	74	69	93%	5	7%
Installing heat recovery system in the kitchen hoods	74	0.0	0.0%	74	100%
Installing an energy management system to control the HVAC system in the hotel	74	4	5%	70	95%
Other	74	24	32%	50	68%

4.9.2. Lighting Practices

The Statements used to assess the efficiency of lighting practices in the four star hotels and rate of their application are shown in (table 7).

The obtained results showed that the four star hotels tend to low or medium cost actions side by side with high cost actions as 93% of the four star hotels subject to the investigation use energy saving fluorescent lamps instead of incandescent lamps, 92% clean lighting fixture regularly, 81% can make use of day light, the wall color that reflects light is used by 77% of the hotels, 73% use dimmers to control light and 12% use other actions such as using timers and photo cell lighting. This result can be due to that the cost of actions related to reduce energy waste in lighting is low compared with other actions. Reference[40] stated that using compact fluorescent lamps can save about 2 to 3 billion of kilowatt-hours annually if used in 90% of the U.S hotels.

Reference[41] as well reported that installing occupancy sensors or key card system in the guest room can result in great saving of energy.

Table 7. Frequency analysis of the second section responses in the checklist of the four star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Replacing incandescent lamps with energy efficient fluorescent lamps in areas where lights would be on for long hours	74	69	93%	5	7%
Making use of daylight as much as possible	74	60	81%	14	19%
Installing dimmer switches to control light	74	54	73%	20	27%
Choosing wall colors that reflect daylight as possible	74	57	77%	17	23%
Cleaning lamps and fixtures regularly to remove dust and grease and improve the light efficiency	74	68	92%	6	8%
Other	74	9	12%	65	88%

4.9.3. Kitchen Operation Practices:

The Statements used to assess the efficiency of kitchen operation practices in the four star hotels and rate of their application are shown in (table 8).

Table 8. Frequency analysis of the third section responses in the checklist of the four star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Using insulated and energy efficient equipment	73	56	77%	17	23%
Heating equipment should be clustered together and away from cooling equipment	73	65	89%	8	11%
Training of staff to Place frozen goods immediately to storage to avoid waste of energy for re-cooling	73	61	84%	12	16%
Adjusting the refrigerators thermostat to the needed temperature to use no more energy	73	71	97%	2	3%
Using low temperature water in dishwasher (50°C- 60°C) and killing bacteria by using detergents	73	48	66%	25	34%
Installing heat recovery unit in dishwasher	73	9	12%	64	88%
Other	73	4	5%	69	95%

It was observed that 97% of the hotels subject to the investigation adjust the refrigerators thermostat to the purpose suited temperature to save energy, 89% cluster heating equipment away from cooling equipment in order to save energy, 84% train staff to store frozen foods immediately in order not to waste energy in refreezing, 77% use insulated kitchen equipment, 66% use hot water of 50℃ to 60℃ in dishwasher especially in the rinsing cycle. Therefore it is well clear that most of these practices fall in the no cost or low cost practices as just 12% of them use dishwasher with heat recovery or install a heat recovery unit that costs more. In this respect[20] referred to the possibility of using heat recovery unit to capture heat from dishwasher's wash cycle to preheat cold water and use it as a hot water. In addition there are 5% of the four star hotels follow other actions such as cleaning and maintenance of equipment.

4.9.4. Laundry Practices

Statements used to assess the efficiency of laundry operation practices in the four star hotels and rate of their application are shown in (table 9).

Table 9. Frequency analysis of the fourth section responses in the checklist of the four star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Maintaining hot water temperature at 60°C	74	50	68%	24	32%
Operating laundry fully loaded at rated capacity according to time schedule	74	64	87%	10	13%
Checking dry cleaning machines regularly to ensure that no leaks occur	74	55	74%	19	26%
Installing of heat recovery system	74	11	15%	63	85%
Insulating ironer chest to prevent unnecessary heat losses	74	61	82%	13	18%
Other	74	2	3%	72	97%

The results obtained clarified that 87% of the total study hotels sample operate the laundry fully loaded, 82% Insulate ironer chest to prevent heat leakage,74% check the dry cleaning machine regularly for any leakage,68% use 50℃ - 60℃ hot water in laundry and 3% perform other practices whereas only 15% install a heat recovery unit in the laundry in the form of a closed cycle of steam generated from a boiler to heat tepid water and return back to the boiler and as such cost the hotel more than the traditional electrical laundry. Therefore these hotels tend to no or low to medium cost practices to reduce energy leakage and waste in laundry operation and that can be due to lack of awareness of new systems and high cost of some practices. Reference[42] and[43] referred to modern high cost laundry systems such as ozone laundry that uses fewer chemicals and sound wave laundry system that uses 10 gallons of water compared with traditional laundry that uses 60 gallons and consequently reduce energy and water waste.

4.9.5. Water Heating Practices

The Statements used to assess the efficiency of water heating practices in the four star hotels and rate of their application are shown in (table 10).

The results obtained indicated that 92% of the total study hotel sample insulate hot water pipes to prevent heat leakage, 78% use a water boiler instead of electric water heaters, 69% install water savers on taps, 60% adjust water heaters

thermostat to the fair degree of 55℃ and 7% follow other actions such as using solar water heaters whereas none of the hotels installed a combined heat and power unit (CHP) to provide with electricity and hot water. Therefore these hotels tend to low to medium cost actions to reduce energy leakage and waste in water heating operations and that can be due to lack of awareness of some systems or it is not viable in the hotel. However,[44] reported that the installation of a CHP unit in two hotels in England made savings of £3900/year and £5430/year. In addition[18] indicated that the adoption of a CHP unit in a hotel in Sharm-Elsheikh made savings of about 106319 pound/year.

Table 10. Frequency analysis of the fifth section responses in the checklist of the four star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Insulating hot water pipes to reduce heat loss	74	68	92%	6	8%
Installing a co-generation unit to provide with electricity and hot water	74	0	0.0%	74	100%
Installing water savers on hot water taps	74	51	69%	23	31%
Using boilers instead of separated water heating units	74	58	78%	16	22%
Adjusting water heaters thermostats at not more than 55°C for guest room water	74	44	60%	30	40%
Other	74	5	7%	69	93%

4.10. Checklist Analysis in the three Star Hotels

4.10.1. Heating, ventilation and air-conditioning practices

The Statements used to assess the efficiency of heating; ventilation and air-conditioning practices in the three star hotels and rate of their application are shown in (table 11).

Table 11. Frequency analysis of the first section responses in the checklist of the three star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Double glazing on windows is installed	64	24	38%	40	62%
Installing occupancy sensors to control temperature in guest rooms	64	0.0	0.0%	64	100%
Using key cards in guest rooms	64	33	52%	31	48%
Maintain insulation on piping and duct systems to prevent energy loss	64	50	78%	14	22%
Installing heat recovery system in the kitchen hoods	64	2	3%	62	97%
Installing an energy management system to control the HVAC system in the hotel	64	2	3%	62	97%
Other	64	19	30%	45	70%

The results obtained indicated that 78% of the total study hotel sample insulates pipes and ducts to prevent energy leakage, 52% use key card to control the guest room energy in the form of a power saver card, 38% fix double glazing on windows to prevent heat loss or gain and 30% perform other practices. On the other hand none of these hotels uses occupancy sensor, 3% installed an energy management system to control HVAC system and 3% installed a heat recovery system in the kitchen hood. These results are similar to the results in the four star hotels in that these hotels tend to no cost and medium cost actions to reduce energy leakage and waste.

4.10.2. Lighting Practices

The Statements used to assess the efficiency of lighting practices in the three star hotels and rate of their application are shown in (table 12).

Table 12. Frequency analysis of the second section responses in the checklist of the three star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Replacing incandescent lamps with energy efficient fluorescent lamps in areas where lights would be on for long hours	64	61	95%	3	5%
Making use of daylight as much as possible	64	53	83%	11	17%
Installing dimmer switches to control light	64	40	63%	24	37%
Choosing wall colors that reflect daylight as possible	64	45	70%	19	30%
Cleaning lamps and fixtures regularly to remove dust and grease and improve the light efficiency	64	59	92%	5	8%
Other	64	4	6%	60	94%

The results clarified that 95% of the three star hotels subject to the investigation use energy saving fluorescent bulbs in areas where lights would be on for long hours, 92% clean lighting fixtures such as reflectors to enhance the lighting efficiency, 83% benefit from the day light in areas such as lobby and restaurants as possible, 70% use wall color that reflects the light, 63% use dimmer switches to control light and 6% use other practices such as using timers and photocell lighting in landscape areas. This result is also similar to the result in the four star hotels in that these hotels tend to low cost side by side with high cost practices. In this respect[18] indicated that hotels could start with low cost practices with obvious areas of waste to obtain quick results and build confidence in the energy management program.

4.10.3. Kitchen Operation Practices

The Statements used to assess the efficiency of kitchen operation practices in the three star hotels and rate of their application are shown in (table 13).

The results obtained revealed that 91% of the three star hotels subject to the investigation adjust the refrigerators thermostat to the proper temperature to save energy, 83% cluster heating equipment away from cooling equipment in order to save energy, 81% train staff to store frozen foods immediately in order not to waste energy in refreezing, 73% use insulated kitchen equipment, 59% use hot water of 50℃ to 60℃ in dishwasher especially in the rinsing cycle, 11%

use dishwasher with heat recovery unit and 6% follow other actions such as cleaning and maintenance of equipment. Therefore it is well clear that most of these practices fall in the no cost or medium cost practices as just 11% of the hotels use dishwasher with heat recovery system that costs more compared with other dishwashers. This result is also similar to the result in the four star hotels and can be due to lack of awareness of new systems that save energy and reduce leakage and waste. In the light of that,[45] and[46] referred to many energy efficient kitchen equipment such as combination steamer that can save 60% of energy compared with other equipment.

Table 13. Frequency analysis of the third section responses in the checklist of the three star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Using insulated and energy efficient equipment	64	47	73%	17	27%
Heating equipment should be clustered together and away from cooling equipment	64	53	83%	11	17%
Training of staff to Place frozen goods immediately to storage to avoid waste of energy for re-cooling	64	52	81%	12	19%
Adjusting the refrigerators thermostat to the needed temperature to use no more energy	64	58	91%	6	9%
Using low temperature water in dishwasher (50˚C- 60˚C) and killing bacteria by using detergents	64	38	59%	26	41%
Installing heat recovery unit in dishwasher	64	7	11%	57	89%
Other	64	4	6%	60	94%

4.10.4. Laundry Practices

The Statements used to assess the efficiency of laundry operation practices in the three star hotels and rate of their application are shown in (table 14).

Table 14. Frequency analysis of the fourth section responses in the checklist of the three star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Maintaining hot water temperature at 60˚C	64	43	67%	21	33%
Operating laundry fully loaded at rated capacity according to time schedule	64	49	77%	15	23%
Checking dry cleaning machines regularly to ensure that no leaks occur	64	35	55%	29	45%
Installing of heat recovery system	64	6	9%	58	91%
Insulating ironer chest to prevent unnecessary heat losses	64	47	73%	17	27%
Other	64	3	5%	61	95%

The results obtained clarified that 77% of the three star hotels subject to the investigation operate the laundry fully loaded according to time schedule, 73% Insulate ironer chest to prevent heat leakage, 67% use hot water of 50℃ - 60℃ in the laundry,55% check the dry cleaning machine regularly for any leakage and 5% perform other practices while only 9%installed a heat recovery unit in the laundry in the form of a closed cycle of steam generated from a boiler to heat tepid water and return back to the boiler and as such costs the hotel more than the traditional electrical laundry. It is well clear that these hotels tend to no cost and low cost measures to reduce energy leakage and waste and that can be due to lack of available new laundry systems that can save more energy compared with other traditional systems. This result is similar to the result in the four star hotels.

4.10.5. Water Heating Practices

The Statements used to assess the efficiency of water heating practices in the three star hotels and rate of their application are shown in (table 15).

Table 15. Frequency analysis of the fifth section responses in the checklist of the three star hotels

Item	Occurrence			Missing	
	Total	No.	Percentage	No.	percentage
Insulating hot water pipes to reduce heat loss	64	46	72%	18	28%
Installing a co-generation unit to provide with electricity and hot water	64	0.0	0.0%	64	100%
Installing water savers on hot water taps	64	38	59%	26	41%
Using boilers instead of separated water heating units	64	29	45%	35	55%
Adjusting water heaters thermostats at not more than 55˚C for guest room water	64	49	77%	15	23%
Other	64	2	3%	62	97%

It was observed that 77% of the total study hotel sampleadjust water heaters thermostat to the fair degree of 55℃, 72% insulate hot water pipes to prevent heat leakage, 59% fix water savers on taps, 45% use a water boiler instead of electric water heaters and 3% follow other practices such as using of solar water heaters, while none of the hotels installed a combined heat and power unit (CHP) to provide with electricity and hot water although its energy efficiency and that can be due to its high cost, they are not aware of it or it is not viable for the hotel. This result is also similar to the result in the four star hotels in that these hotels tend to low to medium cost practices. However,[47] indicated that CHP unit can be viable for small hotels and restaurants. Reference[20] reported that this system can be designed to provide domestic hot water, steam for kitchen and laundry especially for hotels that are not connected to the electricity network.

5. Conclusions

It was found that all the investigated three and four star hotels depend on traditional sources of energy generated from fossil fuels which are respectively according to usage, Electricity, Diesel oil, Liquefied petroleum gas (LPG),natural gas. On the other hand there are 39 of the

investigated 176 three and four star hotels use solar energy only for water heating and they are respectively, 4 hotels of the three star category in Cairo, 14 hotels of the three star category and 9 of the four star category in Hurghada and 5 hotels of the three star category and 7 of the four star category in Sharm El-sheikh.

HVAC systems have the highest mean of energy consumption percentage in three and four star hotels that is 52% in the three star hotels and 52.5% in the four star hotels in Cairo, 52.7% in the three star hotels and 47.5% in the four star hotels in Hurghada and 50% for both three and four star hotels in Sharm El-sheikh respectively and followed by the kitchen that is 45% in the three star hotels and 22.2% in the four star hotels in Cairo, 45% for both three and four star hotels in Hurghada and 70% in the three star hotels and 29.7% in the four star hotels in Sharm El-sheikh.

The chief engineers are aware of different concepts of the energy leakage and waste management where 33.9% of the respondents in the three star hotels and 44.4% of the respondents in the four star hotels interpret the correct concept of energy leakage and waste management in their hotels, but their hotel programs to manage energy leakage and waste do not promote the energy management program in the full sense of word and depend mainly on some actions to save energy.

80% of the respondents in the four star hotels and 67% in the three star hotels agree that wrong practices of the staff in using equipment and devices is the main cause that may lead to energy waste in their hotels.

The financial, technical and labor barriers to energy efficiency improvement represented in high cost of investment, lack of legislation related to energy efficiency improvement in hotels and lack of skilled labor capable of maintaining technological means in three and four star hotels in addition to routine approach to perform work in the three star hotels contribute to the continuous existence of some causes of energy leakage and waste.

All the investigated three and four star hotels do not affiliate with any environmental quality system related to energy efficiency except for 5 hotels of the four star category that comply with the ISO 14001 certificate standards and the Green planet label.

All the investigated three and four star hotels tend to no cost, low cost or medium cost actions to manage energy leakage and waste and that could be due to their lack of awareness of modern technological means that can reduce energy leakage and waste or the high cost of some equipment.

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